

PICES-2017

**Environmental changes in the North Pacific
and impacts on biological resources and
ecosystem services**

North Pacific Marine Science Organization



September 22 - October 1, 2017
Vladivostok, Russia

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Abstracts for oral presentations are sorted first by presentation day and then by presentation time.
Abstracts for posters are sorted by session and then by paper ID number.
Presenter name is in bold-face type and underlined.
Some abstracts in this collection are not edited and are printed in the condition they were received.

Meeting Timetable

Friday, September 22												
09:00 12:30	D-504				D-501				D-601			
14:00 18:00	W3 Highly Migratory Species				W4 Long Term Changes HABs (end at 1900)				W6 ZP Production			
									W2 Coastal Ecosystem Services			
Saturday, September 23												
09:00 12:30	A-517	Rm1/L4	B-537	B-552	B-626	D-501	D-504	D-601	D-604	D-569	D-564	
14:00 18:00	W1 Bering Sea	WG-32 Meeting	SG-MES Meeting	S-HAB Meeting	S-CC Meeting	WG-38 Meeting	WG-30 Meeting	WG-40 Meeting	WG-36 Meeting	WG-35 Meeting	S-MBM Meeting [13-18:00]	
Sunday, September 24												
09:00 12:30	B-626	B-537	D-504	D-564	D-569	D-501	B-552	D-601				
14:00 17:00	Science Board Meeting*	WG-37 Meeting	AP-NPCOOS Meeting	S-CCME Meeting	AP-CREAMS Meeting	AP-NIS Meeting	WG-39 Meeting	WG-33 Meeting				
18:00 20:00	FUTURE SSC Meeting					S-MBM Meeting [13-17:00]						
18:00 20:00	HD Meeting Day 1	MEQ Meeting Day 1	BIO Meeting Day 1	TCODE Meeting Day 1	POC Meeting Day 1			FIS Meeting Day 1	MONITOR Meeting Day 1			
Monday, September 25												
08:45 10:10	[Middle Hall] Opening Session											
10:30 18:20	[Middle Hall] Plenary Science Board Symposium (S1)											
18:30 21:00	[Big Panoramic Hall] Welcome Reception (for all participants and registered guests)											
Tuesday, September 26 [posters can be displayed starting at noon]												
09:00 10:30	[Middle Hall] Plenary Session (S3, S12, S13)											
10:50 14:00	D-501	D-504			D-601			D-604	B-537			
14:00 16:00	S13 (Anthropogenic Effects)		S3 (MSY)			S8/HD-Paper (Marine Ecosys Health)			S6 (Inter Var; Forecasts & Climate Proj)		F&A Meeting (closed)	
16:20 18:00			S12 (Prey Consumption)									
19:00 21:00											FUTURE SSC Meeting	
Wednesday, September 27 [posters available for viewing all day] 5 level Building B												
09:00 12:30	Middle Hall						B-537					
	S10 FUTURE Plenary (Emerging Issues)						F&A Meeting (closed)					
14:00 18:00	B-537	A-517	B-626	D-501		D-504	D-601	D-604				
18:30 21:00	BIO Meeting Day 2	FIS Meeting Day 2	MEQ Meeting Day 2	MONITOR Meeting Day 2		POC Meeting Day 2	TCODE Meeting Day 2	HD Meeting Day 2				
18:30 21:00	Sport Event											

Meeting Timetable (continued)

Thursday, September 28 [posters available for viewing all day] 5 level Building B					
09:00 10:30	[Middle Hall] Plenary Session (S2, S5, S11)				
10:50 12:30	D-601	D-604	D-501	D-504	TBA
14:00 18:00	S4 (Adverse Impacts)	S9 (Meso/Submeso)	S11 (Arctic/Subarctic Envir Var) S5 (Coast Ecosys Cons)	S2 (Microplastics)	13:00-15:00 Public Lectures for University students
18:00 21:00	[Cafeteria Level 5] Poster Session* (reception) “Wine and Cheese”				
Friday, September 29					
09:00 12:20	D-501	D-504	D-601	D-604	
	BIO-Paper	FIS-Paper	MEQ-Paper	POC-Paper	
12:40 13:40	[Middle Hall] Closing Session**				
13:50 18:00	B-537 Science Board Meeting (closed)				
18:30 21:00	Chairman’s Reception [by invitation only]				
Saturday, September 30					
09:00 18:00	D-564 Science Board Meeting (closed)		D-569 Governing Council Meeting (closed)		
Sunday, October 1					
09:00 18:00	D-569 Governing Council Meeting (closed)				

List of Sessions and Workshops

S1	Sept. 25	Environmental changes in the North Pacific and impacts on biological resources and ecosystem services
S2	Sept. 28	Microplastics in marine environments: Fate and effects
S3	Sept. 26	Below and beyond maximum sustainable yield: Ecosystem reference points
S4	Sept. 28	Adverse impacts on coastal ocean ecosystems: how do we best measure, monitor, understand and predict?
S5	Sept. 28	Coastal ecosystem conservation and challenges
S6	Sept. 26	Interannual variability in marine ecosystems and its coupling with climate projections
S8/HD	Sept. 26	Marine ecosystem health and human well-being: a social-ecological systems approach
S9	Sept. 28	Meso-/submeso-scale processes and their role in marine ecosystems
S10	Sept. 27	Emerging issues in understanding, forecasting and communicating climate impacts on North Pacific marine ecosystems
S11	Sept. 28	Environmental variability in arctic and subarctic regions and evaluating fishery management strategies
S12	Sept. 26	Seasonal and climatic influences on prey consumption by marine birds, mammals, and predatory fishes
S13	Sept. 26	Joint PICES-ICES Session on Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services
BIO-P	Sept. 29	BIO Contributed Paper Session
FIS-P	Sept. 29	FIS Contributed Paper Session
MEQ-P	Sept. 29	MEQ Contributed Paper Session
POC-P	Sept. 29	POC Contributed Paper Session
GP		General Poster Session
W1	Sept. 23	The role of the northern Bering Sea in modulating the arctic II: international interdisciplinary collaboration
W2	Sept. 22	Coastal ecosystem services in the North Pacific and analytical tools/methodologies for the assessment
W3	Sept. 22	Linking oceanographic conditions to the distribution and productivity of highly migratory species and incorporation into fishery stock assessment models
W4	Sept. 22	Long-term changes in HAB occurrences in PICES nations; the Eastern vs. Western Pacific
W6	Sept. 22	Advantages and limitations of traditional and biochemical methods of measuring zooplankton production

Session/Workshop Descriptions

S1: Science Board Symposium

Environmental changes in the North Pacific and impacts on biological resources and ecosystem services

Co-Convenors:

Hiroaki Saito (SB)

Se-Jong Ju (BIO)

Elizabeth Logerwell (FIS)

Keith Criddle (HD)

Chuanlin Huo (MEQ)

Jennifer Boldt (MONITOR)

Emanuele Di Lorenzo (POC)

Joon-Soo Lee (TCODE)

Steven Bograd (FUTURE)

Sukyung Kang (FUTURE)

Igor Shevchenko (Russia)

Motomitsu Takahashi (Japan)

Invited Speakers:

Mary Hunsicker (NOAA, USA)

Kirill Kivva (Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Russia)

Kanae Tokunaga (Ocean Alliance, The University of Tokyo, Japan)

James Thorson (NOAA, USA)

Marine ecosystems around the North Pacific are changing. Over the past decade physical, chemical, and biological processes have been altered by climate change and anthropogenic impacts. In response, species' ranges have shifted, disrupting ecosystem goods and services, including fisheries resources upon which communities around the North Pacific depend. Understanding, characterizing and forecasting ecosystem changes will ensure managers and policy makers have the information needed to maintain ecosystem biodiversity, structure and function, and ultimately sustainable utilization of ocean resources. Assessments that use observation-based indicators of ecosystem conditions coupled with numerical models capable of predicting future marine ecosystem conditions at short (seasonal to interannual), medium (decadal) and long-term (multi-decadal) scales can inform management and policy decisions.

We invite submissions related to characterizing and understanding drivers of North Pacific ecosystem change and their impacts to, and resilience of, ecosystem resources and services. Drivers may include but are not limited to climate change, ocean acidification, coastal eutrophication, aquaculture, fishing, pollution, coastal development, non-indigenous species, and cumulative impacts of multiple stressors. Further, it is recognized that there are inherent trade-offs among multiple-use ocean activities, and mechanisms are needed to resolve these to ensure sustainable use of North Pacific resources and ecosystems. Thus, presentations are welcome that address leading indicators of change in exploited resources (i.e., fisheries stocks), non-linear and threshold responses of trophic linkages from phytoplankton to top predators, and approaches integrating monitoring and modeling to forecast ecosystem responses that can inform management and policy options.

S2: MEQ Topic Session

Microplastics in marine environments: Fate and effects

Co-Sponsors: GESAMP, NOWPAP

Co-Convenors:

Wonjoon Shim (Korea)

Hideshige Takada (Japan)

Peter Ross (Canada)

Peter Kershaw (GESAMP)

Lev Neretin (NOWPAP)

Invited Speakers:

Seung-Kyu Kim (Incheon National University, Korea)

Daoji Li (East China Normal University, China)

Chelsea M. Rochman (University of Toronto, Canada)

Microplastics are now ubiquitous from the near shore to open ocean, from the sea surface to bottom, and from subtropical to polar seas. Relatively high abundance of microplastics has been reported in the North Pacific Gyre as well as coastal waters of North Pacific region among the world oceans. In addition, with decreasing size, they become more bioavailable to small aquatic organisms down to zooplankton. Ingested microplastics have been found in various taxa across trophic levels. Associated chemicals in microplastics may be transferred to an organism upon ingestion. Microplastics represent trans-boundary pollution which can also deliver associated chemicals and invasive organisms to regions far removed from source. Microplastics are increasingly recognized as a potential threat to biota in the ocean. However, because of their size detecting the presence of microplastics and adverse biological effects, if any, becomes considerably more challenging. The objective of this session is to present status and trend information for microplastic pollution and its environmental consequences in the PICES region. Papers are invited that assess microplastics 1) hotspots in the PICES region, 2) sources and input pathways, 3) fate and behaviour of microplastics, 4) role as sink or source of associated toxic chemicals, and 5) biological and ecological effects. Recommendations on how to address growing problems associated with microplastics will be also considered.

S3: FUTURE Topic Session**Below and beyond maximum sustainable yield: Ecosystem reference points****Co-Convenors:**

Elliot L. Hazen (USA)

Jennifer Boldt (Canada)

Robert Blasiak (Japan)

Mary Hunsicker (USA)

Invited Speaker:

Robert Blasiak (University of Tokyo, Japan)

PICES SG/WG-CERP is tasked with identifying ecosystem reference points that would integrate across committees to achieve FUTURE goals and missions. This topic review session will examine a) examples of ecosystem reference points that have been established, and b) methodologies for calculating ecosystem reference points from driver-pressure relationships across PICES ecosystems. The goal would be for this topic session to bring together experts from physical, biological, and human dimensions to explore past and future approaches to understand how ecosystem management have and can best set reference points that deal with ecological and societal goals. Reference points for fisheries management are generally determined under a single set of environmental conditions with a single species focus. Almost all forms of resource management rely on reference points in order to manage a species (e.g. BMSY, Potential Biological Removal, Yield per Recruit). However, ecosystem reference points that have been developed have largely focused on additive relationships but more attention is needed on setting reference points in relation to ecosystem functioning such as climatic forcing and predator-prey relationships. One such example, maximum ecosystem yield (MEY) in the Gulf of Alaska and Bering Sea provides an umbrella on total catch, but still does not account for intraspecific dynamics or climate forcing. We propose a topic session that will involve participation from multiple PICES committees and will focus on reviewing examples of ecosystem reference points and methods for defining reference points that have been used internationally. Anticipated outcomes of the session are a report to be distributed to PICES on the summary of the presentations and discussion and a Special issue on “Ecosystem reference points” including a manuscript from WG participants in collaboration with a journal TBD. We anticipate a 1-day topic session with talks focusing on (a) examples of ecosystem reference points, (b) modeling studies examining mechanistic linkages between pressure – driver relationships, and (c) methodological approaches towards identifying reference points.

S4: MONITOR Topic Session**Adverse impacts on coastal ocean ecosystems: How do we best measure, monitor, understand and predict?****Co-Convenors:**

Akash Sastri (Canada)

Naoki Yoshie (Japan)

Jack Barth (USA)

Invited Speakers:

Yuichi Hayami (Institute of Lowland and Marine Research (ILMR), Saga University, Japan)

Peter Zhadan (V.I. Il'ichev Pacific Oceanological Institute (POI), Russia)

Adverse impacts on coastal ocean ecosystems by, for example, episodic harmful algal blooms and hypoxic events and by increasing ocean warming and acidification, are prevalent in North Pacific coastal waters. These can occur both in semi-enclosed basins and open coastal areas, and in regions with and without strong anthropogenic impact. These adverse impacts share a common characteristics in that they all involve linked physical, biological, and chemical processes as well as, in some cases, human-related actions. To achieve a complete understanding of these negative impacts on coastal ocean ecosystems requires multi-parameter observations from a variety of in-water platforms. Measurements include those from physical, chemical and biological sensors and from discrete water samples and net tows. Time series are necessary to define the time scale of the impact and the seasonal and interannual conditions present at the time of the impact. These critical in-water measurements are

often combined with remotely sensed observations and with numerical models to gain further understanding of the origin and evolution of the negative impacts. We invite contributions that identify adverse impacts on coastal ocean ecosystems in North Pacific coastal waters and that use multi-sensor time series and models to understand and predict these phenomena. Contributions may include the description of multi-parameter coastal ocean observing systems designed to address the causes and evolution of negative impacts on coastal ocean ecosystems. We are particularly interested in studies that address these adverse coastal ocean ecosystem impacts from a transdisciplinary point-of-view.

S5: FIS Topic Session

Coastal ecosystem conservation and challenge

Convenor:

Xianshi Jin (China)

Invited Speaker:

Cody S. Szuwalski (University of California, Santa Barbara, USA)

Under the impacts from climate change and human activities, many stocks were depleted, and habitats were degraded, Stock release and artificial reefs construction have been widely used in coastal area for restoring the depleted stocks and conservation of the ecosystem, as well as increasing the abundance for recreational fisheries. This session will focus on the studies of methods, results of the conservation measures and effects on fisheries and ecosystem, aiming at sharing the information of advantages and challenges, evaluating the results and ecological effects and management implications.

S6: POC/FIS Topic Session

Interannual variability in marine ecosystems and its coupling with climate projections

Co-Convenors:

Yury Zuenko (Russia)

Jackie King (Canada)

Masami Nonaka (Japan)

Hee-Dong Jeong (Korea)

Invited Speaker:

Elena Ustinova (Pacific Fisheries Research Centre (TINRO-Centre), Russia)

PICES has long recognized the importance of climate variability and climate change on marine ecosystems, particularly for multi-decadal scales. However, in fisheries management it is the variability at interannual scale that is of greater immediate interest. This session seeks to explore two aspects of interannual scale variability. First, the mechanisms responsible for year-to-year variability in marine ecosystems including fisheries, so one goal of this session is to encourage presentations that share examples of interannual variability (physics, biology, fisheries) where observations may have provided clues about the responsible mechanisms. A second objective of this session is to engage the climate, ocean and ecosystem modeling communities that are working on interannual to decadal-scales to (1) provide the empirical evidence underlying the assumptions for mechanisms of functional linkages between climate variability and ecosystem response at these temporal scales, (2) to assess the retrospective skill of coupled bio-physical models at multiple temporal scales, and (3) to identify how parameter uncertainty can be transferred from shorter forecasting frameworks to longer term projection models. Presentations on research that provide mechanistic understanding of observed changes through time, and connect interannual variability in oceanographic processes or ecosystem responses to short-term variability and long-term climate change are encouraged.

Joined S8 / HD-Paper: HD Topic Session**Marine ecosystem health and human well-being: A social-ecological systems approach****Co-Convenors:**

Keith R. Criddle (USA)
Mitsutaku Makino (Japan)
Ian Perry (Canada)
Mark Wells (USA)

Invited Speakers:

Suhendar I Sachoemar (Agency for the Assessment and Application of Technology (BPPT), Indonesia)
Charles Trick (Western University, Canada)

Ecosystem-based fisheries management seeks to restore, enhance, and protect living resources, their habitats, and ecological relationships to sustain all fisheries and provide for balanced ecosystems. Progress has been made internationally toward adopting ecosystem based fisheries management of marine systems (EBFM), with PICES countries contributing through regional applications in the North Pacific. Examples are the Study Group on Ecosystem-based management science and its application to the North Pacific (SG-EBM: 2003-2004) and the Working Group on Ecosystem-based management science and its application to the North Pacific (WG-19: 2004-2009). Recent initiatives have expanded the concept of ecosystem to include human influences, both positive and negative, which is emerging as coupled marine social-ecological studies (Marine SES). An integrated understanding of how ecosystem changes affect human social systems and their well-being, and vice versa, are necessary to improve environmental stewardship. The PICES Study Group on Human Dimensions (SG-HD: 2009-2011), Section on Human Dimensions of Marine Systems (S-HD: 2011-), and PICES-MAFF Project on Marine Ecosystem Health and Human Well-being (MarWeB: 2012-2017) have contributed to ecosystem-based management efforts in the North Pacific. Also, cooperation with other international scientific organizations/ programs have been developing, such as MSEAS 2016 which was co-sponsored by PICES, ICES, Ifremer, etc. Key questions that structure these scientific activities are: (a) how do marine ecosystems support human well-being and (b) how do human communities support sustainable and productive marine ecosystems? This Topic Session welcomes papers that addresses all aspects of marine socio-ecologic systems, and particularly research that addresses the above two questions.

S9: POC Topic Session**Meso-/submeso-scale processes and their role in marine ecosystems****Co-Convenors:**

Hiromichi Ueno (Japan)
M. Debora Iglesias-Rodriguez (USA)
Sachihiko Itoh (Japan)
Elena Ustinova (Russia)

Invited Speakers:

Sergey Prants (V.I. Il'ichev Pacific Oceanological Institute (POI), Russia)
Rob Suryan (Oregon State University, USA)

Mesoscale and submesoscale (~1 to 100 km) currents and fronts such as eddies, streamers, filaments and streaks are ubiquitous features of the ocean. These complex but coherent patterns in the sea surface are often captured by satellite imagery and partially reproduced by high-resolution numerical ocean-circulation/biogeochemical models. While the interior structure of these fine-scale features and its dynamics are still in exploration, it has been well-known that there are tight linkages between physics and distribution of marine organisms at these scales, which includes dispersion, patchiness and aggregations of plankton, nekton, birds and mammals. Understanding the structure and physics of these horizontal fine-scale features, their effects on distribution and production of marine organisms, and how they influence the functioning of the marine ecosystem and its services such as fisheries yield and efficiency is necessary in order to assess likely system changes and shifts under a changing climate. This topic session aims to discuss the interaction between physics, chemistry, biology and fisheries of the ocean at the meso-

and sub-mesoscale based on observations and modeling. Presentations will include various levels of organization (physics, biogeochemistry, fish/fisheries and other marine predators) from different areas in the PICES region, and participants will be invited to compare differences and discuss the underlying mechanisms.

S10: FUTURE Topic Session

Emerging issues in understanding, forecasting and communicating climate impacts on North Pacific marine ecosystems

Co-Convenors:

Steven Bograd (NOAA, USA)

Sukyung Kang (NFRDI, Korea)

Oleg Katugin (Russia)

Guangshui Na (China)

Invited Speakers:

Zhongyong Gao (Third Institute of Oceanography, SOA, China)

Desiree Tommasi (NOAA SWFSC, USA)

‘Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems’ (FUTURE) is an integrative Scientific Program undertaken by the member nations and affiliates of PICES to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders and the public. While PICES has fostered advances in understanding how environmental and climate variability impacts marine ecosystems, our capacity to forecast these climate-driven impacts, at seasonal to decadal time scales, is less well developed. Similarly, there have been impediments in broadly disseminating results from the FUTURE Science Program in ways that optimize the utilization of the science. In this session, we will provide an assessment of our capacity to forecast climate-driven marine ecosystem changes on seasonal to decadal scales and review strategies for communicating FUTURE and PICES science. Advances in the understanding of climate impacts on marine ecosystems, and a broad dissemination of this information, are essential for preserving a healthy and sustainable North Pacific for FUTURE generations.

S11: FIS/POC Session

Environmental variability in Arctic and Subarctic ecosystems and impacts on fishery management strategies

Co-Convenors:

Mikhail Stepanenko (TINRO-Center, Russia)

Mikhail Zuev (TINRO-Center, Russia)

Thomas Helser (REFM Division, AFSC, Seattle, WA, USA)

Invited Speaker:

Yury Zuenko (Pacific Fisheries Research Centre (TINRO-Centre), Russia)

Environmental variability in Arctic and Subarctic ecosystems affects the recruitment, abundance, behavior and the seasonal spatial distribution of fish and invertebrate populations which present challenges for fishery management strategies. Understanding environmental driven changes in fish populations can be used to improve predictions of assessed populations and may positively impact recreational fishing, commercial harvest and fishery-dependent coastal communities. This session explores the impacts of environmental variability projections to applied fishery problems in Arctic and Subarctic regions and the development of environmentally enhanced strategies of management.

S12: BIO Topic Session**Seasonal and climatic influences on prey consumption by marine birds, mammals and predatory fishes****Co-Convenors:**

Andrew Trites (Canada)

Rob Suryan (USA)

Mike Seki (USA)

Tsutomu Tamura (Japan)

Invited Speaker:

Jock Young (CSIRO, Tasmania, Australia)

Prey consumption by mid to upper trophic level marine birds, mammals, and predatory fishes is influenced by changes in prey abundance, prey availability, ocean climate and anthropogenic stressors. However, the extent to which predators can adapt to such changes and still meet their minimum energy requirements is uncertain. Understanding dietary changes of predators under varying environmental conditions is critical to informing prey consumption models and estimating relative contributions of bottom-up vs. top-down forcing in marine systems. Understanding how prey consumption of marine birds, mammals and predatory fishes will respond to climate change is also needed to predict changes in energy flow pathways in ecosystems, and has consequences for conservation initiatives and ensuring the sustainability of commercially important fishery resources. For this session, we request presentations on topics that address (a) the significance of seasonal changes in prey consumption on energy budgets and ecosystem dynamics, (b) the effects of changes in water temperature and other climatic variables on food requirements, (c) relationships between dietary shifts and population trends, (d) the limits of plasticity in prey selection, and (e) how prey consumption of birds, mammals, and predatory fishes is affected by the recent extreme climatic events—the blob, El Nino, ice cover changes, etc.

S13: BIO Topic Session**Joint PICES-ICES Session on Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services****Co-Convenors:**

Richard B Rivkin (Canada)

Louis Legendre (France)

Nianzhi Jiao (China)

Robin Anderson (DFO, Canada)

Invited Speaker:

Farooq Azam (Scripps Institution of Oceanography, UC San Diego, USA)

Anthropogenic activities influence a suite of oceanic properties, including temperature, circulation patterns, and nutrient inputs and distributions. These activities in turn can alter biogeochemical processes and fluxes that influence marine foodwebs and ecosystem services, for example the biologically mediated ocean carbon pumps, fisheries, and other renewable marine resources. These responses of the ocean to changes in anthropogenic forcings will vary with the magnitude and types of impact, ocean region, and foodweb type. The responses may be local or global in scale. Anthropogenic forcing may alter the magnitude and even the direction of services in complex ways, and understanding how marine systems such as carbon pumps will respond to the changing ocean in the anthropocene requires consideration of cumulative effects of multiple activities.

The first step in the carbon pump process is the transfer of atmospheric CO₂ into the ocean, where it is taken up by phytoplankton, before organic carbon is synthesized, a portion of which is transferred to pelagic and benthic foodwebs (a regional ecosystem service). Some of the organic carbon can be sequestered in the deep ocean or sediments after being exported from the surface, or by transformation into long-lived dissolved organic compounds (a global ecosystem service). Marine carbon export and sequestration currently makes up about 50%

of the anthropogenic CO₂ and is hence among the most important earth-ecosystem services provided by the oceans. Biologically mediated carbon cycles also support other important ecosystem services such as aquaculture and fisheries which may also be altered.

This session invites contributions from researchers who use observational, experimental, and modeling approaches to characterize and assess the effects of changing ocean biogeochemical processes and fluxes on the biologically mediated ocean carbon pumps and other ecosystems services, including fisheries and other renewable marine resources. The topic of this proposed theme session addresses the main focus of the joint PICES/ICES Working Group on Climate Change and Biologically-Driven Ocean Carbon Sequestration.

BIO Contributed Paper Session

Co-Convenors:

Se-Jong Ju (Korea)

Debora Iglesias-Rodriguez (USA)

The Biological Oceanography Committee (BIO) has a wide range of interests spanning from molecular to global scales. BIO targets all organisms living in the marine environment including bacteria, phytoplankton, zooplankton, micronekton, benthos and marine birds and mammals. In this session, we welcome all papers on biological aspects of marine science in the PICES region. Contributions from early career scientists are especially encouraged.

FIS Contributed Paper Session

Co-Convenors:

Elizabeth Logerwell (USA)

Xianshi Jin (China)

This session invites papers addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Fishery Science Committee (FIS).

MEQ Contributed Paper Session

Co-Convenors:

Chuanlin Huo (China)

Darlene Smith (Canada)

Papers are invited on all aspects of marine environmental quality research in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Marine Environmental Quality Committee (MEQ).

POC Contributed Paper Session

Co-Convenors:

Emanuele Di Lorenzo (USA)

Yury I. Zuenko (Russia)

Papers are invited on all aspects of physical oceanography and climate in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Physical Oceanography and Climate Committee (POC).

GP - General Poster Session

W1: MONITOR/TCODE Workshop

The role of the northern Bering Sea in modulating the arctic II: International interdisciplinary collaboration

Co-sponsor: NPRB

Co-Convenors:

Matthew Baker (USA)

Lisa Eisner (USA)

Kirill Kivva (Russia)

Invited Speaker:

Maria Pisareva (Polar Oceanography Group, P.P. Shirshov Institute of Oceanology (IO) RAS, Russia)

The northern Bering Sea is at the confluence of the North Pacific and Arctic Ocean. Physical processes in the northern Bering Sea link currents, productivity regimes, and species distributions and interactions ranging from North Pacific ecosystems to the Arctic. The processes in this region influence the state and ecosystem structure in the southern Chukchi Sea ecosystem as well as the functioning of other Arctic regions. While the Pacific Arctic Region has received great attention during the past few years, scientific efforts in the Northern Bering – Southern Chukchi Sea region are mostly conducted at the national level. International collaboration and data integration remain limited. This workshop is proposed as the second of two consecutive workshops to bring together researchers representing different scientific programs to synthesize knowledge, share data, and discuss further opportunities for cooperation at the international level. The workshop will build on themes addressed in a workshop held at PICES-2016. The format will include invited talks followed by discussion in the morning on the following themes: (1) the physical environment and chemical fluxes, (2) plankton distribution and dynamics, (3) fish populations and dynamics, and (4) recent modeling efforts in the region. In the afternoon, participants will work through facilitated sessions to: (1) consolidate existing and identified data, (2) strategize opportunities for further data integration and coordinated analysis, (3) identify new data streams, new participants, and new research efforts to include, and (4) determine opportunities for long-term data sharing in the region. Participants will be asked to submit applicable Ecological Time Series Observations (ETSOs) and identify available data and metadata on new data streams, including satellite observations, glider and mooring data, oceanographic cruise data, bottom, midwater, and surface trawl data, acoustic surveys, and bathymetric and multibeam data. Workshop products This workshop aims to increase collaboration and build linkages and synergies among scientists and researchers on both sides of the northern Bering and Chukchi seas as well as among a diverse suite of national and international research efforts operating in this region. Data will be integrated with efforts relevant to the North Pacific Ecosystem Status Report. Results will be summarized in a report in PICES Press semi-annual newsletter and, where appropriate, be made available to ongoing research efforts in the region. In addition to support from PICES, we will ask for support from the North Pacific Research Board (NPRB), and the Arctic Monitoring and Assessment Program (AMAP). The proposed topics of the workshop are relevant to several PICES committees and expert groups including MONITOR, POC, BIO, FIS, TCODE, and S-CCME.

W2: HD Workshop**Coastal ecosystem services in the North Pacific and analytical tools/methodologies for their assessment****Co-Convenors:**

Shang Chen (China)

Mitsutaku Makino (Japan)

Daniel K. Lew (USA)

Minling Pan (USA)

Sebastian Villasante (Spain)

Coastal ecosystem services are the benefits people obtain from the coastal ecosystem. These services include seafood, regulation of climate, reduction of storm impacts, waste assimilation, recreation and leisure, and biodiversity maintenance. The identification, quantification, and valuation of ecosystem services and understanding the impacts of human activities and climate change on ecosystem services are key scientific questions. The ecosystem services-based approach to marine ecosystem management is a new approach meant, in part, to enhance human well-being. The goals of this workshop are: (1) to present research that enhances understanding of the interactions between human activities and ecosystem services; (2) to provide a venue for natural scientists and social scientists to exchange results from research on identification, assessment, management and investment of ecosystem services, and (3) to provide Study Group on Marine Ecosystem Services (SG-MES) members and scientists around the North Pacific an opportunity to discuss collaboration on scientific projects within the North Pacific Ocean. We believe this workshop will contribute to a greater understanding of the status of human dimensions of the North Pacific ecosystem and fill some gaps to achieve the objectives outlined by the FUTURE integrative program.

W3: FIS Workshop**Linking oceanographic conditions to the distribution and productivity of highly migratory species and incorporation into fishery stock assessment models****Co-Convenors:**

Gerard DiNardo (USA)

Carrie Holt (Canada)

Invited Speaker:

Yong Chen (School of Marine Sciences, the University of Maine, USA)

This workshop will be convened by the Joint PICES-ISC Working Group on Oceanographic Conditions and the Distribution and Productivity of Highly Migratory Fish, as identified in the Working Group's Terms of Reference. The distribution and productivity of many pelagic fish populations in the North Pacific are determined by large-scale oceanographic processes and climate variability. One hypothesis is that highly migratory species, such as albacore tuna (*Thunnus alalungus*) or Pacific sardine (*Sardinops sagax*), have environmental thresholds and preferences that drive their distribution and productivity. This workshop will provide an overview of contemporary research on the topic, including the identification of statistical modeling approaches that link spatially explicit environmental data (e.g., satellite derived SST) to distributional fish data (e.g., fishery-dependent and fishery-independent), methods to assess impacts of climate variability on fish productivity, and examine methods that explicitly incorporate environmentally driven dynamics into stock assessments for highly migratory species. Group discussion will help facilitate identification by the Working Group of a suitable methodology to use to develop habitat models of albacore tuna and other highly migratory species, and to provide possible scenarios for future fishery CPUE 'hot spots' and advancement of fish stock assessments. We encourage contributions that deal with common difficulties in relating spatially explicit data to fish distributional data (e.g., zero-inflated data, mismatch between spatial or temporal resolution of oceanographic to distributional datasets).

W4: MEQ Workshop**Long-term changes in HAB occurrences in PICES nations; the Eastern vs. Western Pacific****Cosponsor: NOWPAP****Co-Convenors:**

Mark Wells (USA)

Polina Kameneva (Russia)

Invited Speakers:

Nicholas Bond (University of Washington, USA)

Keigo Yamamoto (NOWPAP)

The PICES 2016 Workshop on toxic *Pseudo-nitzschia* blooms in the eastern and western Pacific highlighted the stark differences in economic and social impacts of these HABs, and how these effects have been changing over at least the past decade. For example, toxic *Pseudo-nitzschia* blooms have frequent and intense impacts on fisheries and human health in the eastern Pacific, but have not caused any fisheries closures in the western Pacific, despite the widespread presence of toxigenic species in western Pacific waters. Moreover, in some eastern regions these HABs are increasing in frequency, intensity and duration, but it remains unclear whether these changes are linked to climate pressures. There is a strong need to better identify long-term trends in these and other HAB organisms in the context of climate change pressures in PICES nations. This 1 day workshop will be used to assemble, present, and analyze long-term datasets on HAB organism abundance and impacts from each nation, along with existing time series data of associated environmental parameters. Key country leads will present trends, HAB distribution maps, and oceanographic, meteorological, and linked terrestrial data (e.g., precipitation), including the dynamics of change in these parameters (e.g., pulsed runoff events). Participants will study these trends to identify knowledge gaps, unify methods for data analysis, and propose methods for future data collection to strengthen understanding of climate/HAB linkages. These goals align closely with those of GlobalHAB and NOWPAP, and the International Society for the Study of Harmful Algae (ISSHA), all seeking to strengthen data collection, analysis and communication of findings on climate change and HABs. Representatives from GlobalHAB, NOWPAP and ISSHA will participate in the workshop, both to contribute to the workshop outcome, and to reinforce links with other international partners.

W6: BIO Workshop**Advantages and limitations of traditional and biochemical methods of measuring zooplankton production****Co-Convenors:**

Toru Kobari (Japan)

Akash Sastri (Canada)

Invited Speaker:

Andrew Hirst (School of Environmental Sciences, University of Liverpool, U.K.)

Zooplankton communities occupy a central position in the flow of matter and energy from primary producers to animals at higher trophic levels in marine ecosystems. Over the past two decades, the increasing emphasis on quantitative assessments of marine ecosystem function has been focused on improving our understanding of how marine ecosystems respond to global climate change. Zooplankton (secondary) production represents a quantitative proxy for the functional response of marine ecosystems since it corresponds to the zooplankton biomass accrued through consumption of lower food-web levels. Zooplankton production traditionally has been estimated using methods which either: 1) follow the development of zooplankton populations/communities over the course of several weeks or months (cohort approaches); or 2) employ *ex situ* fixed-period incubations. Incubation-based techniques with simultaneous sampling of natural communities are the most widely used traditional methods in the field. Recent advances in biochemical methods for measuring zooplankton growth and production, such as quantification of RNA/DNA ratios, chitinase, or aminoacyl-tRNA synthetases, have been developed and applied to a diverse range of organisms and habitats. This workshop will examine and compare traditional and biochemical approaches to estimating zooplankton secondary production.

Keynote:

September 28, 10:30

Eco-geographic units across environmentally diverse species' ranges as useful surrogates of the species' management units: Salmonid fishes of the North Pacific as an example

Lev Zhivotovsky

Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Russia
Institute of General Genetics, Russian Academy of Sciences (IOGen RAS), Russia. E-mail: levazh@gmail.com

The concept of a 'management unit' is central to the fields of conservation biology and population ecology. Large populations or groups of related populations of a given species are commonly defined as such units. However, it often is problematic to determine the boundaries between populations as they include the adaptive variation at morphological, physiological, and behavioral traits that provide adaptation to specific habitat conditions, as well as the reproductive barriers that prevent gene flows between the units. Genetic markers have been suggested to be a good tool for discriminating of population units followed by correlation analyses of the genetic parameters (genetic distances, effective population sizes, estimated migration patterns, etc.) and environmental variables. However, population boundaries can be considerably shifted following the climate changes, ecological transformations and anthropogenic impacts on marine ecosystems. If so, genetic parameters may not distinguish fast population/environmental changes as the genetic parameters are slowly evolving.

We suggest a two-step approach for defining a 'proxy' of management units based on a combined use of environmental, geographic, and genetic data that are estimated from multiple population samples chosen across the species' range. First, the set of samples is subdivided into 'eco-geographic units' (EGUs) according to the environmental gradients, types of life strategies, and other ecological characteristics that presumably associate with population adaptations and inter-population reproductive isolation. Second, the selected EGUs are tested for their congruence with genetic data by comparing the genetic differentiation and other genetic estimates of population samples within EGUs to that between different EGUs.

The EGU-approach places the environmental/ecological variables at the first line in searching a template for management units and, after that, uses the genetic data to confirm and correct the proxy. This seems to be natural as the genetic structure of populations evolves following the changes in surrounding environmental conditions. This approach calls for wider and deeper studies in population biology and ecology of marine organisms.

Some of the issues discussed are: the relationship of the EGU concept with the concepts of evolutionarily significant units (ESUs) and other approaches, designing of EGUs in practice, the level of EGUs in a hierarchical population structure; the weights of genetic and phenotypic markers in estimating population differentiation, and others.

References

- Zhivotovsky et al. 2015. *Conservation Genetics* 16:431-441 <doi: 10.1007/s10592-014-0670-4>
Zhivotovsky. 2016. *Russian Journal of Marine Biology* 42:373–382 (transl. from Russian).

**Plenary Sessions
Abstracts**

September 26, 9:00 (S3-Plenary)

Towards common ecosystem reference points for North Pacific ecosystems

Robert **Blasiak**^{1,2}

¹ Stockholm Resilience Centre, Stockholm University, Sweden

² Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan. E-mail: robert.blasiak@su.se

Sustainable management of marine resources is a particular challenge in the North Pacific, due among other things to high levels of climate variability, diverse ecosystems, and varying assessment methodologies. Identifying a number of common ecosystem reference points that can be applied to ecosystems in the North Pacific could provide a stronger basis for productive communication and cooperation on the management of marine resources. This talk will focus on examples of ecosystem reference points being used by member nations as well as relevant indicators identified by PICES working groups. Existing commonalities and differences will be considered, as well as the general or specific applicability of such indicators to ecosystems in the North Pacific.

September 26, 9:30 (S12-Plenary)

From regional to global-scale understanding of tuna food webs

Jock W. **Young** (and the CLIOTOP trophodynamics team)

CSIRO Marine and Atmospheric Research, Tasmania, Australia

E-mail: jock.young@csiro.au

Most marine food web studies are by necessity regional in nature. They are limited in time and space. Predicting the impacts of major global changes such as ocean warming on marine food webs, particularly of top predators is limited. This is particularly true for the tunas that travel vast distances and through multiple country jurisdictions. It also means that predictive models for one region may not be applicable to another. I present here the development and application of a global data base that aimed to bring data from different regions to examine the impact of ocean warming on marine trophodynamics, in this case three tuna species, yellowfin (*Thunnus albacares*), bigeye (*T. obesus*) and albacore (*T. alalunga*) tuna. I present data from both stomach contents and biochemical approaches and discuss their relative advantages. Two hypotheses are presented. First, the likely increase in smaller midtrophic prey with ocean warming and second, the “tropicalization” of diets to less nutritious prey and the potential decrease in productivity.

September 26, 10:00 (S13-Plenary)

Microbial structuring of marine ecosystems: Significance for carbon cycling, climate and fisheries

Farooq **Azam**

La Jolla, California, U.S.A.

E-mail: fazam@ucsd.edu

Microbial interactions within the ocean carbon cycle are a major uncertainty in predicting the future ocean biogeochemical state and climate. Microbes’ metabolic actions profoundly influence, qualitatively as well as quantitatively, the behavior of the fixed carbon—affecting carbon sequestration, energy flow to the fisheries and ocean-atmosphere exchange of CO₂. These microbial interactions occur at the nanometer (molecular) to millimeter spatial scales of the conceptualized organic matter continuum of the ocean. I will discuss progress and challenges in understanding the mechanistic bases of these interactions and how they are providing novel insights and hypotheses on the ocean’s biogeochemical dynamics and molecular connectivity. A biochemical view of the ocean biogeochemical state and dynamics should help better predict marine ecosystems’ response to climate change with implications for carbon export and sequestration, ecosystem services, and broadly for global habitability.

September 28, 9:00 (S2-Plenary)

Contamination and effects of plastic debris in the marine environment

Chelsea M. **Rochman**

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Discarded plastics are now globally ubiquitous across freshwater and marine habitats. Much of this material is smaller than 5 mm in size, and is referred to as microplastics. As a consequence of widespread contamination, microplastics have been reported in a great diversity of marine habitats and animals. Plastic pollution, big and small, is made up of a diversity of polymers and are associated with a cocktail of chemicals, including those that are added during manufacturing (i.e. BPA, PBDEs, phthalates, lead) and that sorb to the material from ambient seawater (e.g., DDT, PCBs, PAHs, copper). It is now understood that plastics and their associated chemicals can have adverse impacts at several levels of biological organization – from sub-organismal to population and assemblage. As such, there is concern regarding whether and how plastic pollution poses a threat to the marine environment, wildlife and humans. Using recent insights from my own work and the work of others, this presentation will review the contamination of plastic debris in marine ecosystems, the impacts of plastic debris and associated chemicals on animals and potential impacts to human health.

September 28, 9:30 (S5 Plenary)

Managing highly modified marine ecosystems

Cody **Szuwalski**

University of California, Santa Barbara, Santa Barbara, CA, U.S.A.
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Interest in implementing or reforming management for exploited marine ecosystems around the world is high, particularly in countries where management is minimal or non-existent. Fisheries in many of these countries have histories of intense fishing pressure, markets for a wide range of species and sizes, and large communities that are often reliant on ocean resources for their livelihoods. In such cases, conflicting goals for management exist (e.g. high yields, job preservation, conservation) for which trade-offs must be considered and it is not immediately clear that replicating ‘Western style’ management (e.g. single species management focused on producing maximum sustainable yield) will satisfy the needs of the communities in these countries. I will discuss a case study in the East China Sea that compares single species management to the status quo—an intense, indiscriminate fishery. We found that implementing single species management could halve the catches produced from the East China Sea as a result of reversing trophic cascades that have occurred via indiscriminate, highly intense fishing practices. I will further discuss the relationship between aquaculture, stock enhancement, and artificial reef building and fishery yields in China and end with thoughts on the future of management in highly modified marine ecosystems.

September 28, 10:00 (S11 Plenary)

Environmental impacts on zooplankton and pollock fishery in the northern Bering Sea

Yury **Zuenko** and Eugene Basyuk

Pacific Fisheries Research Center (TINRO), Vladivostok, Russia
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Seasonal and interannual patterns of the water structure, circulation, temperature, salinity, the zooplankton abundance and species composition are considered for the main fishing grounds of walleye pollock in the northern Bering Sea – Cape Navarin area. The Lawrence Cold Pool (LCP) influences on oceanographic conditions in this area by its western periphery. If LCP is small (after relatively warm winters), the Navarin area is subjected in summer to water advection from the south (Navarin Current) that carries to the shelf relatively warm and saline water inhabited by deep-water zooplankton, including euphausiids, but abundance of local cold-water copepods is low. On the contrary, LCP is wide-spread after severe winters and limits the advection to the Navarin area and the subsurface water warming there, as well as the transport of euphausiids, though these conditions are favorable for reproduction and growth of both local and deep-water zooplankton. Good feeding conditions for pollock are formed in the Navarin area in summer in both cases – that’s a reason of its migration into the Russian EEZ in June-July, accessible for large-scale Russian fishery. However, period of its active feeding by copepods is rather short because of their migration into deep layers for spawning in late summer. Therefore, backward southeastern migration of pollock begins very early (in August-September) if allochthonous euphausiids are absent in the area. In case of the euphausiids northward transfer, they reach the Navarin area in late summer and continue good feeding conditions, therefore the pollock stay there until November-December. There still are no evidences of drastic climate-scale changes in feeding conditions and pollock fishery in the northern Bering Sea but higher frequency of “too warm” years with lowered reproduction of euphausiids and their effective northward transport is expected in the case of continue warming.

**Oral Presentations
Abstracts**

S1: Science Board Symposium

Environmental changes in the North Pacific and impacts on biological resources and ecosystem services

September 25

11:15 (S1-12262) Invited

Measuring density dependence, portfolio effects, and climate-drivers in the North Pacific using spatio-temporal models and causal statistics

James T. **Thorson**

Fishery Resource Analysis and Monitoring Division, Northwest Fisheries Science Center (NWFS), National Marine Fisheries Service (NMFS), NOAA, Seattle, WA, USA. E-mail: James.Thorson@noaa.gov

Modern statistical models can predict population density for multiple species and/or stages across space and time, allowing comparative analyses of ecosystem function across marine ecosystems worldwide. However, environmental management requires predicting outcomes under hypothetical human interventions, and these predictions require understanding not just correlations (e.g., historical associations between climate and fishes) but also causation (e.g., impacts from changing fishing pressure under new climate conditions). Here, I use three examples to illustrate the potential benefits of comparative spatio-temporal analysis of marine communities. First, I summarize a worldwide meta-analysis of the “basin model of marine biogeography”, showing that fishes in the North Pacific show stronger range expansion on average during population increases than fishes in other well-sampled regions. Next, I compare changes over time in portfolio effects (PE) across space and species for multiple marine ecosystems, highlighting that the Eastern Bering Sea shows decreasing PE during the past decade. Finally, I introduce a probabilistic framework for forecasting fish distribution shifts, and demonstrate it by attributing historical shifts for Alaska pollock to temperature, size-structure, and otherwise-unexplained drivers. I conclude by advocating future avenues for comparative spatio-temporal research, including (1) addressing the sensitivity of spatial distribution forecasts to assumed causal mechanisms, and (2) discriminating among alternative ecosystem forecasts using formal techniques including retrospective bias and predictive variance.

11:45 (S1-12288) Invited

Nutrient fields reveal identity of ecosystems: A case study from the Bering Sea

Kirill **Kivva**

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Ecosystems of the upper ocean layer largely rely on availability of dissolved inorganic nutrients (DIN). Physical processes that drive water mixing and transport, partly determine spatiotemporal characteristics of nutrient distribution. In addition, autotrophic organisms consume DIN and produce primary organic matter, while heterotrophs simultaneously remineralize it into DIN. Thus, variability of dissolved nutrients reflects many physical and biological processes and may be treated as a signature of an ecosystem. The Bering Sea consists of numerous ecosystems, which are commercially valuable and important for the North Pacific and Arctic. Many oceanographic surveys have been conducted in the area and have resulted in the collection of substantial natural science data, particularly, on nutrient distribution. Present work aims at elucidating seasonal and multi-year variability from observations on DIN distribution. Results reveal mean ecosystem characteristics including relative abundance of diatoms, phytoplankton limitation patterns, and export of organic matter. Some portions of the eastern and northern shelf of the Bering Sea were sampled at similar dates in 10-14 different years. This allows interannual comparison of physical and biological conditions. While the findings do not completely describe these ecosystems, they serve as useful and simple way to represent time series of several important ecosystem characteristics. The study is supported by RFBR, research project No. 16-35-00388 мол_a.

12:15 (S1-12246)**Future projected impacts of ocean warming to potential squid habitat in the North Pacific**

Irene D. Alabia¹, Sei-Ichi **Saitoh**¹, Hiromichi Igarashi², Yoichi Ishikawa², Norihisa Usui³, Masafumi Kamachi², Toshiyuki Awaji⁴ and Masaki Seito⁵

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² Japan Agency for Marine Earth-Science and Technology, Yokohama, Kanagawa, Japan

³ Oceanographic Research Department, Meteorological Research Institute, Tsukuba, Japan

⁴ Graduate School of Science, Kyoto University, Kyoto Japan

⁵ Aomori Prefectural Industrial Technology Research Center, Aomori, Japan

Climate-driven changes in the marine ecosystem largely influence the distribution, abundance and the consequent availability of marine resources to the fishery. In this study, we examined the potential habitat distributions of the neon flying squid (*Ommastrephes bartramii*) under the projected impacts of ocean warming. We used the sea surface temperature (SST) projections from the three CMIP5 climate scenarios (RCP4.5, RCP6.0, and RCP8.5) representing low to high future emissions. Based on the squid habitat models, SST showed the highest effect on the present potential squid habitat distribution that accounted for at least 60% of the predicted spatial patterns from May to July 2000–2010. Moreover, the projected future potential squid habitats showed pronounced differences in spatial and temporal patterns relative to the present habitat distributions across the different regions of the western and central North Pacific. The future squid habitat predictions revealed a net reduction in the suitable squid habitat coupled with a corresponding northward shift. Moreover, the magnitude of the predicted habitat changes was proportional to the levels of warming for the representative periods from May to July 2025, 2050 and 2100. These trends could translate to shorter squid fishing periods and offshore shifts of squid fishing grounds. Thus, insights into the future spatio-temporal patterns of the potential squid habitat could have important implications concerning the availability of squid resources to the fishery and for evaluation of fishery management under climate change.

14:00 (S1-12167) Invited**Towards socially and ecologically adaptive fisheries resource governance: A case of spiny lobster fishery in Shima Peninsula, Japan**

Kanae **Tokunaga**

The University of Tokyo, Tokyo, Japan

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In Japan, spatial rights for coastal fisheries are assigned to fisheries cooperative associations (FCA). This can be characterized as a combination of territorial use rights fisheries (TURF) and cooperatives. Previous studies pointed out that such a management arrangement facilitate coordination among fishermen. This study examines a management system employed by a spiny lobster fishery in Shima peninsula, Japan, which operates under a TURF managed by the local FCA. Using the landings and effort data along with the qualitative information obtained from the interviews, we examined the degree of coordination among fishermen and how fishermen adapt their behaviors to inter- and intra-annual social and ecological changes. There are three key findings. First, we found that fishermen were more sensitive to changes in stock conditions than the changes in market conditions. Second, seemingly inefficient individual operation is a contributing factor to achieve adaptive governance. In this fishery, the fishermen adopted the management system that switches from an effort and revenue pooling operation to an individual operation in mid-season. The system enables fishermen with different fishing strategies, skill levels, income requirements, and gears that they operate outside of the spiny lobster fishing season to take collective action. Finally, we observe a misfit between the management institution and the ecosystem. Although there are multiple TURFs that harvest the same stock, there is no coordination among these TURFs to manage the stock. Despite this, preliminary findings indicate that the fishermen coordination in the aforementioned fishery may have a positive spill over to the other TURFs.

14:30 (S1-12114)**Durable entitlements and resilience in fishery social ecological systems**Keith R. **Criddle**University of Alaska Fairbanks, Juneau, AK, USA
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Sustainability of fisheries and fishery dependent communities depends on intrinsic characteristics of ecological and environmental systems that govern the response of fish stocks to environmental forcing and exploitation and intrinsic characteristics of social, economic, and legal systems that determine who may fish and how fishing may occur. Some fisheries and fishery dependent communities have proven resilient to changes in fish abundance and distribution, exvessel prices and input costs, macroeconomic conditions, living costs and employment, and demography. Durable individual entitlements to shares of the allowable catch increase profitability and help fishermen adapt to modest adverse changes in stock abundance, exvessel prices, and input costs but these highly constrained management strategies reduce resilience to non-stationarities and large perturbations. In addition, while durable entitlements increase choice and therefore resilience from the perspective of individuals, they decrease the resilience of some fishery dependent communities.

14:50 (S1-12191)**Mechanisms triggering the 1976-77 regime shift in the North Pacific**Katerina **Giamalaki**¹, Claudie Beaulieu¹, Davide Faranda², Stephanie A. Henson³ and Adrian P. Martin³¹ Ocean and Earth Science, University of Southampton, UK. E-mail: ag2e13@soton.ac.uk² Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France³ National Oceanography Centre Southampton, UK

During winter 1976-77 the North Pacific underwent a major regime shift. The event was detected in the physics, such as the sea surface temperature, as well as the biology of the region. The response was prominent in all the trophic levels and subsequently affected the fisheries and the economy of the region. Here we investigate the possible mechanisms that could have triggered and maintained the late 1970's shift. We test the hypothesis of an extreme sea level pressure event abruptly changing the oceanic conditions in winter 1976-77 and the maintenance of these altered conditions by changes in air-sea interaction processes. A novel approach combining dynamical systems theory and state-of-the-art statistical methods is applied to time-series of the North Pacific, such as sea level pressure and heat exchange datasets. The results present evidence of extreme atmospheric pressure patterns, specifically a persistent Aleutian Low during winter 1976-77, which may have triggered the regime shift. Likewise, sudden changes in the heat exchange were identified in the western part of the North Pacific, particularly in the Kuroshio-Oyashio Extension region, which may have helped maintain the shift conditions in the area. These results contribute to a better understanding of the North Pacific ecosystem dynamics that can trigger regime shifts with economical impacts such as in the late 1970's.

15:10 (S1-12238)**Biological mediated carbon cycling and sequestration in the ocean and climate change, A new dimension and perspective**Nianzhi **Jiao**, Richard B. Rivkin and Louis Legendre

Xiamen University, Xiang-An Campus, Xiamen, Fujian, China, PR. E-mail: jjiao@xmu.edu.cn

Carbon sequestration is an important Earth-ecosystem service provided by the oceans. In addition to the well-known Biological Pump (BP), which is based on the vertical transport of organic matter from surface to the deep ocean and seabed, carbon is also sequestered by the Microbial Carbon Pump (MCP), which is the biochemically-mediated microbial transformation of labile organic matter into refractory dissolved organic carbon compounds (RDOC) that can remain (i.e. sequestered) in the water column for 100's to 1000's of years. The MCP provides a robust approach to an enigma proposed half a century ago, i.e. the formation of a huge pool of dissolved organic carbon in the deep ocean with an inventory equivalent to the total inventory of atmospheric CO₂ and an average estimated residence time of ~5000 years. A working group operating under the Scientific Committee for Oceanic Research (2008-2014) made significant progresses in formulating the MCP theoretical framework and understanding its processes, and this lead to experimental and modeling studies and associated intriguing insights and implications.

Given the need of developing better knowledge on the mechanisms of climate change, a joint working group authorized under the North Pacific Ocean Science Organization (PICES) and the International Council for the Exploration of the Sea (ICES) was created in late 2015 (WG 33 for PICES, and WGCCBOCS for ICES) with the theme of climate change and biologically-driven ocean carbon sequestration. Within the WG, oceanographers, experimental biogeochemists, marine ecologists, and carbon-cycle modelers summarize the existing knowledge on the BP and the MCP, and foster integrated understanding of ocean carbon sequestration processes and their controlling environmental factors as well as their consequences. The presentation will review the activities and findings within the context of the role of ocean carbon processes in global ecosystems and climate

15:50 (S1-12323) Invited**Developing indices for early detection of abrupt change in northeast Pacific Ocean ecosystems**Mary **Hunsicker**¹, Michael Litzow², Sean Anderson³, Jin Gao^{4,5}, Chris Harvey⁴, Sam McClatchie⁶, Eric Ward⁴ and Stephani Zador⁷¹ NOAA, Northwest Fisheries Science Center, Newport, OR, USA. Email: mary.hunsicker@noaa.gov² Farallon Institute, Petaluma, CA, USA³ Department of Fisheries and Oceans, Nanaimo, BC, Canada⁴ NOAA, Northwest Fisheries Science Center, Seattle, WA, USA⁵ University of Washington, Seattle, WA, USA⁶ Southwest Fisheries Science Center, La Jolla, CA, USA⁷ NOAA, Alaska Fisheries Science Center, Seattle, WA, USA

Ecological regime shifts are an important source of uncertainty, affecting our ability to successfully manage fisheries in the northeast Pacific (NEP). While past NEP regime shifts have been associated with sudden change in the Pacific Decadal Oscillation, an important prediction of ecological theory is that abrupt shifts are also expected in ecosystems undergoing persistent or incremental external perturbation, including bottom water hypoxia, eutrophication, habitat loss, and fishing pressure. Though such shifts may be rare, the degree to which these events can disrupt commercial fisheries can hardly be overstated. We are using a large set of biological time series from the California Current Ecosystem, Gulf of Alaska, and Eastern Bering Sea to quantify the state of these systems with two empirical metrics, a State Index and an Early Warning Index. The goal of the State Index is to reduce the time required to detect abrupt community-level changes in each system. The goal of the Early Warning Index is to apply generic regime shift indicators to track changes in the relative likelihood of a sudden ecological shift. In addition, we aim to develop reference points based on how the indices have performed in the past to enable scientists and managers to distinguish normal variability from changes signaling a major shift.

16:20 (S1-12058)**Ocean acidification trends in coastal waters in Japan**Miho **Ishizu**¹, Yasumasa Miyazawa, Tomohiko Tsunoda and Tsuneo Ono¹ Japan Agency for Marine-Earth Science and Technology, Yokohama-shi, Kanagawa, Japan
E-mail: mishizu@jamstec.go.jp

Long-term pH trends in coastal waters of Japan were examined by using water quality measurements in public waters from 1978 to 2009 at about 1484 stations, archived by the Regional Development Bureau of Ministry of Land, Infrastructure, Transport and Tourism under Ministry of the Environment as part of a monitoring program following the Water Pollution Control Law. Long-term pH trends demonstrated a tendency for coastal waters to acidify. The average and standard deviation without significance were estimated at -0.0015 and 0.0075 yr^{-1} , and with significance at -0.0045 and 0.0021 yr^{-1} , respectively. Alkalization trends were, however, also detected in some observatories, unlike the results in the open ocean. No latitudinal and longitudinal patterns existed, even within a prefecture. Distinct trends to acidify evidently have progressed at a faster rate than the waters of the open ocean. It is important to recognize these ocean acidification trends in coastal waters, which provide a warning about changes in the regional marine environment.

16:40 (S1-12078)**Ecological impacts of Yellow Sea Cold Water Mass variation on the early life history of Pacific cod (*Gadus macrocephalus*)**Jianchao **Li**, Rui Wu, Chi Zhang, Yang Liu and Yongjun Tian

College of Fisheries, Ocean University of China, Qingdao, PR China. E-mail: lijianchao@ouc.edu.cn

The Yellow Sea Cold Water Mass (YSCWM) is an important component of the marine ecosystem in the Yellow Sea (YS). Characterized by a strong thermocline that covers a large area of the YS at water depth between 10-20m during peak summer, and with ocean temperatures lower than 10°C and sea surface temperatures differences larger than 15°C , the YSCWM becomes an appropriate habitat for cold-water species such as Pacific cod. Using seasonal fishery surveys in the Yellow Sea during 2016-2017, seabed-mounted ADCP observation during 2012-2013 and supplementary seasonal hydrological research cruises in YS, we diagnose the patterns of seasonal hydrodynamic variability of the YSCWM and examine its impacts on juvenile Pacific cod. Daily increment and micro-chemistry analysis on otolith of juvenile Pacific cod were carried out, and the results indicate that the early life history of Pacific cod is linked to the hydrological and hydrodynamic variability of the YSCWM. Different oceanographic factors exert specific ecological controls on the Pacific cod. Thermocline dynamics concentrates phytoplankton and fine-sized suspended particle matters. Near-inertial oscillation accelerates the mixing in regions of water stratification to provide adequate DO and nutrient. Monthly spring tides are related to an acceleration of body growth during the summer slow increment period within the YSCWM. The difference in the growth of the juvenile Pacific cod between two years are also discussed in the context of the impact of the "Super El Nino" in 2015/2016, to reveal the ecological impact of extraordinary climate events on the early life history of Pacific cod in the YS.

17:00 (S1-12135) (replaced with the edited version July 27)

The influence of atmospheric condition on fishing grounds of walleye pollock in the East/Japan Sea

Hae Kun **Jung**, Soon Man Kwon, Kang So Seol and Chung Il Lee

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The oceanic and atmospheric conditions around East/Japan Sea (EJS) are affected by both continental and oceanic air mass simultaneously. Specifically, the Siberia High (SH) and Aleutian Low (AL) pressure systems are the two main centers of action affecting the atmospheric condition in Northwest Pacific. However, around the EJS, long term changes in wind speed and air temperatures are related to the pressure gradient between Siberian and Kuroshio region. Fluctuations in this pressure gradient have been related with SH and Arctic Oscillation (AO). However, the main factor to control the change in pressure gradient seems to be a latitudinal shift of AL. As a result, during the same phase of AO periods, fluctuations in the pressure gradient have indicated different patterns due to latitudinal shift of AL. This relationship between AO and AL is related with atmospheric and oceanic conditions in the western coast of EJS. During warm period with weak pressure gradient, surface temperature increase and the frontal boundary between warm and cold waters moves northward with strong wind and high air temperature. In addition, the effect of low salinity water mass in intermediate layer depth originates in North Korea Cold Current is weaker than normal. As a result, walleye Pollock spawning and nursery ground condition have a negative effect for the early life history of walleye Pollock.

17:20 (S1-12124)

Transport of the Fukushima radioactivity plume to the Eastern North Pacific: Impacts on biological resources

John N. **Smith**¹, Jay Cullen² and Jean F. Mercier³

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The large discharge of radioactivity into the Pacific Ocean off Japan from the 2011 Fukushima Dai-ichi nuclear reactor accident generated considerable concern about potential impacts on marine biota in the eastern North Pacific. Time series measurements of ¹³⁴Cs and ¹³⁷Cs in seawater on Line P documented the initial arrival of the Fukushima signal by ocean current transport at a location 1500 km west of British Columbia, Canada in June, 2012, about 1.3 years after the accident. Between 2012 and 2015 the Fukushima radioactivity signal continued to increase in surface water on Line P and eventually began to level off at probable maximum values in 2016-2017 as documented by biannual monitoring surveys. Although radioactivity contamination of fish off Fukushima was initially severe, analyses of biological samples performed under the auspices of the InFORM monitoring program off British Columbia have revealed little evidence of elevated radioactivity levels in fish or other biota. These results, based on both measurements and biological modeling studies are a consequence of the low Fukushima radionuclide levels in seawater and the low biological half-lives of several months for Cs in fish. Although the ecosystem impacts off British Columbia associated with radioactivity releases from Fukushima have been minimal, the communication of these results to the public and general community acceptance of their veracity has been a challenge requiring many public lectures, scientific publications and considerable media outreach, thereby providing a cautionary note for studies of future ecosystem threats associated with grim anthropogenic drivers.

17:40 (S1-12065)

Atmospheric transboundary transport of pollutants in East Asia

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Atmospheric aerosols were collected in the Vladivostok Russia and in the Sea of Japan. Atmospheric aerosol samples in the Vladivostok and the Sea of Japan were taken using Japanese made sampler (Kimoto Company, Japan) by procedure approved in the international program SEAREX.

Concentrations of polynuclear aromatic hydrocarbons (PAHs) and macro (Al, Ca, Mg, Na, K, Fe, Mn) and trace (Pb, Cd, Ni, Zn, Co, Cu, Cr) chemical elements were determined by standard procedure. In 2006-07 Zn, Cd & Pb from pollution sources well correlated with PAHs in Vladivostok. In background taiga-mounting station this correlation was observed only for Cd. In 2013-14 well correlation was observed between PAHs and Zn, Pb & Ni. Radionuclide (Cs-137, Cs -134 and I-131) were measured by gamma-spectrometer with a detector of High Purity Germanium GEM150 with digital multichannel analyzer DSPEC jr 2.0 (ORTEC, USA).

After Fukushima accident we observed in atmospheric aerosols: 1. Vladivostok - Maximal values of Cs-137 and Cs -134 concentrations ($166 \mu\text{Bq}/\text{m}^3$ and $169 \mu\text{Bq}/\text{m}^3$ respectively) were reached in samples taken from 8 to 15 April and radioactive cloud came to Vladivostok from the regions of Siberia and North-Eastern part of China. 2. Maximal gamma-ray activity of Cs-137, Cs -134 and I-131 over the Sea of Japan surface was $61 \mu\text{Bq}/\text{m}^3$, $153.7 \mu\text{Bq}/\text{m}^3$ and $787 \mu\text{Bq}/\text{m}^3$ respectively.

The research was carried out in the framework of the project "The Computation of the Fields of Currents, Transport, and Transformation of Pollutants and Environmental Hazards in the Russian Far East" following the program of the Presidium of Russian Academy of Sciences No. 43 "Fundamental Problems of Mathematical Modeling."

S2 MEQ Topic Session

Microplastics in marine environments: Fate and effects

September 28

11:00 (S2-12154) Invited

Microplastic in the marine environments, China

Daoji **Li**¹, Shiye Zhao¹, Juying Wang², Huahong Shi¹ and Guyu Peng¹

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² National Marine Environmental Monitoring Center, SOA, Dalian, PR China

China has investigated on microplastic pollution in various marine environmental compartments, and accumulated important baseline data. The results show that microplastic has been widespread in China's coastal waters: 1) the mean abundance of microplastic in the surface waters of Bohai, East China Sea (ECS) and South China Sea (SCS) monitoring sections is 0.29 n/m³, far below the value of Changjiang estuary (4137.3 n/m³). The concentration of microplastic in sediments of the Changjiang estuary is in the range of 20 - 340 n/kg. The concentrations of coastal and tidal beaches were highest in the southern coasts of China, with an average abundance of 6675 n/m². 2) Microplastic shapes are diverse, where fiber predominates, and includes fragments, particles, films and other types. However, plastic microspheres in personal care products reported in previous research have rarely been detected. Meanwhile, it was found mussels generally ingested microplastic, with wild specimen (2.7 n/g) feeding rates higher than those of farmed specimen (1.6 n/g). The occurrence rate of microplastic in 21 species of marine fishes is 100%, and the ingested microplastic range between 0.2 and 17.2 n/g. Five species of zooplankton in the SCS also fed microplastic. The ingestion abundance of zooplankton collected by 160 μm net was 131.5 n/m³. 3) The concentrations of PAHs, PCBs, DDTs adsorbed by beach plastics were 136.3 - 2384.2 ng/g, 21.5 - 323.2 ng/g and 1.2 - 127 ng/g, respectively. With the support of China's national key R & D plan for microplastics, the state of marine microplastic contamination in China will soon be clearer.

11:30 (S2-12050) Invited

Microplastics in Arctic surface water and sea ice: 2016 ARAON Expedition

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The Arctic is one of the pristine environments on earth but is already affected by floating microplastics (MPs) according to previous studies (38-234 pieces/m³ in sea ice and 0.34 pieces/m³ in the Atlantic arctic polar water). However, there is still unclear in transport pathway of MPs to arctic environment. We investigated MP in the Pacific ocean-side polar region covering Bering Strait and Chukchi Sea, expedited by Korean research ice breaker *R/V ARAON* in 2016. MPs in 12 surface water samples, collected by manta-trawl net, ranged from 0.13 to 1.66 pieces/m³ (0.66±0.50) with a decreasing trend from the Bering Strait to the pole. The most abundant synthetic polymer identified was paint particles (47%) and polyester (46%), followed by PE (1.1%), PP (1.0%), and others, reflecting increasing shipping activity in this region. Fiber-type polyester was predominant (93.4%) when excluding paint particles and its abundance decreased with going to the pole. Sea ice samples (n=7) collected at the farthest north contained MPs of 12,900±9,500 pieces/m³, indicating the strong trap of MPs into sea ice. Differently from surface seawater, polyester (90%) was the most abundant synthetic polymer. Cotton, one of natural polymers, accounted for 12.3±16.2% (in surface water) and 49.2±46.2% (in sea ice) of fibers found but was not included into the presented MPs. Abundance of MPs found in this study was much higher than those in previous arctic surface water or sea ice. These findings indicate the potentially much more input of MPs to the arctic environment in recent years, particularly via the Bering Strait.

12:00 (S2-12027)

Global distribution of microplastics: An overviewWon Joon **Shim**^{1,2}, Sang Hee Hong^{1,2} and Soeun Eo^{1,2}¹ Korea Institute of Ocean Science and Technology, Geoje, R Korea
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Spatial distribution of microplastic abundance with compositional data of size, shape and polymer type in various environmental matrices is key element for exposure analysis in risk assessment scheme. Reflecting world-wide use of plastics and transportation of plastic litter through ocean current, microplastics are ubiquitous from coastal to open ocean, from tropical and polar seas and from surface water to deep sea floor. Abundance of microplastics in water ($n=73$) and sediment ($n=57$) of marine environments reported in the literature was reviewed and available data were synthesized to overview global distribution of microplastics. The abundances of microplastics were sampling method dependent with seven orders of magnitude range and demonstrated significant negative relationship with net mesh size regardless of sampling regions and time. The mean floating microplastic abundance (net mesh 300-350 μ m) per basin was in order of Mediterranean > North Pacific > South Atlantic > North Atlantic > South Pacific. The mean abundance of microplastics on beach in Asia was significantly higher than those reported in America and Europe. Nearshore and surface water tended to showed higher abundance than offshore and water column, respectively. Either fragment or fiber type microplastic was dominant in sea surface, but more dense fiber type was dominant in subtidal sediments. Polyethylene, polypropylene, polystyrene and polyester types were dominants in both water and sediments. Global distribution model generally well matched with in situ observation data of microplastic abundance in order of basin. There was, however, mis-match in between abundance and size of microplastics in field observation and in laboratory toxicity study.

12:20 (S2-12260)

Monitoring and assessment of marine plastics and microplastics – Towards harmonised methodsPeter J. **Kershaw**¹, Francois Galgani² and Alexander Turra³¹ GESAMP, London, UK. E-mail: peter@pjkershaw.com² IFREMER, Corsica, France. E-mail: Francois.galgani@ifremer.fr³ University of Sao Paulo, Brazil. E-mail: turra@usp.br

The significance of the impact of marine plastics and microplastics on the marine environment is becoming widely accepted by politicians and policy makers at local, national, regional and global scales. For example, the issue was one of the main themes discussed repeatedly at the June 2017 UN Oceans Conference in New York. The G7 and G20 countries have recently developed Marine Litter Action Plans, which are in addition to Action Plans being developed within the Regional Seas framework. A fundamental requirement of developing and implementing an Action Plan is establishing reliable monitoring and assessment programmes. The information gained helps to focus reduction measures and measure the effectiveness of appropriate measures. Unfortunately, a lack of well-established guidelines and protocols is hampering effects to collect reliable data and share comparable information. This paper will describe progress of the GESAMP *Working Group on Marine Plastics and Microplastics* in producing a set of harmonized sampling and analysis protocols, with special emphasis on microplastics.

14:10 (S2-12075)**Vertical distribution and composition of microplastics in Korean coastal waters**

Young Kyoung Song^{1,2}, Soeun Eo^{1,2}, Gi Myung Han¹, Sang Hee Hong^{1,2} and Won Joon Shim^{1,2}

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² Korea University of Science and Technology, Daejeon, R Korea

Vertical distribution and composition of microplastics were determined in six enclosed bays and two coastal areas of Korea in July and August, 2016. Collected seawater of 100 L from surface using stainless tray and middle and bottom using pump, was filtered through 20 µm size mesh hand-net. Volume-reduced samples were filtered through a 5 µm filter paper and plastic like particles on the filter papers were identified with a µFT-IR microscope. The abundance of microplastics from six regions of surface (n=31), middle (n=31) and bottom (n=31) was in the range of 460-5,480, 10-1,060 and 30-2,200 particle/m³ for plastics. The mean abundance of plastics from surface waters (1,795±1,276 particle/m³) was significantly higher ($p < 0.05$) than those in middle and bottom (394±300 and 441±492 particle/m³). The abundance of plastics was decreased by increasing water depth ($p < 0.05$), but this tendency did not show in the stations having thermocline layers. Among the four categories of microplastics (fragment, fiber, sphere, film), fragment type accounted for the highest portion (65.0-89.7%). The dominant polymer types were polypropylene (PP; 59.3%) and polyethylene vinylacetate (EVA; 18.1%) from surface, PP (50%) and PE (21.8%) from middle, and PP (42.1%) and PE (26.5%) from bottom, respectively.

14:30 (S2-12068)**River discharge as a source of plastic litter pollution in the Northwest Pacific Russia**

Nikolai Kozlovskii and Anatolii Kachur

Pacific Geographical Institute FEB RAS, NOWPAP POMRAC. E-mail: geo@tig.dvo.ru

At present, the marine litter issue including contamination of marine water areas with microplastic is a major environmental concern worldwide. An important task related to solving of the marine litter problem is to identify possible sources of contamination with microplastic litter. It is considered that river discharge is a considerable source of microplastic pollution of the marine areas. Besides studying plastic contamination in the coastal area, in 2016-2017 we also carried out field studies in estuarine areas of the Tumen River and the Razdolnaya River, two large transboundary rivers discharging into the Amur Bay. Qualitative (type/size composition) and quantitative assessment of plastic contaminants is given to compare the data of contamination with coastal area; concentration of microplastics is calculated.

14:50 (S2-12214)**Microfiber source characterization in the Northeastern Pacific Ocean**

Katerina Vassilenko, Mathew Watkins, Anahita Etemadifar, Marie Noel and Peter S. Ross

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Microplastics, and in particular microfibers, are documented to be widely distributed in the world's oceans, but surprisingly little is known about the sources of these particles. We have conducted research on source, transport, fate and effects of microplastics and microfibers in the NE Pacific, including studies of i) microplastics in seawater, ii) ingestion of microplastics by zooplankton, and iii) debris along the British Columbia shoreline. Risks to marine biota are unclear, but our finding of ingestion of microplastic particles by two species of zooplankton at the bottom of the ocean food web raise troubling concerns about ecosystem-wide impacts. Microfibers accounted for approximately 75% of enumerated microplastic particles, but were higher nearshore than offshore. The specific sources of microfibers are unclear, but shedding of fibers from textiles is thought to be a significant contributor of plastic pollution. We are collaborating with apparel retailers and manufacturers to study synthetic textile shedding and fate in the marine environment. Our efforts involve heavy investment in standardized and validated procedures for identification, classification and quantification of microfibers released during household laundry. The efficiency of washing machine lint traps is being tested as an option to mitigate the release of microfibers into the wastewater stream. We are also evaluating weathering of microplastics as a function of UV, oxygen, seawater and biofouling. Our efforts will help to track ocean microfibers back to their sources and provide essential information to support design solutions.

15:10 (S2-12330)

Fate of floating debris released from Korean riversSeongbong Seo^{1,2} and Young-Gyu Park^{1,2}¹ Ocean Circulation and Climate Research Center, Korea Institute of Ocean Science and Technology, Ansan, R Korea
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Through a river various types of floating debris are released into the ocean. Using a Lagrangian particle tracking model, trajectories of the marine litters that are originated from five major rivers in Korea, which are the Han, Keum, Youngsan, Seomjin, and Nakdong Rivers, are investigated. Daily ocean current data from a global model of about 1/12 degree horizontal resolution, the Global HYCOM analysis, were used in the particle model. We assumed that the amount of the litters released from each river is linearly proportional to the seasonally varying river outflow, which was obtained from Water management information system of Korea. Particles are released from each river for one year, and then tracking is continued for another six months. Most of the particles beached coast near the river while moving with local currents. Thus the litters from the rivers located along the west coast of Korea (Han, Keum, and Youngsan Rivers) beached on the west coast of Korea primarily, and then Chinese or Japanese coast secondarily. The ones from the river located along the southern coast of Korea are directly influenced by the Tsushima Warm Current and transported to the Japanese coast. Due to the surface circulation system in East Sea a very limited amount of litters beached on Russian coast.

15:50 (S2-12137)

Microplastic concentrations in wild and cultured clams and their environment in British Columbia, CanadaGarth A. Covernton^{1,2}, Sarah E. Dudas^{1,2}, Christopher M. Pearce^{1,3}, Helen J. Gurney-Smith^{1,4} and John F. Dower¹¹ University of Victoria, Victoria, BC, Canada. E-mail: gcov@uvic.ca² Vancouver Island University, Nanaimo, BC, Canada³ Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada⁴ Fisheries and Oceans Canada, St. Andrews Biological Station, St. Andrews, NB, Canada

Microplastic contamination is an emerging threat to marine ecosystems. Many aquatic animals – ranging from mammals to invertebrates – have been shown to ingest microplastics. These particles can disrupt digestive and reproductive processes, act as vectors for harmful chemical pollutants, and reduce overall animal health. As relatively non-specific filter feeders, bivalves are susceptible to ingesting and concentrating microplastics from the water column. In southern British Columbia (BC), shellfish aquaculture is an important industry, and Manila clams (*Venerupis philippinarum*) and Pacific oysters (*Crassostrea gigas*) are the dominant culture species. Shellfish aquaculture often uses plastic infrastructure (anti-predator netting, fencing, rope, cages, trays, floats) that may degrade and release secondary microplastics. We quantified the microplastic content of these two species in southern BC by transplanting an initial population of adult individuals to shellfish farms and nearby non-aquaculture intertidal areas in 6 regions important for shellfish aquaculture and possessing varying degrees of farming intensity. The bivalves were collected after 2-3 months, chemically digested with 10% KOH to remove tissue, filtered, and their microplastic content visually quantified against procedural blanks using a compound microscope. Sediment and water samples were also collected and analyzed for microplastic content. Results suggest that microplastic fibres are the dominant type of microplastic found and are ubiquitous in BC waters, and that shellfish grown on aquaculture sites do not contain significantly more microplastics than those grown at non-aquaculture sites. The number and range of microplastic particles found in BC shellfish are similar to reported microplastic concentrations in bivalves from around the world.

16:10 (S2-12080)

Assessment of microplastic contamination in commercial bivalves from South KoreaYou Na **Cho**^{1,2}, Mi Jang^{1,2}, Gi Myung Han¹, Won Joon Shim^{1,2} and Sang Hee Hong^{1,2*}¹ Oil and POPs Research Group, Korea Institute of Ocean Science & Technology, R Korea² Department of Marine Environmental Sciences, Korea University of Science and Technology, R Korea
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With the increase of plastic usage worldwide, plastic debris has become ubiquitous in the ocean. As plastic debris is fragmented gradually into small plastics through environmental weathering process, they become available to a wide range of marine species covering from large marine organisms (e.g. mammal, seabird, sea turtle, etc.) to small invertebrates (e.g. bivalves, lugworms, clams, etc.). Among marine species, bivalves are of particular interest because of their substantial filter-feeding activity, resulting direct exposure to microplastics in water column, and its potential risk for human health by seafood consumption. Bivalves are typically eaten whole body without the removal of digestive tract. This study investigated microplastic contamination in commercial bivalves from South Korea. Oyster (*Crassostrea gigas*) and mussel (*Mytilus edulis*), accounting for 66.35% of total shellfish consumption in South Korea, were selected as monitoring species and bought randomly from fishery markets in three major cities (Seoul, Busan, and Gwangju). Microplastic pollution was widespread in commercial bivalves from Korea with detection frequency of 93%. The mean microplastic concentration was 0.07 ± 0.06 particles / g (0.77 ± 0.74 particles / individual) in oyster and 0.12 ± 0.10 particles / g (0.68 ± 0.64 particles / individual) in mussel. Fragment (74%) was dominant type of microplastic, and the most common size class is 100 – 200 μm (48%). The dominant plastic was polystyrene (PS), followed by polyethylene (PE) > polypropylene (PP) > polyester in oysters, and PP > polyester > iPP (PP+PE) in mussels. The high abundance of PS in oysters and mussels might be related to the extensive use of expanded polystyrene (EPS) buoys for shellfish farming in South Korea. The annual dietary exposure for Korean shellfish consumer was estimated to 725 particles / year, and high microplastic dietary intake was found in age groups above 40.

16:30 (S2-12295)

Seasonal variability in vulnerability for Cassin's Auklets exposed to plastic pollution in the Canadian Pacific regionPatrick D. **O'Hara**¹, Stephanie Avery-Gomm, Jocelyn Wood, Laurie Wilson, Victoria Bowes, Jean-Pierre Desforges, Peter Ross, Sean Boyd and Ken MorganEnvironment and Climate Change Canada, Sidney, BC, Canada
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Marine plastic pollution is an emerging global conservation challenge, impacting organisms at all trophic levels. Clarifying interactions between marine birds and plastic pollution is important for understanding and estimating impacts. Exposure to plastic pollution can vary seasonally and timing of exposure to elevated concentrations can interact with critical periods in the annual cycle. For example, plastic consumption may affect bird survival during migration or over the winter when survival is typically more challenging. In this paper we explore seasonal exposure of Cassin's Auklet (CAAU) to plastic pollution with an exposure model during the breeding season, and infer exposure during the winter based on necropsy results from carcasses collected during a large mortality event in 2014. The exposure model quantifies plastic exposure by determining core foraging areas and plastic concentrations found in those areas. Core foraging areas during the breeding season were determined using a Generalized Additive Model (GAM) based on at-sea observation data (May, June, July – 1990-2010) and 50% Home Range Kernels based on radiotelemetry data (May, June 1999-2001). Plastic concentrations within these core areas were interpolated based on samples taken during late summer 2012. We found breeding CAAU were exposed to low concentrations of plastics when they are probably exploiting upwelling features. These results were consistent with results from a study recently published based on chick provisioning. On the other hand, 41% of necropsied CAAU had consumed plastic indicating that they are exposed to increased concentrations when upwelling ceases and/or they are targeting plastic as food during the winter.

16:50 (S2-12035)**Ecological effect of micro-sized plastics: Research trends and research needs**Youn-Joo **An** and Yooeun ChaeKonkuk University, Seoul, R Korea
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Micro-sized plastics and plastic debris are distributed in aquatic ecosystems around the world and have a range of effects on aquatic organisms, including impaired growth, reduced fertility, and higher mortality rates. This study focuses on the effects of micro-sized plastics in marine and freshwater ecosystems. We discuss these studies in depth and suggest directions for future research. We believe that this study makes a significant contribution to the literature because, despite the growing problem of microplastics pollution, the issue has only recently received attention and much remains unknown about the effects of these substances in the environment. This work highlights directions for future study that may suggest ways to ameliorate the environmental effects of microplastics. *This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and future planning (2016R1A2B3010445).*

17:10 (S2-12129)**Assessment of microplastic fibers impacts from the chronic exposure to juvenile sheepshead minnow (*Cyprinodon variegatus*)**Jin Soo Choi, Youn-Joo Jung, Yunwi Heo and June-Woo **Park**Korea Institute of Toxicology, Jinju, R Korea
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Plastics are widely used in various sides of human life, and the debris is eventually released into marine environment. Plastics in the environment are degraded by the effects of waves, ultraviolet light, or hydrolysis into micro-sized pieces (microplastics), usually formed in irregular shapes. In addition to these fragments, microfibers spread throughout the environment are found in many seawater, sediments and biota. However, microplastic fibers with the same environmental conditions cannot be purchased, so they are rarely used in laboratory research and their application to existing preparation techniques is limited. In this study, microfibers were fabricated by sectioning polyester of 10 ~ 15 μm in diameter with a size of 100 μm using cryotome protocol (Cole et al., 2016). Microplastic fibers were exposed to concentrations of 0.5 $\mu\text{g/L}$ and 5 mg/L (Environmentally realistic, Lenz et al., 2016) for 42 days to investigate the effects of organ distribution, swimming behavior and hormonal changes on juvenile sheepshead minnow (*Cyprinodon variegatus*). Microplastic fibers were accumulated in the digestive system, decreased swimming behaviors (total distance travelled and maximum velocity) of sheepshead minnow, when compared to control. Microplastic fibers generated cellular reactive oxygen species, and steroid hormone levels were decreased in a dose-dependent manner. This study provides insights into environmentally relevant microplastic fibers will help to improve understanding of their environmental impacts.

17:30 (S2-12142)

**Applying precautionary principle to microplastics governance framework:
Solutions in the absence of “complete” scientific evidence**

Lev Neretin

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Research on the sources, distribution and impacts of microplastics on individual organisms and ecosystem functioning continues to grow exponentially. The UN Environment report (2016) identified several major source categories of microplastics, including fragmentation of larger plastic litter, releases from the use of cosmetics and personal care products, fibres from textiles and clothing, emissions of plastic particle dust from tyre wear, plastic pellet losses, ship maintenance and losses, and routine wear and tear of fishing gear. Similarly to a larger size marine litter, “leakage” of microplastics to the ocean could occur at all stages of the life cycle of the plastics containing products with low efficiency of waste water treatment playing a crucial role downstream. Thus management of microplastics should ideally consider the application of the “6Rs” approach: Reduce – Redesign – Refuse - Re-use – Recycle– Recover applied in the regional and local context. In the absence of conclusive scientific information about the distribution, fate and impacts of microplastic particles to justify well informed policy response at various spatial scales, this presentation argues for the application of precautionary principle to governance of microplastics and identifies “win-win” solutions for both macro- and microplastics policy and management response using examples from multilateral institutions, regional, national and local action by governments, private sector, civil society, and academia. Special focus is given to the countries of the North Pacific region (China, Japan, R. Korea, and the Russian Federation).

S3 FUTURE Topic Session

Below and beyond maximum sustainable yield: Ecosystem reference points

September 26

11:00 (S3-12311)

Time-varying processes in stock assessment: A bridge to ecosystem-based reference points

James T. **Thorson**

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Environmental management involves a continued co-evolution of scientific methods, management policies, and decision analysis linking the two. This link between science and policy has a long history in single-species stock assessment, and stock assessments may therefore provide a bridge between single-species and ecosystem-level management. In this talk, I first review the sensitivity of single-species reference points to ecosystem-changes that affect maturity, mortality, or growth. I then discuss ongoing research to incorporate climate impacts into single-species assessments by estimating biological rates that vary over time. In particular, I emphasize recent research using information from multiple species to estimate indices representing changing recruitment and growth rates for demersal fishes in the Northeast Pacific. These indices can be incorporated into Stock Synthesis to account for ecosystem-level patterns in productivity, although recent research suggests the need to incorporate multiple time-varying processes simultaneously. Finally, I discuss changes in assessment review and practice that are likely needed to periodically update and review ecosystem-level indices for use in single-species stock assessment. Throughout, I emphasize the ways in which single-species assessments can address changes in ecosystem-level productivity, and therefore serve as a bridge to ecosystem-level reference points.

11:20 (S3-12325)

Development of ecosystem indicators to characterize ecosystem responses to multiple pressures: A summary PICES Working Group 28

R. Ian **Perry**¹, Motomitsu Takahashi², Jennifer Boldt¹ and members of WG28

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Marine ecosystems of the North Pacific, both coastal and offshore, are impacted by multiple pressures, such as increased temperature, harmful algal blooms, invasive species, etc. Multiple pressures can act synergistically to change ecosystem structure, function and dynamics in unexpected ways that differ from single pressure responses. Further, it is expected that pressures will vary by region, and likely over time. Working Group 28 was formed to identify multiple pressures and marine ecosystem responses in the PICES area, and in particular to propose indicators for these pressures and responses. Outcomes of WG 28 include frameworks linking pressures to impacts, identifying multiple pressures on North Pacific marine ecosystems including selected case studies, developing ecosystem indicators for responses to multiple pressures, and recommendations for such indicators and an approach to their application. This presentation provides a summary of these outcomes, with co-authorship from all of the members of WG28.

11:40 (S3-12079)

A study on the estimation of the potential yield in the Korean waters of the East China Sea

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In the estimation of the potential yield (PY) in the Korean waters of the East China Sea, two approaches were employed. One approach is the ecosystem dynamics analysis which includes the ecosystem modeling method (EMM), and the other approach, production-based analysis includes the holistic production method (HPM), the population production method (PPM) and the fishery production method (FPM). The EMM used the ecosystem model Ecopath with Ecosim, utilizing catch and a variety of ecological data for each species group categorized by a self-organizing mapping. In this analysis, we assumed that the converged value during the Ecosim simulation setting the fishing mortality (F) as zero is exploitable carrying capacity (ECC) of each group and then PY was estimated using the Gulland's formula (1971). The HPM utilized time-series catch and fishing effort data (1966-2014) for all the species combined and employed a surplus production model to estimate PY in the Korean waters of the East China Sea. The PPM used stock assessment results such as maximum sustainable yield (MSY) for each species group. The FPM utilized time-series catch and fishing effort data for each fishery type. Accordingly, PY of the Korean waters of the East China Sea was estimated to range from 0.9 million mt by the PPM to 1.3 million mt by the FPM. The estimate of PY as 1.0 million mt by the HPM is regarded as the most reasonable one, since the HPM uses relatively fewer assumptions and long time-series data. However, this PY estimate should be considered preliminary. It was recognized that uncertainty, due to the lack of confidence in input data, should be improved. In a planned future study, this will be resolved and is expected to produce a more reliable estimate of PY.

12:00 (S3-12321)

Characterizing driver-response relationships and defining ecological thresholds in large marine ecosystems

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There is growing interest within the science and management community in better anticipating and managing for shifts in marine ecosystems. This is evident in the increasing amount of work dedicated to understanding the mechanisms of ecosystem shifts and identifying ecosystem thresholds. Here, we present an overview, key findings and management relevance of two studies germane to this topic. The first study is a synthesis of existing peer-reviewed literature that provides a quantitative assessment of the prevalence, strength, and shape of nonlinear driver-response relationships in pelagic marine ecosystems. The outcome of this work indicates that it is safer to assume that driver-response relationships are nonlinear than linear and that detectable thresholds can be expected in many single driver-response relationships in pelagic marine ecosystems. The second study builds on this work and other past studies by presenting a framework based on multimodel inference to define ecosystem-based thresholds for human and environmental pressures. To demonstrate how to apply the framework, two decades of data from the California Current ecosystem are explored using gradient forest and generalized additive model analyses, screening for nonlinearities and potential threshold responses of ecosystem states across environmental and human pressures. This research revealed threshold responses of multiple ecosystem states to environmental and human pressures. Moreover, this work provides a new way to interpret changes in the intensities of these pressures in relation to the ecological integrity of the California Current ecosystem.

S4: MONITOR Topic Session**Adverse impacts on coastal ocean ecosystems: How do we best measure, monitor, understand and predict?****September 28****11:00 (S4-12030) Invited****The mechanisms influencing the timing, success and failure of spawning in natural populations of the sea urchin *Strongylocentrotus intermedius* in the northwestern Sea of Japan**Peter **Zhadan**¹ and Marina Vaschenko²¹ V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, Vladivostok, Russia. E-mail: pzhadan@poi.dvo.ru² National Scientific Center of Marine Biology, FEB RAS, Vladivostok, Russia

During the course of the study of the reproductive cycle of the sea urchin *Strongylocentrotus intermedius* (A. Agassiz, 1863) in wild populations along the coast of the Primorye region of Russia (northwestern Sea of Japan) we found that, despite the seasonal maturation of gonads by 100% of individuals, spawning did not occur for 20–90% of *S. intermedius* individuals in some years. We proposed that spawning failure is attributable to the absence of natural signal/signals necessary for induction of sea urchin spawning. To test this hypothesis, we developed a complex methodological approach that included video recording of sea urchin spawning behaviour (at 1-min intervals) in combination with automatic data-logging of environmental variables (tide level, temperature, salinity, and chlorophyll *a* and oxygen concentrations) in the habitats of the study animals (at 10-min intervals). The study was conducted in two bays, Kievka Bay (42.830° N, 133.691° E) and Alekseev Bay (42.981°N, 131.730°E), differing by levels of primary production. A significant positive correlation ($p < 0.001$) was found between chlorophyll *a* concentration and the average hourly frequency of *S. intermedius* spawning events, as assessed through video recording, whereas there were no such correlations for temperature, salinity, dissolved oxygen or tidal activity. *Our studies revealed the following hierarchy of biotic and abiotic factors influencing S. intermedius spawning: (1) increasing the phytoplankton concentration induces spawning in males and (2) both an elevated phytoplankton level and the presence of sperm stimulate spawning in females.* Circadian and lunar rhythms are additional factors affecting this process.

11:40 (S4-12028)**Elaboration of Ecological Quality Objectives as a step forward in cooperation to protect the marine environment in the Northwest Pacific**Vladimir M. **Shulkin**¹, Anatoly N. Kachur¹ and Alexander V. Tkalin²¹ Pacific Geographical Institute, FEBRAS, Vladivostok, Russia. E-mail: shulkin@tig.dvo.ru² Far Eastern Regional Hydrometeorological Research Institute, Vladivostok, Russia

The Northwest Pacific Action Plan (NOWPAP) is one of the UNEP Regional Seas programs which aims to support sustainable development and management of coastal and marine environments in China, Japan, South Korea and Russia. To reach the “good environmental status” is one of the most general goals of this long-term project. Following the Marine Strategy Framework Directive (MSFD) in Europe, the elaboration of ecological quality objectives (EQOs) with a set of operational criteria and indicators has been proposed as a way to facilitate the achievement of that goal in the NOWPAP region. This presentation will describe the recent NOWPAP activities in this field, including the list of EQOs with the operational criteria and indicators suggested so far. The suitability of the suggested indicators, taking into account the data availability, monitoring systems and existing environmental quality standards in the NOWPAP member states will be discussed. The main difficulty in setting up regional EQOs and associated indicators and targets is a lack of legal framework for the comparison, discussion, and integration of environmental quality data. Other trouble is a difference in the national monitoring systems and in the natural and socio-economic conditions. A possible way forward in elaborating regional EQOs within the NOWPAP sea area might include harmonization of national approaches with establishment of numerical targets for certain indicators. After the adoption of the Sustainable Development Goals (SDGs) by the UN General Assembly, NOWPAP EQO indicators should be also aligned with the SDG indicators.

12:00 (S4-12009)

Seasonal dynamics of nutrients in the river water and its influence on productivity of the coastal zone in the Japan/East Sea

Anna S. Vazhova

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Rivers are the main source of terrigenous nutrients to the coastal sea and may be responsible for such adverse impacts as red tides or hypoxia and anoxia in the estuarine areas. In order to evaluate the impact of rivers on chemical environments in the coastal zone, monitoring of river water properties along the coast of southern Primorye has been conducted since 2016. Prominent seasonal dynamics of chemical indicators are revealed which generally correspond to seasonal changes of freshwater discharge caused by the monsoon cycle of precipitations. The maximum nutrient contents, except iron, are observed in winter (DIN ~ 2.5 Mmol/L, DIP ~ 0.5 Mmol/L, silicates ~ 115 Mmol/L) and the iron concentration is highest in spring (~ 0.1 mg/L). However, this natural variability is distorted by anthropogenic load in several rivers with the basins in industrial and agricultural areas, including the territories of P.R. China (Suifen/Razdolnaya River): their waters are the richest in nitrogen and phosphorus in summer (DIN ~ 45 Mmol/L, DIP ~ 2.5 Mmol/L) and in dissolved iron in autumn-winter (~ 0.9-1.3 mg/L). Spatial variability is very similar for all nutrients in any season (correlation coefficients between DIN and Fe concentrations are 0.75-0.99, between DIP and Fe – 0.83-0.99) and is evidence of a common nature of their growth in the polluted rivers, presumably decomposition of organic wastes. Transferred to the sea, the nutrient elements of terrestrial origin are converted back to organic matter enhancing coastal waters productivity, but the consequences of this impact are principally different for the natural regime with the winter-spring maximum and for the distorted regime with the summer-fall maximum. In the latter case, eutrophication of the estuarine areas develops because of the coincidence of light and nutrient supply for photosynthesis. That's why red tides are more frequent in the external estuaries of these rivers (though this problem is still inactual for Russian waters) and hypoxia appears at the sea bottom after the summer blooms because of biochemical consumption of oxygen for mineralization of detritus.

12:20 (S4-12031)

Seasonal and diurnal distributions of the phytoplankton bloom, organic and suspended matter contents indicators in the Amur Bay and adjacent area (Japan/East Sea) according to satellite data

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According to in situ observations of hydrochemical properties in Amur Bay (AB) and Posyet Bay (PB) during 'late summer - early autumn', the researchers of our institute identified cases of near-bottom water hypoxia. Phytoplankton blooms, streams of organic and suspended matter affect the formation of near-bottom hypoxia during conditions of water stratification. The aim of this work is to study the seasonal and diurnal distributions of chlorophyll-*a* concentration and fluorescence, coefficients of light absorption by detritus and yellow substance and light backscattering by suspended particles of mineral and biological origin in the above-mentioned areas for period of 2013-2014. We then compared these variables to change of the water temperature, the wind and precipitation quantity. We used the 1st and 3rd level data on water color from the MODIS-Aqua and GOCI-COMS satellite sensors. The data are the composited monthly, the instant intra-diurnal data. Data on the Sea Surface Temperature from the MODIS-Aqua sensor were also used. Data were taken from site – <http://oceancolor.gsfc.nasa.gov>. These data were processed using the SeaDAS software of versions 6.4 and 7.3. Data on wind speed and direction, and quantity of atmospheric precipitation were obtained for hydrometeorological stations "Vladivostok" and "Posiet" via site – <http://rp5.ru>. Data on precipitation were also taken with TRMM satellite for the areas bounded by coordinates 1) 42.5-43.5° N; 131-132.2° E and 2) 42.2-42.7° N; 130.5-131.2° E. These data were obtained by means of the Giovanni System which is found on site – <http://oceancolor.gsfc.nasa.gov>. Features of the seasonal phytoplankton bloom and organic and suspended matter contents indicators variability in the Amur Bay (AB) and Posyet Bay (PB) were determined and their differences between 2013 and 2014 are revealed. Conclusions are drawn about the indicators distributions variability at northern and southern winds with small and large quantities of precipitation. Examples of these distributions are given by area - from the Razdolnaya River confluence in the AB to the Tumannaya River confluence in sea.

14:10 (S4-12051)**Coral communities in the North-West Pacific coastal ecosystems: Environmental impacts, future trends and distribution**Tatiana N. **Dautova**National Scientific Centre of Marine Biology FEB RAS, Far East Federal University, Vladivostok, Russia
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High levels of biodiversity are considered as an essential requirement for the resilience of ecosystems and is defined as the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a set of environmental factors. More than 75% of the coral reefs are threatened by human activity ranging from coastal development, marine pollution, sedimentation and eutrophication from inland deforestation and farming. Scleractinian corals are frame-building organisms which play an essential role in both warm and cold Pacific waters. The unfavorable environmental factors (eutrophication, sedimentation, wave action, and El Nino warming) influence coral communities and allow the prosperity of opportunistic Scleractinian corals Porites and Faviidae. Both natural and anthropogenic catastrophes may result in 54% Porites predominance as it was found in the coral communities of western South China Sea during the last two decades in the Gulf of Tonkin and Nha Trang Bay and lead to the shift in the structure of the coral populations. Research on the species richness of Octocorallia is substantial in the frame of the worldwide and local biodiversity/marine ecology problems. Solving the complex problems of the taxonomy, genetic diversity and species-specific ecology is needed to trace the possible ways for soft coral dispersal both in tropical shallow and temperate ecosystems in the North Pacific.

14:30 (S4-12101)**Monitoring based research in Ariake Sea, Japan -To solve the environmental and fisheries problems**Yuichi **Hayami**Institute of Lowland and Marine Research, Saga University, Saga, Japan
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The Ariake Sea is a gulf type ROFI or large estuary located in Kyushu island south west Japan. It has a large tidal range up to 6 m during spring tide in the bay head. Because of the shallow topography and large tidal amplitude, there are widespread mud flats which represent about 40% of the total tidal flat area in Japan. Many environmental and fisheries problems have occurred and became a social problem after 2000. These issues include summer hypoxia, decrease of bivalve catch and decrease of macrobenthos. However, it was difficult to understand the causes for the problems since there was little oceanographic research until 2000. Therefore, detailed monitoring systems were constructed including continuous monitoring of hydrography and water quality with monitoring towers and buoys to clarify the causes for the problems. This monitoring data showed that hypoxia was occurring every summer in the bay head and it was frequently varied due to the neap-spring tidal variation and weather. Also, to understand the mechanisms of the decadal-scale changes, historical monthly monitoring data from 1970s were analyzed. The increase of hypoxia and red tide in summer indicates that these problems would be caused by eutrophication. However, the mechanism is different from many other bays such as Chesapeake Bay and Seto Inland Sea, because the terrestrial nutrient load has increased little and there are widespread tidal flats remaining. In this presentation, I will show the importance of the multi-scale monitoring to solve the environmental problems in coastal sea.

15:10 (S4-12039)

Large variability of hypoxia off the Changjiang Estuary

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Hypoxia off the Changjiang Estuary, one of the largest in the world, has been observed frequently and with large variability in the recent decade. It is difficult to understand what causes hypoxia to change with limited of field surveys. A coupled model has been used and comprehensively evaluated, which is applicable and reliable for hypoxia studies in the East China Sea. Event-scale reduction of hypoxia occurred during the weakening of stratification in mid-July and mid-September was associated with strong stirring due to tropical storms or strong northerly winds. Change in wind direction shifted the location of hypoxia by altering the spread of Changjiang Diluted Water. Increase in river discharge led to an expansion of hypoxic water under the summer monsoon. Sensitivity experiments suggested that the hypoxia extent was affected by the change in nutrient concentration of the Changjiang as well as that in the Kuroshio. Sensitivity experiments also suggested the importance of sediment oxygen consumption to the size of the hypoxic zone.

15:50 (S4-12029)

Seasonal microbial community composition in the Jinhae Bay hypoxic zone, South Korea

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Jinhae Bay is one of the most polluted coastal areas in South Korea. Eutrophication problems including hypoxia and red tides are major concerns in this region. Presumably, bacterial community compositions have been substantially affected from these environmental changes as they are mostly passive and dependent on external forcing. However, little is known about the microbial community dynamics in Jinhae Bay. Therefore, we first investigated seasonal bacterial community compositions in the Jinhae Bay hypoxic zone (Latitude: 35°00'N and Longitude: 128°33'E) using pyrosequencing. The physio-chemical properties in the water column were temporally and vertically dynamic. Strong stratification was well developed during early summer to early fall (June to September), resulting in hypoxic bottom waters. Bottom-water oxygen deficiency recovered from late fall (October) due to active vertical mixing. The resulting high quality 5,418,926 reads were clustered into 55,400 operational taxonomic units (OTUs) classified with the phyla Proteobacteria (43%), Cyanobacteria (18%), Bacteroidetes (16%), Verrucomicrobia (6%), and Actinobacteria (6%). It was found that the bacterial community dynamics varied seasonally among each water column. The bacterial community compositions in surface and middle depth waters remained relatively constant, whereas those in bottom waters differed between seasonal and hydrological dynamics. Furthermore, principle coordinates analysis based on OTU data indicated that bacterial communities in surface depth were more variable than the bottom and middle depths. Our results suggest that the dynamics of physicochemical conditions over the water column are decisive factors in shaping the pattern of bacterial communities in Jinhae Bay.

16:10 (S4-12077)**A modeling study of hypoxia in the bottom layers off the Changjiang Estuary in summer**Jingjing Zheng^{1,2}, Guimei **Liu**¹, Shan Gao¹ and Hui Wang¹¹ National Marine Environmental Forecasting Center, Beijing, PR China² State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, PR China

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The phenomenon of low dissolved oxygen (known as hypoxia) in coastal ocean systems is closely related to a combination of anthropogenic and natural factors. Marine hypoxia occurs in the Yangtze Estuary, China with high frequency and long persistence. It's known that it is related primarily to organic and nutrient enrichment influenced by river discharges and physical factors, such as water mixing. In this paper, a three-dimensional hydrodynamic model was coupled to a biological model to simulate and analyze the ecological system of the East China Sea. By comparing with observational data, the model results can reasonably capture the physical and biochemical dynamics of the Yangtze Estuary. In addition, sensitivity experiments were also used to examine the role of physical forcing (river discharge, wind speed, wind direction) in controlling hypoxia in waters adjacent to the Yangtze Estuary. The results showed that the wind field and river discharge have significant impact on the hypoxia off the Yangtze Estuary. The seasonal cycle of hypoxia was relatively insensitive to synoptic variability in the river discharge, but integrated hypoxic areas were sensitive to the whole magnitude of river discharge. Increasing the river discharge was shown to increase hypoxic areas, while decreasing the river discharge was tended to decrease hypoxic areas. The variations of wind speed and direction had great impact on the integrated hypoxic areas.

16:30 (S4-12299)**Spatialtemporal variation of nutrients and eutrophication in Xiamen Bay**Qingsheng **Li**, Cui Wang, Jinlong Jiang, Keliang Chen and Jinkeng Wang

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According to the data on water quality monitoring in Xiamen Bay in 2010, we explored variability in trends of nitrogen and phosphorus nutrients and their mutual relations, and discussed the degree of eutrophication in Xiamen Bay. The results showed that the distribution trend of surface COD, DIN and PO₄-P is roughly progressively decreasing from the western sea of Xiamen, Maluan Bay and Jiulong River Estuary to outside of the bay. Correlation analysis showed that the main source of COD, DIN and PO₄-P in the investigated sea was the input of nutrients from land-based emissions along the coast of Xiamen Bay and Jiulong River. The sources of COD, PO₄-P and NH₄-N may be the same, which had similar biogeochemical process. While the main source of NO₃-N may be Jiulong River input. The variation range of N/P value of Xiamen Bay was 2.26~117.30, and the value of N/P in most areas of Jiulong River Estuary, Southeastern Sea and Dadeng sea area were greater than 16. According to the N/P value, the structure of nutrients was phosphorus-restricted, while the north of western sea area, Tongan Bay and Maluan Bay belonged to nitrogen-restricted sea areas. The range of the eutrophication index of the sea area in Xiamen Bay (E) was 0.013~118.168, while the eutrophication index of Maluan Bay, the north of western sea and the sea near Gaoji Seawall was higher.

16:50 (S4-12304)

Detecting multi-scale temporal dynamics of acoustically estimated zooplankton biomass: A case study of high-resolution ocean observatory system in Saanich Inlet (BC, Canada)

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Saanich Inlet is an inverse estuary located at the southeastern end of Vancouver Island (British Columbia, Canada) with naturally anoxic water at depth through much of the year. Physical conditions in the inlet broadly reflect those along the west coast of Vancouver Island and respond similarly to anomalous conditions such as the warm anomaly of 2014-15 and ENSO events. Zooplanktons in this fjord have been monitored using a 200kHz echosounder (Acoustic Zooplankton Fish Profiler) mounted on cabled observatory system platform (VENUS, Ocean Networks Canada) since 2006. Eleven years (2006-2017) of high-resolution bioacoustics time-series allows for the first detection and analyses of zooplankton dynamics on multiple time scales (weekly, biweekly, monthly and quarterly) using Empirical Dynamic Modeling. The fluctuations in acoustically measured migration zooplankton biomass (mostly *Euphausia pacifica*) are identified as significantly nonlinear on biweekly, monthly and quarterly scales ($\theta = 1.5, 1.5$ and 1 , respectively). The biweekly and monthly scales have also been suggested as appropriate scales for characterizing euphausiid population dynamics and for better short-term forecasting potential in this system. In addition, time-series measurements of environmental indices (e.g. temperature, salinity, oxygen and Chlorophyll a concentration) collected via multiple observatory systems sensors are used to explore the forces and processes driving euphausiid dynamics at different time scales. Application of nonlinear time series analysis will facilitate a better understanding of how the zooplankton dynamical features in Saanich inlet respond to previous and perhaps future adverse conditions.

17:10 (S4-12222)

Winner or loser: Sea cucumber's future in a changing ocean

Xiutang **Yuan**

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We are facing a changing ocean: seawater pH is decreasing. In this context, Ocean acidification (OA) caused by continuously increasing atmospheric carbon dioxide (CO₂) levels may exert negative consequences on marine organisms and ecosystems. Sea cucumbers are one of the five classes in echinoderms and play an important role in ecosystem functioning (as ecosystem engineer) and the economy (fisheries). In the changing ocean, the fate of the ecologically and economically important holothurians has been of concern. This talk will address the sea cucumber's possible future from aspects of the early-life stage, adult physiology (acid-base balance, somatic growth, gonad development, metabolism and calcification) and behavior. The aims of this talk are to disclose the potential impacts of OA on carry-over effects, the fisheries and holothurian-dependent ecosystem functioning, and to give some hints of previous mass extinction partly caused by ocean acidification such as the Permo-Triassic event (winner or loser). In addition, future research that focused on sea cucumber's responses to a changing ocean are also proposed.

17:30 (S4-P9 moved to oral)

The Hakai Institute Oceanography program: An examination of oceanographic properties from the northern Strait of Georgia to the central British Columbia coast

Jennifer M. **Jackson**¹ and Brian P.V. Hunt^{1,2}

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² Institute of Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada

The Hakai Institute Oceanographic Program has been collecting year-round data from British Columbia's central coast since 2012, from the Discovery Islands since 2014, and from Johnstone Strait since 2015. Together these regions encompass a range of different environments, from glacially-fed mainland fjords, to tidal-mixed inlets and the open continental shelf. Hakai's oceanography program collects physical (CTD and oxygen sensor), biological (from viruses through forage fish), and chemical (carbonate chemistry and nutrients) data. Here we jointly examine the physical and biological data from the regions outlined above to characterize regions that are broadly representative of key ocean habitats on the British Columbia coast. Data will be examined in the context of large-scale climate events such as the 2014-2016 marine heatwave.

S5: FIS Topic Session

Coastal ecosystem conservation and challenge

September 28

14:10 (S5-12242)

Signature of global warming on dynamics of anchovy *Engraulis japonicas* stock in the Yellow Sea

Xiujuan **Shan**^{1,2}, Xianshi Jin^{1,2}, Yunlong Chen¹ and Tao Yang¹

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With the increasing effects of climate change and human activities on marine ecosystem, the dynamics of fishery resources are greatly changed. The response of the biological characteristics of marine fishery stocks to environmental changes, as well as the redistribution of the fishery stocks under climate change scenarios, are of great importance and guidance to the rational exploitation of the fishery resources. As the key species in food web of the Yellow Sea, anchovy *Engraulis japonicus* plays a critical role in fish community, as well as to marine ecosystem. The occurrence frequency of anchovy was less than 40% in 1986, while it was bigger than 60% since 2000. In 2001 and 2006, it peaked at 93% and 82%, respectively. However, the changing trend of RDI was not consistent with occurrence frequency. The RDI was positively correlated with the sea surface temperature (SST) of the Yellow Sea in January and the Southern Oscillation Index (SOI), while it showed the negative correlation with the Pacific Decadal Oscillation (PDO) and Nino 3.4 index. The wintering anchovy stock showed the obvious northward trend, reached as much as to 2.5-2.7oin the next 30 years. The average speed of shift to northward could be 0.09o per year. There were no significant differences among the four climate change scenarios(RCP 2.6,RCP4.5, RCP6.0, RCP8.5). In the sensitivity analysis, the scale constant k was not sensitive to the redistribution of anchovy stock, while theintrinsic rate of population increase r was closely related to its redistribution.

14:30 (S5-12019)

Kelp of *Laminaria* thickets recovery in dependence on abiotic and biotic environments

Tatiana **Krupnova**, Yury Zuenko, Irina Tsypysheva and Vladimir Matveev

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Thickets of kelps degrade recently in many coastal areas, including the Japan Sea, and are replaced by non-commercial weeds, as coralline algae. The lower stock of *Laminaria* is the reason for reducing its landing, so it is negative for processing industry and employment in coastal villages. Besides, *Laminaria* is a species-edificator, as a substratum for settling of fish and invertebrates eggs and larvae, shelter for their juveniles, and a food for sea urchins. To solve this problem, the Program of *Laminaria* stock recovery is applied that has two blocks: investigation of the reasons of its degradation and development of measures for its restoration and preservation:

The first block includes the studies in two directions: (1) Oceanographic mechanisms of shortening the period optimal for the early stages of *Laminaria* development. (2) Possible anthropogenic reasons of negative influence on *Laminaria* reproduction, as overharvesting, weakening of nutrients supply because of deforestation, et cetera. The second block includes the following measures: (1) Researches in the coastal zone to reveal the areas prospective for restoration of *Laminaria* thickets; (2) Development of biotechnology for the *Laminaria* thickets restoration

Selection of the *Laminaria* taxa prospective for artificial reproduction These results are generalized as a Biotechnology for *Laminaria* Thickets Recovery, that is a complex of recommendations, partially constant (as how to choose the reproductive thalli, how to transport them, how to stimulate them for zoospores production, how to settle them to the sea bottom, etc.) and partially dependent on real environments (as terms of the zoospores release in dependence on meteorological and oceanographic conditions). Implementation of these recommendations allows to get high harvests of the *Laminaria* and to provide good feeding base for sea urchins.

14:50 (S5-12261)

Zooplankton communities in the coastal northeast Pacific Ocean: A comparison of a highly productive region and a light-limited high nutrient, low chlorophyll regionNatalie **Mahara**¹, Brian V.P. Hunt^{2,3} and Evgeny A. Pakhomov^{1,2}

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Zooplankton have long been recognized as an important link between primary producers and higher trophic levels. The Discovery Islands (DI) and Johnstone Strait (JS) regions along the northeastern side of Vancouver Island, BC remain vastly understudied biologically. JS has been proposed as a trophic gauntlet where zooplankton limits higher trophic levels due to environmental conditions, highlighting the need for a better understanding of local zooplankton communities. Preliminary data suggest JS is permanently well-mixed with low temperatures, high surface nutrient concentrations, and low chlorophyll biomass throughout the spring and summer months. In the DI, stratified stations have productive surface waters, whereas well-mixed stations have low primary productivity similar to conditions found in JS. This suggests that environmental conditions directly influence primary productivity, however the same link has not been demonstrated in the connection with zooplankton communities. Vertical zooplankton tows were conducted at 9 sites throughout the DI/JS region from mid-April until early-July in 2015 and 2016. Data suggest that zooplankton community composition is >55% dissimilar between JS and DI sites. Cluster Analysis suggests that within the DI, community similarity depends on a combination of seasonality and stratification, with zooplankton composition being >65% dissimilar in some cases. In Johnstone Strait, zooplankton communities before mid-May appear to be approximately 50% dissimilar to those after mid-May. Understanding the drivers behind spatial and temporal changes in zooplankton communities along the BC coast may lead to a better understanding of trophic dynamics in marine ecosystems.

15:10 (S5-12061)

Improving estimations of fish species abundance and distribution via accounting for the effects of diel vertical movementsLisha **Guan**¹, Xiujuan Shan^{1,2} and Xianshi Jin^{1,2}

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Many fish show diel vertical movements (DVM), which is a key factor affecting the catchability of most fisheries-dependent or fisheries-independent surveys. Calibrations of abundance indices from these surveys to maintain a consistent catchability is important for evaluating spatio-temporal variability in fish population abundance. However, such calibrations rarely account for DVM. In this study, a spatio-temporal delta-generalized linear mixed model (GLMM) is developed for improving abundance index calibration and density distribution estimation. The model includes the hour of a day as a random effect to quantify the time-variant effects of DVM on catchability. Additionally, the comprehensive effect of habitat variables is modeled via spatial and spatio-temporal correlations. We then fit the model to the fall bottom trawl survey data for small yellow croaker in the Yellow Sea during the period of 2006 - 2010 as a case study. Results show that the spatio-temporal delta-GLMM can successfully reveal the time-variant effects of DVM, which match the ecology of small yellow croaker. Moreover, the model yields more precise estimates of total abundance than the currently advanced geostatistical delta-GLMM which does not consider the time-variant effects of GVM.

15:50 (S5-P6, moved to Oral, Sept. 28)

DNA barcoding and electronic microarray for common fish species in Shandong coastal waters

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Marine biodiversity is an important indicator of ecosystem health and the material basis for the development and utilization of marine biological resources. Shandong coastal waters are the main breeding grounds for Bohai and Yellow Sea fisheries resources. These waters provide a wealth of biological resources and a superior fisheries habitat for China, Japan, South Korea, and North Korea. However, the Shandong offshore fisheries resources have been trending downward in recent years, and species abundance and diversity have decreased. Therefore, identifying and classifying the fish species in these coastal waters are urgently required to effectively protect and use these resources. In this study, 229 DNA sequences of the cytochrome oxidase subunit I (*COI*) gene from 77 common marine fish species in 13 orders, 50 families, and 73 genera from offshore of Shandong were analyzed to test the efficacy of species identification using a DNA barcode microarray. The results showed that interspecific genetic distance was larger than intraspecific distance. All 77 sequences formed species units in a neighbor-joining dendrogram, indicating that DNA barcodes can be used to identify these 77 species. Sixty-four specific probes were screened to identify the corresponding species among the 77 species based on the *COI* genes and accounted for 83.1%. Thus, the DNA barcode microarray provided technical support and a new way to identify fish species in the coastal waters offshore of Shandong.

16:10 (S5-12268)

Potential influence of oceanic environmental change on seaweed bed distribution in Tsushima Islands

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Seaweed bed depletion, so-called “barren ground,” is a serious problem in the coastal area of Tsushima Islands, like other parts of Japan. There are many possible reasons for causing barren ground, such as elevating seawater temperature, grazing by herbivorous animals and the lack of iron, nitrogen and phosphate (nutrient salts) in the coastal area. As seaweed bed distribution in the eastern area of Tsushima Islands is different from that in the western area, the influence of an oceanic environmental change in the East China Sea should be evaluated in addition to conditions in the coastal area. In this study, we conducted water quality investigation and comparison of the oceanic environmental change between northeastern and southwestern areas of Tsushima Islands. Water qualities, such as iron, nitrogen and phosphate, were monitored from June 2015 to March 2017. As a result, no clear differences were found for these concentrations between northeast area and southwest area. Meanwhile, we compared seasonal change and long-term trend of seawater temperatures, salinities and current velocities between the northeastern and southwestern area by analyzing re-analysis data from 1993 to 2013 (FRA-JCOPE 2.1). It was found that salinity in summer has decreased in both areas since 1993, but it was more evident in the southern area. In addition, eastward velocity in the southwestern area was strengthened especially in summer. These results indicate that the increase of the Changjiang diluted water may be one of the main reasons for changing the oceanic environment of Tsushima Islands.

16:30 (S5-12100)**Relationship of energy metabolism and juvenile Pacific salmon survival of during adaptation at sea**Anton **Klimov**, Aleksey Lozovoy and Irina Zhiganova

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The research was made on the trawl survey data collected in the Okhotsk Sea coastal water in August-September in 2013-2016. In order to figure out the patterns for the energy metabolism and juvenile Pacific salmon survival at sea. Trophic interactions and lipid qualitative and quantitative transformations in juvenile muscle tissue on leaving estuaries and emigration to the offshore were considered. Leaving the estuary, coinciding in case of pink salmon with the beginning of active feeding, has found critical. There is no energy reserved in lipids, but there are risks for a huge part of smolts of energy disbalance (spends prevailing). Having fast energy forage as larval or alevin fish gets very important (even for classic plankton eaters as chum, pink or sockeye) on leaving rivers. The fish component, comparing it to plankton crustaceans, provides less calories, but can be digested and used faster. That should mean more frequent feeding and accelerates synthesis of proteins and growth of bones. Along that the faster linear growth of juvenile fish increases the chance to escape predators. The idea was illustrated by the data of 1984 and 2012, when the number of pink salmon smolts turned 3-4 times less than expected. We also provide analyses how far different the feeding conditions were on the west and east coasts of Kamchatka and whether extension of shelf can play role in feeding and energetic metabolism of juvenile Pacific salmon.

16:50 (S5-12066)**Habitat history reconstruction of the Japanese-Spanish mackerel *Scomberomorus niphonius* in the southern Yellow Sea, inferred from otolith chemistry**Xindong **Pan**, Chi Zhang, Zhenjiang Ye, Binduo Xu, Yang Liu and Yongjun Tian

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Japanese-Spanish mackerel, *Scomberomorus niphonius*, is highly migratory and widely distributed in the northwestern North Pacific. It is commercially important species in China Seas, particularly in the southern Yellow Sea which is one of the most important fishing grounds. In spite of the over-exploitation in the China Seas, *S. niphoniu* still maintained a high yield over the past decades. This phenomenon cannot be explained without understanding of large-scale movement of *S. niphonius* and its influence on regional population dynamics and stock structure. This study tried to reconstruct the habitat history of *S. niphonius* in the southern Yellow Sea using otolith chemistry. *S. niphonius* of two years age groups during spawning seasons were collected from coastal waters of Jiangsu Province in Yellow Sea, then transverse sections of otoliths were analyzed from its core to the margin by using laser ablation ICPMS. Element:calcium ratios were integrated with microstructural analysis to produce profiles of different life stages for measured elements. The results revealed that only Ba:Ca showed significant difference between life stages. It indicates that variation in Ba:Ca was most informative and *S. niphonius* seemed to prefer low salinity habitats at the stages of hatching and post-hatching development, while the high salinity habitats seemed to be preferable for the stage of wintering. These results provided further evidence for the common migration trajectory. Furthermore, element differences among life stages of hatching and spawning implied the possibilities that not all *S. niphonius* have the behavior of natal homing, which can lead to complex population connectivities and stock structure.

S6: POC/FIS Topic Session**Interannual variability in marine ecosystems and its coupling with climate projections****September 26****11:00 (S6-12169) Invited****Interannual variability of oceanographic conditions in the North-West Pacific and Far-Eastern Seas and examples of its effects on fisheries**Elena I. Ustinova and Yury D. SorokinPacific Fisheries Research Centre (TINRO-Centre), Vladivostok, Russia
E-mail: eustinova@mail.ru

The structure and possible mechanisms of interannual variability of oceanographic conditions are considered. Variance of air and water temperature in the Far-Eastern Seas is contributed mainly by high-frequency oscillations (quasi-biennial and ENSO scales), while the major part of the ice cover variance is formed by low-frequency oscillations with a time scale ≥ 10 years. The spectral maximum shifts toward low frequencies in winter in the northern areas, but relatively short cycles prevail in the Subarctic Front zone and in the Tatar Strait. Interannual variability of coastal sea surface temperature (SST) is maximal in summer-autumn. Year-to-year variations are distinguished by low predictability, mostly because of the instability of quasi-biennial oscillations. Interannual variability of seasonal and mesoscale processes affects the migration of small pelagic fish, in particular in the Subarctic Front zone. An obvious example is the influence of the seasonal dynamics of the Kuroshio-Oyashio and the position of the large anticyclonic eddy off Hokkaido on the saury, mackerel and sardine fisheries in summer-fall. Another example of the short-term processes impact with long-term consequences is the extreme winter-spring cooling in the Kuroshio-Oyashio in 1963, which caused a mass mortality of small pelagic juveniles. In a wide sense, all regime shifts are “dramatic” for marine ecosystems because of the abrupt change in environmental conditions.

11:30 (S6-12057)**Wind-driven and intrinsic interannual variability in the Kuroshio Extension jet and its eddy activities**Masami Nonaka¹, Hideharu Sasaki¹ and Niklas Schneider²¹ JAMSTEC, Yokohama, Kanagawa, Japan. E-mail: nona@jamstec.go.jp² IPRC Univ. of Hawaii, Honolulu, HI, USA

Interannual to decadal variability in the Kuroshio Extension is examined. Previous studies show the interannual intrinsic variability induced by oceanic internal dynamics under atmospheric forcing. In the present study, the intrinsic interannual variability in the western boundary currents under realistic interannually varying atmospheric forcing is investigated for the past 35 years using the five member, eddy-resolving, quasi-global OGCM ensemble with slightly different initial conditions but driven by identical atmospheric states. Substantial spread of interannual variability is shown. Differences among the realizations are of similar magnitude or larger than the wind-driven variability in the western boundary current region. This quantifies the substantial uncertainty at the western boundary due to intrinsic ocean processes. Besides, we have found that interannual variability of eddy activity in the Kuroshio Extension region is partially wind-driven; this signal propagates westward in association with the current velocity anomalies.

11:50 (S6-12023)**On the effect of atmospheric forcing on the upper heat content variability in the Japan/East Sea from 1948 to 2009**Dmitry V. Stepanov¹, Anatoly Gusev² and Nikolay Diansky^{2,3}¹ V.I. Il'ichev Pacific Oceanological Institute, Vladivostok, Russian

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² Institute of Numerical Mathematics of the RAS, Moscow, Russia³ Zubov State Oceanographic Institute, Moscow, Russia

High-resolution retrospective numerical simulations are used to investigate the upper layer (0-300 m) heat content variations in the Japan/East Sea. Variability of the heat content is weakly driven by the net heat flux fluctuations over the Japan/East Sea (the correlation coefficient is about +0.5). The heat supply and heat loss occur mainly in the northern part of the sea and along its eastern coasts. The increase in heat content in the northern area is caused by a strengthening of the cyclonic circulation while the contribution of the net heat flux is small. This increase has been particularly apparent since the 1990s because of a strengthening cyclonic gyre in the Japan Basin. At the same time, the upper layer heat content has increased in the southern part of the Japan/East Sea, driven by a strengthening of both the net heat flux and intensity of the Tsushima Current nearshore branch. The vertical heat flux in the northern Japan/East Sea changes significantly with depth.

12:10 (S6-12298)**Bridging the gap between mechanistic understanding and climate projections: An example based on the Bering Sea Project**Anne B. Hollowed¹, Alan C. Haynie¹, Kristin Holsman¹, Kerim Aydin¹, Al Hermann², Wei Cheng², Jon Reum² and Amanda Faig³¹ Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA. E-mail: Anne.Hollowed@noaa.gov² Joint Institute for the Study of Atmosphere and Ocean, University of Washington, Seattle, WA³ School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA

As the international scientific community strives to provide policy-relevant scientific advice with respect to the implications of climate change on marine ecosystems, the need for mechanistic understanding of physical–biological couplings is critically important. This presentation will illustrate how results from a large interdisciplinary interagency partnership are being used to inform climate change projections for the southeastern Bering Sea ecosystem. In 2007, the North Pacific Research Board, the National Science Foundation and the National Marine Fisheries Service partnered to conduct an integrated study of the Bering Sea ecosystem. The results of this multi-million dollar research effort provided several new insights into the processes governing recruitment, growth, and predator–prey interactions. This talk will describe the evidence for these mechanistic linkages and discuss how the mechanisms are formulated to drive the Alaska Climate Integrated Modeling (ACLIM) projections of climate change impacts on the Bering Sea. The structure of the ACLIM project is designed to quantify scenario, parameter, and structural uncertainty through a multi-model projection suite across a range of ecosystem complexity. This talk focuses on parameter uncertainty and model complexity. The paper serves as a starting point for the discussion of how best to quantify and communicate the full range of uncertainty associated with projected impacts of climate change impacts on marine fish and fisheries.

14:00 (S6-12276)

What was the major factor that has caused declines in coccolithophore abundance in the North Pacific Subtropical Gyre since 2005?

Joo-Eun **Yoon**¹, Il-Nam Kim¹, SeungHyun Son², Alison M. Macdonald³ and Ki-Tae Park⁴

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Calcifying marine phytoplankton, such as coccolithophores, are known to be susceptible to ocean acidification resulting from a substantial increase in upper ocean anthropogenic CO₂. In contrast to the canonical perspective, recent studies in the North Atlantic Subtropical Gyre showed a basin-scale long-term increase in coccolithophore abundance and suggested that increased CO₂ had a positive effect on their growth. However, there were, as yet, no such findings for other basins. Here, the long-term trend of coccolithophore abundance in the North Pacific Subtropical Gyre is presented based on Hawaii Ocean Time-series monthly data (i.e. temperature, salinity, nutrients, pH, total alkalinity, dissolved inorganic carbon (DIC), and phytoplankton pigments) obtained in 1988-2015 at Station ALOHA (22°45'N, 158°00'W). The integrated coccolithophore abundance in the layer from the sea surface to ~160 m depth showed an increasing trend between 1988–2004, followed by a decreasing trend through 2015. Over the entire period from 1988 to 2015, DIC concentrations increased continuously, though earlier the coccolithophore abundance was coupled with DIC. Interestingly, the coccolithophore abundance decreasing in the North Pacific in 2005-2015 contrasts with the increase in the North Atlantic. Environmental factors potentially responsible for a recent decline in coccolithophore abundances in the North Pacific Subtropical Gyre are suggested, and mechanisms driving the difference between two basins are discussed.

14:20 (S6-12287)

What is driving interannual variability in lower trophic levels near Explorer Seamount (Canada)?

Tetjana **Ross**¹, Moira Galbraith¹, Tammy Norgard² and Marie Robert¹

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An ecologically significant area off the west coast of Vancouver Island, which is home to seamounts, hydrothermal vents and at times the bifurcation of the main eastward trans-Pacific currents into the Alaska and California coastal currents, is explored using multi-parameter oceanographic time-series since the mid-1990s. Interannual variability in indicator zooplankton species and chlorophyll is considered and links of these changes with the variability of chemical and physical parameters are determined in an attempt to understand the mechanisms driving these changes. These variations are discussed within the context of fisheries and climate change.

14:40 (S6-12008)

Climate change and trends of phytoplankton abundance in the East China SeaJinhui **Wang**^{1,2}, Yutao Qin^{1,2} and Shouhai Liu^{1,2}¹ East China Sea Branch, SOA, Shanghai, 200137, PR China
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According to qualitative and quantitative analysis of a phytoplankton data series collected in the East China Sea, *Skeletonema costatum* and *Noctiluca scintillans* were the most common species in 1980-1990s, but *Gymnodinium catenatum*, *Gonyaulax polygramma*, *Chattonella marina*, *Phaeocystis globosa*, and *Karenia mikimotoi* have appeared here in mass since the 2000s, with the latter two species now forming the spring blooms. These time-series are compared with possible natural and anthropogenic drivers, including climate change, eutrophication processes, ballast water discharge, and the ecosystem succession. Do the changes in phytoplankton relate with global climate change? We have no answer yet, and we do not know how to predict the timing and direction of the next shifts in the phytoplankton community.

15:00 (S6-12241)

Interannual variability in the zooplankton community and its relationship with environmental variables in the Bohai Bay, ChinaLu **Yang**, Qiulu Wang, Yan Xu and Haiyan Huang

National Marine Data and Information Service, Tianjin, PR China . E-mail: annie0404aa@qq.com

Zooplankton community structure and variations are considered on the basis of monitoring data in the Bohai Bay, China from 2004 to 2015. The relationship between the zooplankton and environmental variables is examined. Species number and biodiversity indices of zooplankton show an increasing trend in the Bohai Bay. Among 8 phyla identified, two major groups of Arthropoda and Coelenterata show increasing abundance in recent years. As a result, the zooplankton composition in the Bohai Bay has changed dramatically: the number of large-sized copepods such as *Calanus sinicus* and *Labidocera euchaeta* has decreased gradually, while small copepods such as *Acartia pacifica* and *Centropages dorsispinatus* as well as gelatinous zooplankton such as *Oikopleura dioica* and *Eirene ceylonensis* have expanded. The definite effect of environmental variables, such as changes in temperature, salinity and nutrients concentration on the zooplankton community in the Bohai Bay, is revealed.

15:20 (S6-12139)

Influence of the Three Gorges Dam on the East China Sea ecosystemChristina E. **Kong**¹, Sinjae Yoo^{1,2} and Chanjoo Jang^{1,2}¹ Ocean Science and Technology School, Busan, R Korea
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The Three Gorges Dam on the Changjiang (Yangtze) River is the largest hydropower project in the world, implemented in June 2003, and its potential impact on the marine ecosystem since that time is discussed. Long-term trends of primary production, chlorophyll-*a* concentration (CHL), photosynthetically active radiation, sea surface temperature, and euphotic layer depth in the coastal East China Sea are investigated for the last 17 years (1998-2014) and their correlation with anomalies of the Changjiang River discharge is examined to understand their potential influence on marine productivity. In addition, CHL dynamics before and after 2003 is considered. Large-scale variability of the productivity indices does not show any correlation with the Three Gorges Dam operation, and all indices have no significant trends. Thus, an insignificant influence of the Three Gorges Dam on primary productivity of the East China Sea is concluded.

16:00 (S6-12141)

Seasonal and interannual variability of satellite chlorophyll-a in the Malacca Strait

Susanna **Nurdjaman** and Age Hidayat

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Thirteen years of Aqua MODIS ocean color data are used to characterize variability of chlorophyll-*a* concentration over seasonal to interannual timescales in the Strait of Malacca and to assess the effect of the ENSO (El Niño Southern Oscillation) and IOD (Indian Ocean Dipole) phenomena on productivity of this area. Fluctuations with periods of 6 months, 12 months and 3.5 years dominated in the Chl-*a* variability that corresponds to Asian Monsoon variations. The average Chl-*a* concentration was higher in November-February (during the northeast monsoon) and lower in April-June (during the southwest monsoon), with the extremes in January (up to 5 mg/m³) and June (0.15 mg/m³). During the northeast monsoon, high Chl-*a* concentration is conditioned by terrestrial nutrients input with river discharge and correlates with heavy rainfall. In general, Chl-*a* concentration in the northern part of the Strait of Malacca is lower (0.46 mg/m³ on average) than in its southern part (3.3 mg/m³). ENSO and IOD phenomena condition lowered concentrations of chlorophyll in the Malacca Strait.

Joined S8 / HD-Paper: HD Topic Session

Marine ecosystem health and human well-being: A social-ecological systems approach

September 26

11:00 (S8-HD-P-12149)

PICES-Japan MAFF Project “MarWeB”

Mitsutaku **Makino**¹ and Ian Perry

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The Ministry of Agriculture Forestry and Fisheries of Japan (MAFF) funded a PICES project on Marine Ecosystem Health and Human Well-being (MarWeB) for 2012-2017. The project key questions are (a) How do marine ecosystems support human well-being? and (b) How do human communities support sustainable and productive marine ecosystems? The project focused on three major initiatives: (1) Social-ecological interactions related to integrated multi-trophic aquaculture (IMTA) in Indonesia; (2) Social-ecological interactions related to small-scale oyster aquaculture in Guatemala; and (3) Development of the “well-being cube” approach to assessing national well-being related to marine systems.

11:30 (S8-HD-P-11976) Invited

Sato-umi concept and sustainable aquaculture implementation in the coastal area of Indonesia

Suhendar I **Sachomar**¹, Mitsutaku Makino², Mark L. Wells³, Ratu Siti Aliah¹, Masahito Hirota⁴ and Tetsuo Yanagi⁵

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Since 2013, PICES (The North Pacific Marine Science Organization) and BPPT (Agency for the Assessment and Application of Technology) have worked together to implement and promote the Sato-Umi concept in Indonesia by developing demonstration pond experiments and international workshops. The three demonstration pond experiments explored the technical feasibility and practicality of integrated multi-trophic aquaculture (IMTA). The first experiment used a large (4000 m²) pond sectioned to allow four experimental treatments to show that IMTA improves water quality stability, e.g., DIN and DIP, relative to monoculture. In addition, compared to monoculture, IMTA increased total biomass production. The second and third annual experiments, using a smaller (1000 m²) pond, yielded similar results in biomass production with slight differences in resulting water quality (DIN and DIP) stability. Together, these experiments show that the area, pond condition and completeness of the IMTA components affect performance of water quality stability and biomass production. International workshops and training sessions on SATO-UMI for sustainable aquaculture were conducted in 2013 (Jakarta), 2014 (Karawang, West Java, and Pekalongan, Central Java), 2015 (Jakarta), and 2016 (Bantaeng, South Sulawesi). The workshops were organized to promote harmonious and productive management of coastal and marine resources to improve human well-being.

12:00 (S8-HD-P-12215)

Integrated multi-trophic aquaculture in traditional pond aquaculture, Indonesia

Suhendar I **Sachoemar**¹, Warih Hardanu², Mark **Wells**³, Mitsutaku Makino⁴, Masahito Hirota⁴, Ian Perry⁵, Ratu Siti Aliah¹ and Atri Triana Kartikasari²

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Traditional pond shrimp aquaculture in Indonesian communities is distinguished by its comparative simplicity and low intensity approach (~15 vs. >300 shrimp/m²), essential to avoid the otherwise significant expense of pond aeration. Nevertheless, these operations are a major source of eutrophication to coastal waters. The Indonesian government is proposing enormous expansion of pond shrimp aquaculture to enhance coastal economies, heightening the need for nutrient mitigation strategies. We investigated co-culturing the macroalga *Gracilaria*, an aquaculture product of secondary value, on bamboo rafts within shrimp ponds to reduce nutrient loading without negatively affecting shrimp yield. Rafts were used because earlier tests showed that macroalgae became light-limited in the turbid pond waters. The findings demonstrate that adding *Gracilaria* does not negatively affect shrimp production, and in some cases may increase shrimp growth. *Gracilaria* biomass doubled in the first half of the 110-day experiment, enhancing economic recovery from pond operations and contributing to markedly lower concentrations of dissolved nutrients. However, *Gracilaria* biomass did not further increase over the second half of the experiment, likely because of light limitation caused by greater biomass on the rafts. Disruption of the pond floor sediments by periodic human traffic (to shake the bamboo mats to remove silt) appeared to increase denitrification and P removal, reducing the nutrient loads further. Moreover, local grass contaminants in the control pond seemed particularly effective for the removal of nutrients from pond waters. These project findings highlight new approaches for low cost nutrient remediation to limit traditional pond aquaculture impacts on coastal ecosystems.

12:20 (S8-HD-P-12213) Invited**When the nets leave the waters: A community needs assessment for the lost fishing communities of Pacific coastal Guatemala – Balancing ocean and human health**Charles **Trick**¹, Vera L. Trainer², William Cochlan³ and Julian Herndon⁴¹ Western University, London, ON, Canada

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² Northwest Fisheries Science Center, NOAA, Seattle, WA, USA³ San Francisco State University, Tiburon, CA, USA⁴ Joint Institute for the Study of the Atmosphere and Ocean, University of Washington-NOAA, Seattle, WA, USA

As part of the PICES-led scientific mission to assess changes in the relationship between coastal communities, the health of community members and their connection with coastal marine resources, we have been working with two Pacific coastal towns in Guatemala. In collaboration with our local colleagues (Leonel Carrillo, Director, Center for the Study of the Sea and Aquaculture (CEMA) and Professor Carolina Marroquin, University of San Carlos), we have engaged in a series of conversations with community members from two geographically isolated villages along the Pacific coast of Guatemala - Las Lisas and Monterrico. Our goal was to identify factors that influence the balance between sustainable human communities and productive marine ecosystems. Specifically, considering the on-going global changes in climate and the real or perceived loss of coastal fisheries and human social and economic conditions, the project objectives are two-fold: 1) to determine how marine ecosystems support human well-being and 2) to identify how human communities support sustainable and productive marine ecosystems. “Sato-umi,” from the Japanese socio-ecological model, which recognizes the well-balanced availability of various ecosystem services, and a community needs assessment (CNA) were considered in the generation of a model of risk assessment.

The significance of this work illustrates the considerable risks to the fabric of community structure and helps define the specific concept of “wellness,” when fisheries are lost due to climate shifts or to the intrusion of non-local fishing fleets. The study communities, “poster children” of a vast number of communities faced with diminishing marine resources, are integral to our understanding of the costs of altered marine ecosystems.

14:20 (S8-HD-P-12040)**Towards international cooperation in the development of Marine Spatial Plans for the North Pacific: Economic, social, and environmental dimensions**Amrtatjuti V. **Sereda** and Vyacheslav Lobanov

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Marine Spatial Planning (MSP) represents a viable mechanism for ensuring the conservation and sustainable use of the ocean environment and marine resources in the North Pacific. The Agenda for Sustainable Development calls for establishment of MSPs by 2030 to address key targets of SDG14. In this paper, we discuss the potential for and necessity of international cooperation in development of MSPs. In view of actual geographical, geopolitical, economic and environmental conditions, we discuss the strategic value of Russia-Japan-Korea and Russia-USA cooperation in development of the MSPs for the Japan Sea and Bering Sea, respectively. Cohesive nationally owned sustainable development strategies supported by integrated national scientific and economic frameworks should be a base for these MSPs. At the same time, *the issue under consideration* is associated with domestic public resources and interests, addressing the matters of science, technology, innovation and capacity-building as well as a subsequent development of a unified and balanced **social-ecological** vision on marine regional management to meet the region's specific environmental challenges in a globalizing world. In achieving this, an objective scientific activity of academic and research institutions with the support of the UN system, other intergovernmental organizations, international and regional financial institutions, non-governmental and civil society organizations, the private sector, are also critical in order to combine the scientific knowledge on marine regions thus integrating available resource mobilization targets into complex research projects that will be designed to accommodate planning requirements translating sustainable development policies into concrete actions at national and international levels.

14:40 (S8-HD-P-12155)

Development of broadly distributable metrics of ocean conditions using real-time data and marine ‘community-observatories’ along the British Columbia coast

S. Kim **Juniper**, Maia Hoeberechts, Marlene Jeffries, and Akash Sastri

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Providing access to real-time metrics of ocean conditions is an important community-level, capacity-building component of sustainable ocean management. This approach requires both local measurements of ocean conditions and the development of useful, real-time data products. Ocean Networks Canada (oceannetworks.ca) operates a regional-scale cabled observatory in the Salish Sea and off the west coast of Vancouver Island, and a number of community-based, real-time cabled observatories in coastal British Columbia and in the Canadian arctic. The coastal observatories are situated in locations relevant to local community and scientific interests. Ocean Networks Canada currently provides four types of data products relevant to ocean conditions in these communities: 1) community observatory webpages; 2) state of the ocean plots; 3) temperature baseline and anomaly plots; and 4) acoustic (ocean noise) baseline and anomaly plots. We describe these location-specific data products, their current and future use as operational indicators of ocean health and their relevance to the development of broader regional ocean health indices. In addition, we outline the accompanying outreach and ocean literacy learning programs that also contribute to capacity building in these communities.

15:00 (S8-HD-P-12209)

An index system for assessment of the performance of construction strategies marine ecological civilization

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The term, *ecological civilization*, coined by the Chinese government, connotes a vision of sustainable development that reflects Chinese values. Construction strategies that adopt an ecological civilization framework: (1) enhance the transition from traditional industries to the environmentally-friendly industries with associated resource-savings, high efficiency utilization of resources, and low-carbon discharges; and (2) improve environmental quality of air, freshwater, seawater and soil through treatment of effluents, ecological restoration, and environmental protections. Since 2015, marine construction projects have been examined by the State Oceanic Administration of China and coastal local governments for consistency with ecological civilization principles. In this paper, we report on the development of an index system for assessing outcomes in terms of ecological civilization and apply the indexes to examine marine construction in coastal provinces and cities. This index system is based on the marine-social-economic complex system to encourage the good governance of coastal and marine affairs. The index system consists of six first-level indicators and 15 second-level indicators. The first-level indicators include: (1) Marine economic development, weighted at 10/100; (2) Optimization of spatial pattern of sea area use, weighted at 15/100; (3) Efficiency of marine resources utilization, weighted at 25/100; (4) Performance of marine pollution treatment and environmental protection, weighted at 25/100; (5) Popularization of marine culture and awareness, weighted at 10/100; and (6) Marine governance system and policy, weighted at 15/100. This index system was used to assess the ecological civilization performance of marine construction in the coastal western waters of the Yellow Sea for seven coastal cities in Shandong province, China.

15:20 (S8-HD-P-12012)**Features of media-covering and promotion of marine and fishery researches in Russia**Konstantin OsipovPacific Research Institute of Fisheries and Oceanography (TINRO-Center), Vladivostok, Russia
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Fisheries are an important element of social life and economic activity in Far Eastern Russia. Publications and releases in official, commercial, and scientific media contribute to public perceptions of the condition of fisheries. However, to date, the role and contributions of science to the development and management of fisheries in Far Eastern Russia have not been clearly represented to the public. Indeed, inaccurate representations, in mass media, of science's role in fishery's development, have led to underestimation and disregard of science-based social and research programs in Russia's Far East. Articles and broadcasts in local media, including some based on interviews with local government officials, often understate the importance of complex research undertaken by marine science organizations. Effectively engaging local media and government officials in the popularization of marine science will foster the development of a positive image of and public support for Russian marine science and greater acceptance of the validity of science-based management of marine resources. This study describes some of the challenges to be overcome in creating greater awareness of the need for and quality of marine and fishery research in Russia's Far East region. Suggestions for improving engagement with media and government officials to highlight the role of science in support of the social and economic development of coastal regions in Russia are presented.

16:00 (S8-HD-P-12308)**Groundtruthing social vulnerability indices of Alaska fishing communities**Anna N. Santos¹, Kim Sparks¹, Stephen Kasperski² and Amber Himes-Cornell³¹ Pacific States Marine Fisheries Commission, 205 SE Spokane Street, Suite 100, Portland, Oregon 97202, USA.² Alaska Fisheries Science Center, NOAA National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle Washington 98115, U.S.A. stephen.kasperski@noaa.gov³ Université de Bretagne Occidentale, AMURE/LABEX/IUEM, 12 rue de Kergoat - CS 93837, 29238 BREST Cedex 3, France
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Community vulnerability and well-being is increasingly evaluated through quantitative social indices. Given that such indices are typically developed using secondary data sources rather than primary data collection, it is necessary to understand their validity if they will be used to inform policy and decision-making. This paper presents a groundtruthing exercise of quantitative indices that characterize the well-being of Alaska fishing communities as a step in validation. We utilized ethnographic data collected from 13 communities and a capital assets framework to groundtruth the indices, in which qualitative ranks of vulnerability were compared against quantitative indices. The majority (71.5%) of ranks were in complete or moderate agreement, and the results indicate that most of the indices are reliable, yet some indices could be modified to better reflect realities in Alaska. Indices of commercial fishery engagement and reliance appeared to be more reliable than socio-economic indicators, particularly for smaller fishing communities. For smaller communities, the indices did not appear to accurately reflect community vulnerability or secondary data was lacking. Utilization of the capital assets framework also confirmed the indices do not capture social, political, or ecological factors that affect levels of community vulnerability. Cost of living, lack of employment opportunities, reliance on subsistence resources, loss of fishery permits, and outmigration are central concerns across fishing communities of Alaska affecting their well-being. We conclude that quantitative indices are useful rapid assessment tools; however, they should be validated, and complimented with ethnographic data to increase their effectiveness as policymaking and management tools.

16:20 (S8-HD-P-12112)

The economic importance of wild Pacific salmon

Keith R. Criddle

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This presentation explores the economic role of Pacific salmon (*Oncorhynchus* spp.) in Alaska, including an overview of the development and evolution of commercial fisheries, their diminished but locally important role as a subsistence good and basis for barter, their increasingly important value in sport fisheries and as a source of other non-monetary benefits, their social and cultural roles of salmon and salmon fisheries, and the regional economic impact of salmon fisheries. The economic and social effects of evolving systems for governing and managing salmon catches are discussed because those systems vary through time and greatly affect the magnitude and distribution of economic value. Interdependencies between aquaculture and the capture fisheries are also discussed to highlight their influence on exvessel prices through their impact on global markets and on the social and institutional structure of the fisheries for Pacific salmon.

16:40 (S8-HD-P-12113)

Retrospective benefit-cost analysis of federally-funded buyback programs for Southeast Alaska salmon purse seine permits

Keith R. Criddle¹ and Jennifer Shriver²

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In 1975, 419 perpetual transferable limited entry permits (LEPs) were issued for the Southeast Alaska salmon purse seine fishery. Beginning in the 1990s, ever increasing global supplies of farmed salmon precipitated a collapse in exvessel prices for wild salmon and concomitant declines in exvessel revenues and permit values such that by the early 2000s, exvessel prices and the value of LEPs hovered at around 20% of their peak values. In response, fishermen lobbied for a buyback program to permanently retire some permits. The first phase of the buyback program was financed under a federal grant and led to the retirement, in 2008, of 35 permits. The second phase was financed under a federally backed fishery reduction loan that led, in 2012, to the retirement of 65 additional permits. It was anticipated that these reductions in the supply of LEPs would bolster average revenues for remaining vessels and increase the market value of remaining permits. This benefit-cost analysis assesses whether the increased value to remaining permittees offsets the cost to taxpayers of financing the buyback. Doing so necessitates disentangling concomitant but unrelated changes in exvessel prices and catch volumes. Multivariate statistical analysis indicates that the buybacks increased the asset value of LEPs and forestalled the reentry of latent fishing capacity. However, because the buybacks do not alter the fundamental conditions that predispose the dissipation of rents, relief accorded by the buyback is likely to be ephemeral.

S9: POC Topic Session**Meso-/submeso-scale processes and their role in marine ecosystems****September 28****10:55 (S9-12000) Invited****Lagrangian maps as a new tool to simulate transport processes in the ocean**Sergey V. Prants, M.Yu. Uleysky and M.V. BudyanskyPacific Oceanological Institute, Russian Academy of Sciences, Vladivostok, Russia
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Lagrangian methods are now actively used in simulation of large-scale transport and mixing in the ocean due to tremendous progress in satellite monitoring and in advanced technology of satellite-tracked buoys and drifters providing continuous, near real-time and global data at high space resolution. Combination of that data with outputs of high-resolution global and regional numerical models of ocean circulation and ideas and methods from dynamical systems and chaos theory enables to simulate and analyze transport and mixing in the ocean at sub- and mesoscale. We develop a methodology for computing and analyzing different kinds of Lagrangian maps for a large number of synthetic tracers advected by altimetry-derived and numerically-generated velocity fields. A number of examples demonstrates the effectiveness of that tool to analyze evolution of mesoscale eddies, to estimate a risk of contamination of specified eddies by Fukushima-derived radionuclides and to identify Lagrangian fronts favorable for fishing in the Asian marginal seas and the North Western Pacific. An extensive review of these methods with applications can be found in the new coming book “Lagrangian oceanography: large-scale transport and mixing in the ocean. Berlin, New York. Springer Verlag, 2017” by S.V. Prants, M.Yu. Uleysky and M.V. Budyansky.

11:20 (S9-12300) Invited**Characteristics of meso- and submeso-scale features used by highly migratory marine predators**Robert M. Suryan¹, Rachael A. Orben², Stephanie A. Loredó², Jessica M. Porquez²¹ Department of Fisheries and Wildlife, Oregon State University, Auke Bay Laboratories, Ted Stevens Marine Research Institute, Juneau, AK, USA. E-mail: rob.suryan@oregonstate.edu² Department of Fisheries and Wildlife, Oregon State University, Newport, OR, USA

Highly migratory marine species like seabirds transit within large marine ecosystems and across entire ocean basins to locate important foraging areas. Individual-based, Lagrangian tracking studies have demonstrated the use of hierarchical search patterns to locate meso- and submeso- scale oceanographic features where concentrated foraging occurs. Integrating individual-based movement with satellite oceanographic data identifies important near surface, horizontal characteristics of targeted features. Complimentary, vessel-based, Eulerian observations provide a broader predator community perspective and identify horizontal and vertical water column processes of features targeted by multiple predators. We use a combination of satellite-based remote observations and *in-situ* sampling to describe characteristics of meso- and submeso-scale features targeted by seabirds throughout the North Pacific Ocean. Features targeted included offshore eddies, shelf-break fronts, water mass convergences, and estuary plumes, with use varying in space and time. Spatio-temporal persistence (i.e., predictability) was a consistent characteristic among features, while chlorophyll concentration, gradients and other characteristics were more variable and feature- or species-specific. Characteristics of meso- and submeso-scale features used by highly migratory, predatory species provide important insight into physical and biogeochemical processes that enhance tropic transfer of energy to upper trophic levels. Such mechanistic understandings of energy transfer are key to informing ecosystem models and factors influencing ecosystem change.

11:45 (S9-12159)

Roles of the ocean mesoscale in the lateral supply of mass, heat, carbon and nutrients to the Northern Hemisphere subtropical gyres

Ayako **Yamamoto**¹, Jaime B. Palter², Carolina O. Dufour³, Stephen M. Griffies⁴, Daniele Bianchi⁵, Mariona Claret⁶, John P. Dunne⁴, Ivy Frenger⁷ and Eric D. Galbraith⁸

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Lateral transport at the boundaries of the subtropical gyres plays a crucial role in providing nutrients that fuel gyre primary productivity, heat that helps restratify the surface mixed layer, and dissolved inorganic carbon (DIC) that influences air-sea carbon exchange. Mesoscale eddies are hypothesized to be an important component of these lateral transports; however, previous studies have not explicitly quantified the role played by these eddies for the respective subtropical budget. Here, we quantitatively assess the physical mechanisms that control the transport of mass, heat, nutrients and carbon across the North Pacific and North Atlantic subtropical gyre boundaries using the eddy-rich ocean component of a climate model (GFDL's CM2.6) coupled to a simple biogeochemical model (mini-BLING).

Our results suggest that lateral transport across the subtropical gyre boundaries supplies a substantial amount of mass and tracers to the ventilated layer of both Northern Hemisphere subtropical gyres, with Kuroshio and Gulf Stream acting as main exchange gateways. Mass, heat, and DIC supply is mainly driven by the time-mean circulation, while mesoscale eddies oppose the mean, removing mass, heat and DIC from the gyres. Nutrient transport differs markedly from the other tracers, as nutrients are principally supplied to both subtropical gyres by mesoscale eddies, owing to the large down-gradient eddy transport of nutrients into the subtropical gyres. The lateral nutrient supply, combining the roles of both mean and eddy components, provides more than three quarters of the total nutrient supply into the subtropical gyres, surpassing a recent estimate based on a coarse resolution model.

12:05 (S9-11993)

The mesoscale eddy activity in the Alaskan Stream area and its impact on biological productivity

Andrey G. **Andreev**, Sergey V. Prants, Maxim V. Budyansky and Michael Yu. Uleysky

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We demonstrate the transport pathways of the Alaskan Stream water in the eastern subarctic Pacific and the eastern Bering Sea with the help of altimetry-based Lagrangian maps from October~1, 1994 to September~12, 2016. A mesoscale eddy activity along the shelf-deep basin boundaries in the Alaskan Stream region and the eastern Bering Sea is shown to be related with the wind stress curl in the northern North Pacific in winter. A significant correlation is found between the concentration of chlorophyll a in the Alaskan Stream area and eastern Bering Sea in August–September and the wind stress curl in the northern North Pacific in November–March. The mesoscale dynamics, forced by wind stress curl in winter, may determine not only lower-trophic-level organism biomass but also salmon abundance/catch in the study area.

14:00 (S9-12003)

The submesoscale vertical pump of an anticyclonic eddyAnnalisa **Bracco**¹, Yisen Zhong², Jiwei Tian³, Jihai Dong⁴, Wei Zhao³ and Zhiwei Zhang³¹ Georgia Institute of Technology, Atlanta, 30306 GA, USA
E-mail: abracco@gatech.edu² Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, PR China³ Ocean University of China, Qingdao 266100, PR China⁴ Nanjing University of Information Science and Technology, Nanjing, 210044, PR China

Oceanic mesoscale eddies with typical sizes of 30–200 km contain more than half of the kinetic energy of the ocean. They have an average lifespan of several months and are major contributors to the transport of heat, nutrients, plankton, dissolved oxygen and carbon in the ocean. Mesoscale eddies have been observed and studied over the past 50 years, nonetheless our understanding of the details of their structure remains incomplete due to lack of systematic high-resolution measurements. To bridge this gap, a survey of a mesoscale anticyclone was conducted in early 2014 in the South China Sea capturing its structure at submesoscale resolution. By modeling an anticyclone of comparable size and position at three horizontal resolutions (1, 5 and 10 km) the resolution requirements for capturing the observed variability in dynamical quantities are verified. The role of ageostrophic motions on the vertical transport associated with the anticyclone is then assessed. Results indicate that different submesoscale processes contribute to the vertical transport depending on depth and distance from the eddy center, with frontogenesis playing a key role. Vertical transport by anticyclones cannot be reliably estimated by coarse-resolution or even mesoscale-resolving models, with important implications for global estimates of the eddy-driven vertical pumping of biophysical and chemical tracers.

14:20 (S9-12171)

The observed slope current of the Northern Slope of South China SeaDongfeng **Xu**^{1,2}, Chenghao Yang^{1,2}, Jun Wang^{1,2}, Mingquan Xu^{1,2}, Hong Chen^{1,2} and Yaochu Yuan^{1,2}¹ State Key Laboratory of Satellite Ocean Environment Dynamics, Hangzhou, PR China
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The current along the Northern Slope of South China Sea (SNSCS) is not clear for the shortage of long-term mooring observation, especially for the summer season. Based on the mooring station (ST1: April 2014 to April 2015, deployed in the SNSCS, West of SanYa, Hainan 111.7°E, 18.4°N, water depth: 1000m) results, a steady southwestward current exists in all month of in the whole year at the depth of 150m~380m with the annual velocity of about 15cm/s. Northwestward flow exists in the upper water of 150m and deep water (deeper than 500m) from June till July (with a strong baroclinic effect of a three-layer current structure). The effect of super Typhoon (RAMMASUN July 18 2014) can reach till the depth of 300m observed from the velocity vector. For the mooring station (ST2: May 2015 to March 2017, deployed at 114.5°E, 19.5°N, water depth: 1200m) the results show a more the barotropic effect compared with STA1. In summer, the slope current in STA2 flows northeastward and intensified in the deep water differs from that in STA1. The slope current shows a low-frequent variability at about 100 days period. Mesoscale eddies have large effect on the cross-shelf exchange when they encounter the slope. An example of eddy-pair influence shows a strong cross-shelf exchange in June of 2015.

14:40 (S9-11986)

The interaction of the mesoscale and submesoscale eddies in the Sea of Okhotsk

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Multisatellite data are used to study the interaction between the mesoscale and submesoscale eddies in the deep Kuril Basin of the Sea of Okhotsk. Analysis of long-term series of satellite altimetry observations demonstrate that the circulation in the Kuril Basin is determined by quasi-stationary mesoscale anticyclonic eddies. The anticyclonic circulation can be generated by the negative wind stress curl during warm season (June – September). The satellite images reveals that submesoscale processes (small-scale eddies and streamers) is determine the interaction of mesoscale eddy with the waters of the tidal mixing region around of the central Kuril Islands. Submesoscale cyclonic eddies are formed at the Kuril tidal mixing fronts and near the Bussol Strait. By applying the Lagrangian analysis based on satellite altimetry data, we demonstrate that submesoscale eddies move on the periphery of the mesoscale eddy within the advective streamer and it's bounded by transport barriers. Formation and destruction of the submesoscale eddies caused by the horizontal stirring leads to injection of cold and nutrients rich water from the Kuril Islands area in the deep Kuril Basin. During summer the interaction submesoscale and mesoscale eddies support the high concentration of the chlorophyll- a in the upper layer of the north-eastern part of the Sea of Okhotsk.

15:00 (S9-12024)

Mesoscale eddies and eddy energy sources in the Okhotsk Sea during the winter-spring period, 2005-2009

Dmitry V. Stepanov¹ and Vladimir Fomin²

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Based on an eddy-permitting ocean circulation model, the eddy kinetic energy (EKE) sources are studied in the upper 200 m in the Sea of Okhotsk. An analysis of spatial distribution of the EKE

showed that high-energy mesoscale variability occurs on the western boundary of the Sea of Okhotsk, where the East-Sakhalin Current extends. It was found the pronounced seasonally varying EKE with maximal magnitudes, amounting to 3.5×10^3 J/m² in winter, and minimal magnitudes, amounting to about 0.3×10^3 J/m² in summer. An analysis of the EKE sources and the energy conversions showed that time-varying (turbulent) wind stress is a major contribution to mesoscale variability on the western boundary of the Sea of Okhotsk. The contribution of baroclinic instability to the generation of mesoscale variability on the western boundary of the Sea of Okhotsk predominates over that of barotropic instability. To demonstrate the mechanism of baroclinic instability, it was considered the circulation on the western boundary of the Sea of Okhotsk from January to April 2005. An analysis of hydrological conditions showed that isopycnals tilt toward the sea surface and the strong vertical shear of the along-shore velocity occurs from January to May 2005. In April, the mesoscale eddies are observed on the western boundary of the Sea of Okhotsk. It was established that the seasonal variability of time-varying (turbulent) wind stress and the baroclinic instability of the East-Sakhalin Current are major reasons of mesoscale variability on the western boundary of the Sea of Okhotsk.

15:20 (S9-12197)

On the nature of wind-forced upwelling in Barrow CanyonMaria N. **Pisareva**¹, Robert S. Pickart², Paula S. Fratantoni^{2,4} and Thomas J. Weingartner³¹ P.P. Shirshov Institute of Oceanology RAS, Moscow, Russia
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The Pacific-origin water that flows northward through Bering Strait influences the interior Arctic Ocean. It carries large amounts of freshwater and heat and is also a significant source of nutrients, phytoplankton and zooplankton to the region. During summer months a significant fraction of the transport of Pacific water exits the Chukchi Sea through Barrow Canyon. This canyon is known to be a biological “hotspot” due to its elevated nutrient concentrations, enhanced productivity rates, and high benthic biomass. As such, investigation of Barrow Canyon (which is included into the DBO program) is crucial for improving our understanding of this important regional ecosystem.

The focus of the current research is the mesoscale process in the Barrow Canyon – upwelling. Using timeseries from a mooring deployed from 2002-4 near the head of Barrow Canyon, together with atmospheric and sea ice data, we have identified 25 upwelling events, occurring when both the Beaufort High and the Aleutian Low are strong. During the warm season most of the events brought Winter water to the head of the canyon, while upwelling of Atlantic water occurred during the cold season. Although two of the strongest events were associated with particularly strong forcing – both of which brought Atlantic water to the head of the canyon – there was no statistical correlation between the strength of the atmospheric forcing and the magnitude of the upwelling. This appears to be related to the ice cover in that the strongest upwelling events occurred for partial ice cover.

16:00 (S9-12123)

Submesoscale eddies in Peter the Great Bay of the East/Japan SeaAlexander Ostrovskii¹, Pavel **Fayman**², Vyacheslav Lobanov³ and Young-Gyu Park⁴¹ P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia² Far Eastern Regional Hydrometeorological Research Institute, Vladivostok, Russia. E-mail: Pavel.Fayman@gmail.com³ V.I. Ilyichov Pacific Oceanological Institute, Russian Academy of Sciences, Vladivostok, Russia⁴ Korea Institute of Ocean Science and Technology, Ansan, R Korea

Submesoscale cold-core ($T < 0^{\circ}\text{C}$) eddies were observed near the shelf break in Peter the Great Bay (PGB) of the East/Japan Sea in February-March 2010. The CTD observations were carried out at the mooring station employing the profiler Aqualog, the CTD sensor suites in the near-bottom and near-surface layers respectively. Additionally we used the satellite-born imagery and scatterometry. The analysis suggested the cold-core submesoscale eddies supply the densest water ($\sigma_{\theta} > 27.24 \text{ kg/m}^3$) to the shelf break zone where it may cascade downward into the deep northern basin. The observed densest water was richer in suspended particles and oxygen by 0.4 ml/l than the surrounding water.

To study the origin of the submesoscale cold-core eddies we used the Regional Ocean Modeling System (ROMS). The model simulated two branches of Primorye Current (PC) over the continental slope and in the shelf zone in the cold season of 2010. It appeared that the moored profiler Aqualog was located near the second branch of PC. In Ussuri Bay (UB), the anticyclonic gyre of 10 - 30 km in diameter was developed in the model. At the gyre periphery, the submesoscale cyclones were often generated. The eddy lifetime varied from 2 to 10 days and their diameter could reach 10 km. The eddies moved southward towards the isobath 60 m, then westward with average speed of about 5 cm/s. The model confirmed that the submesoscale cyclonic eddies can transport the coldest water in the near-bottom layer from UB towards the open sea.

16:20 (S9-12119)

Variations of the turbulent eddy diffusivity in the Primorye Current region of the northwestern East/Japan Sea in the warm seasonAlexander Shatravin¹, Alexander **Ostrovskii**¹, Vyacheslav Lobanov² and Jae-Hun Park³¹ P.P. Shirshov Institute of Oceanology, Moscow, Russia

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Small-scale mixing is a mechanism of crucial importance for both ocean circulation and biological processes. Estimation of mixing efficiency demands high resolution measurements. Yet, available datasets remain sparse despite great interest by the scientific community and progress in instrumentation. Here we present estimates of the turbulent kinetic energy dissipation rate and the diapycnal turbulent eddy diffusivity of mass in the northwestern East/Japan Sea obtained on the basis of observational survey by using the moored profiler Aqualog in April-October 2015. The profiler was equipped with a CTD probe and an acoustic Doppler current meter and delivered vertical profiles of temperature, salinity and current velocity 8 times per day with vertical resolution of approximately 1 meter. The estimates of the diapycnal turbulent eddy diffusivity of mass are based on Polzin's finescale parameterization approach and Mixing Oceanographic Toolbox. Spatial and temporal inhomogeneities of thermohaline and hydrodynamic conditions caused by meanders of the strong longshore currents and numerous eddies of various spatial scales are characteristic for the research region. During the period of deployment the diffusion coefficients varied by several orders of magnitude. We investigate the depth-time variability of obtained estimates of mixing parameters and analyze the relation between the initial and intermediate variables during periods of enhanced or decreased mixing, which allows for better understanding of physical mechanisms governing strong fluctuations of mixing coefficients. We also analyze remote sensing data in order to relate observed fluctuations of mixing parameters to ocean mesoscale and sub-mesoscale processes.

16:40 (S9-12041)

Short-term variability of the thermohaline stratification under the seasonal pycnocline in the Primorye Current zone in the Japan/East SeaOlga **Trusenkova**¹, Alexander Ostrovskii², Alexander Lazaryuk¹, Vyacheslav Lobanov¹, Dmitry Kaplunenko¹ and Svetlana Ladychenko¹¹ V.I. Il'ichev Pacific Oceanological Institute, Vladivostok, Russia

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The Primorye (Liman) Current is the cold coastal jet near northwestern boundary of the Japan/East Sea. While flowing southwestward, the current develops instabilities and meanders. As the flow intensifies, it becomes progressively more unstable and sheds vortices, which move southwestward along the continental slope. The current meanders and eddies as well as the propagating coastal waves result in strong vertical displacements of isopycnals. To determine magnitude and time scales of the thermohaline stratification variations we deployed the moored Aqualog profiler at 42.5°N, 133.8°E at the depth of 440 m at the continental slope during the warm season from April 18 through October 15, 2015. Every day during the survey, 8 vertical profiles of temperature and salinity were obtained below the seasonal pycnocline in the layer between 64 and 260 m where the sigma-t was in the range of 26.9 and 27.3. The temporal variation of the depth of the 27.15 sigma-t isopycnal was analyzed by using Hilbert-Huang transform. Five Intrinsic Mode Functions (IMF) were derived as follows. IMF 1 represented high-frequency observational noise. IMFs 2 and 3 showed fluctuations at the scales of 2-3.5 and 8-13 days, respectively, that were linked to travel times of submesoscale and mesoscale dynamic structures above the mooring. IMF 4 accounted for the signal of approximately 20-day period. IMF 5 and residual term together indicated the deepening of pycnocline from June through mid-August and shallowing during the next month. This study was supported by the Russian Foundation for Basic Research grant No. 16-05-00899.

17:00 (S9-12263)

Transportation route and habitat of Japanese eel (*Anguilla Japonica*) larvae in association with mesoscale eddy area

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Japanese eel, *Anguilla Japonica*, is known to have a spawning ground near the West Mariana Ridge in the northern part of the North Equatorial Current (NEC). The hatched larvae had been thought to be transported to the western boundary of the North Pacific Ocean by the NEC, and then to the coastal areas of East Asia while being transported northward by the Kuroshio. However, the larvae are often caught in the inner subtropical gyre of the North Pacific Ocean in recent surveys conducted by the Japan Fisheries Research and Education Agency (FRA), indicating that the steady current such as the NEC is not the only path of Japanese eel larval transportation. This observation agrees with our result of numerical particle tracking experiment showing a route towards the Kuroshio via the inner region of subtropical gyre by deviating from the transport route along the NEC. The larvae tended to be caught near the edge of cyclonic mesoscale eddies in inner region of subtropical gyre. Our high resolution hydrographic observation indicated a relatively high dissolved oxygen content at sub-surface layer along the rim of the cyclonic eddy, where many larvae were caught. These data suggest that the history of local environmental changes due to eddy activities have influence on the survival of Japanese eel larvae which are transported in the inner region of the subtropical gyre.

17:20 (S9-12297)

Mesoscale processes influence on migrations and the fishing grounds formation of saury, sardine and mackerel in the Northwest Pacific

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We analyzed the impact of mesoscale processes on migrations and the fishing grounds formation of saury (*Cololabis saira*), sardine (*Sardinops melanostictus*), and mackerel (*Scomber japonicus*) in the Northwest Pacific. Mesoscale variability in this highly dynamic region is characterized by strong seasonality and interactions with larger scales. Positions and configurations of mesoscale and large-scale fronts determine the feeding migration patterns of these epipelagic fishes in the food-rich subarctic waters in June and southern migrations in autumn. Large anticyclonic eddies located east off Hokkaido Island are very important for fisheries. Occurrence and dynamics of the eddies and related fronts affects not only the fishing grounds formation of the fisheries species, but also on the size-age composition. Besides, last year successful fishing was realized near the boundary of the anticyclonic eddy located east off Bussol Strait. Disintegration of saury and mackerel concentrations under dissipating mesoscale inhomogeneities occurs earlier in comparison with sardines aggregations due to the different feeding behavior. In this study, the problems of mesoscale inhomogeneities monitoring and forecasting for sustainable fisheries management are discussed, too. Serious difficulties are limited oceanographic profiling and biological sampling during the fishing season. Nevertheless, modern scientific information system for the support of fisheries expedition provided by TINRO-Center is useful for fisherman, managers of fisheries organizations and scientists.

17:40 (S9-12150)

Enhanced biological productivity in a warm core ring

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A warm core ring 2015C originally spun off from the Kuroshio Extension in the summer of 2014 migrated to northwest toward the east-coast Japan and then spent about a year at off the Sanriku-coast in the Oyashio-Kuroshio transition zone until its extinction in early 2016. We conducted cross-sectional observations of the 2015C by using an underwater glider (SeaGlider) and the R/V Wakataka-maru (692t) in May, July and September of 2015. The eddy structure observed in May was distinctive of an anticyclonic eddy with depressed density interfaces at the eddy center. On the other hand, the same eddy observed in July and September had a lens shaped structure with a deep main pycnocline and a shallow seasonal pycnocline (i.e., a mode-water eddy type structure). With the shoaling of the seasonal pycnocline, the nutricline was also shoaled in the eddy center. Significantly high Chlorophyll-a concentrations (July: 6.4 mg/m³, September: 2.9 mg/m³) were also observed at the subsurface chlorophyll maximum in the center of 2015C. Since the shoaling of the seasonal pycnocline was not observed in May but in July; the wind driven upwelling near the eddy center caused by strong wind events may be responsible for the density structure change and the following extraordinary summer phytoplankton bloom in the center of 2015C.

S10: FUTURE Topic Session**Emerging issues in understanding, forecasting and communicating climate impacts on North Pacific marine ecosystems****September 27****09:05 (S10-12255) Invited****Biogeochemical carbon cycling of Bering Sea and their impacts on the Western Arctic Ocean in the past two decades**Zhongyong **Gao**¹, Liqi Chen¹, Min Chen², Heng Sun¹, Jinlu Tong², Qi Li², Longshan Lin¹ and Di Qi¹¹ Third Institute of Oceanography, SOA, Xiamen, 361005, PR China

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Biogeochemical carbon cycling of the Bering Sea and the Western Arctic Ocean (WAO) were integrated from the first (1999) to the seventh (2016) summer cruises of the Chinese National Arctic research Expedition (CHINARE). Parameters of biogeochemical carbon cycling, including CO₂ system parameters, (*p*CO₂, pH, dissolved inorganic carbon, total alkalinity, calcium) and their related physical and chemical parameters, were measured. Water masses and their transport from the Bering Sea to the WAO were traced by isotopes such as δD, δ¹⁸O, ²²⁶Ra, ²²⁸Ra, etc. The distribution of freshwater components in the Bering Sea and WAO were clarified. With the exception of a part of the southeast Bering Shelf, the Bering Sea could be divided into the Bering Shelf Region (BS), Bering Slope Current Region (BSC), Northern Bering Basin Region (NBB) and Southern Bering Basin Region (SBB) based on their biogeochemical characteristics. Interannual and Decadal of variations of Bering Sea waters and their impacts on the WAO by the Bering throughflow were revealed. Some fish species revealed a northward shift in distribution during the past two decades, and primary production was enhanced by the nutrient supply and accompanied by strong carbon uptake in the Chukchi Sea. Meanwhile, the surface and subsurface waters were acidified within the context of large-scale water mass exchange and local physical and biogeochemical processes from the northern North Pacific to the Western Arctic Ocean.

09:35 (S10-12232) Invited**Climate predictions to support fisheries management in a changing ocean**Desiree **Tommasi**

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Variability in ocean conditions is known to shift the distribution and productivity of marine fish and invertebrate species. These changes have implications for fishing communities, the fishing industry, and fisheries management, with a range of management decisions, from time-area closures to annual catch limits, being affected. Despite progress in our understanding of climate impacts on marine ecosystems, environmental information is still rarely integrated into fisheries management decision. This has in part been limited by the absence of climate information at the temporal and spatial scales at which fisheries operate and are managed. Recent improvements in forecasting capability of global dynamical climate prediction systems at the seasonal to multi-annual scale, however, raise prospects for improved utility of these tools to support fisheries management in a changing ocean. Here, we present an overview of advances in seasonal to multi-annual prediction of fisheries relevant environmental variables and highlight, using a range of case studies, their value to fisheries management decisions. Challenges and priority developments are also discussed.

10:05 (S10-12120)**Seasonal forecast skill in the CCS and its connection to climate variability**

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The California Current System (CCS) is a biologically productive Eastern Boundary Upwelling System that experiences considerable environmental variability on seasonal and interannual timescales. Given that this variability drives changes in ecologically and economically important living marine resources, predictive skill for regional oceanographic conditions is highly desirable. Here, we assess the skill of seasonal sea surface temperature (SST) forecasts in the CCS using output from multiple Global Climate Forecast Systems, and describe mechanisms that underlie SST predictability. A simple persistence forecast generates considerable skill at short lead times, while skill above persistence derives primarily from predictable evolution of ENSO-related variability. Specifically, during ENSO events climate forecast systems can skillfully predict anomalous alongshore winds, which drive upwelling anomalies and consequently temperature anomalies. This mechanism prevails during moderate to strong ENSO events, while years of ENSO-neutral conditions are not associated with significant skill above persistence for SST forecasts. We find also a strong latitudinal gradient in predictability within the CCS; SST forecast skill is highest off the Washington/Oregon coast and lowest off southern California, consistent with variable wind forcing being the dominant driver of SST predictability. These findings highlight mechanisms that underlie forecast skill as well as sources of limitation in forecast skill. We will also discuss implications for regional downscaling of seasonal forecasts and for short-term management of living marine resources.

10:50 (S10-12210)**The pelagic plankton and demersal fish communities of Pacific Canada over the past four decades: Ecosystem variability or change?**

R. Ian **Perry**¹, Moira Galbraith², Ken Fong¹, Brenda Waddell¹, Roy Hourston² and Richard Thomson²

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Over the past 40 years, Pacific Canadian marine ecosystems have experienced regime shifts, ENSO events, and marine heat waves. There have also been severe reductions of iconic fish populations and fish catches, with at times significant impacts to marine-dependent coastal communities. Large-scale models project future changes in the species compositions of this area, leading to declines of cool-water and increases of warm-water taxa, with the potential for further disruption but also opportunities for the provision of ecosystem services to people. In this presentation, we use observational data collected off the south-west coast of Vancouver Island, Canada, over the past four decades to identify the short and long-term trends of demersal fish, and pelagic plankton, populations in this area. We ask specifically whether, to date, these are more indicative of variability or of directional trends, and if periods of good, or poor, productivity (biomass accumulation) can be identified. We compare these results from the biological observations with physical variables to understand potential natural system drivers of these patterns. Although this is a heavily exploited marine ecosystem, its overall variability is driven foremost by physical conditions, which puts constraints on the options for management actions to influence changes in this fishery system.

11:10 (S10-12088)

Biotic and abiotic impacts on walleye pollock (*Gadus chalcogrammus*) population off the east coast of Korea over the last 5 decadesMoojin **Kim**¹, Sukyung Kang² and Suam Kim¹¹ Pukyong National University, Busan, R Korea
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We examined the relationship between walleye pollock population and their surrounding environment off the east coast of the Korean Peninsula. Walleye pollock abundance was estimated using cohort analysis. Catch statistics with the abundance at age-2 and age-3 were compared with other ecological parameters, and tested for statistical significance. The Cross-Correlation Function analysis showed that there was a significant positive correlation between juvenile walleye pollock catch and zooplankton biomass in June with a time lag of 3 years ($r=0.549$, $p<0.05$). Furthermore, there were positive correlations between juvenile pollock catch and seawater temperature at 10 m and 20 m in December with a time lag of 3 years ($r = 0.515, 0.507$, $p<0.05$), and with seawater temperature at 50 m and 75 m in December with a time lag of 2 years ($r = 0.659, 0.592$, $p<0.05$). Age-2 abundance was positively correlated with 75 m temperature in April with a time lag of 2 years ($r = 0.671$, $p<0.05$). These results imply that biotic as well as abiotic environmental factors during the early life stages of pollock have a significant influence on variability in walleye pollock recruitment. Furthermore, assuming the first maturity at 25 cm and 50% maturity at 37 cm, the Proportional Size Distribution (PSD) ranged between 30 and 70 in Period 2, which means that recruitment variability is stable during this period. The PSD values also showed the opposite with age-2 and age-3 abundance of walleye pollock.

11:30 (S10-12212)

The FUTURE Science Program: Highlights and next stepsSteven **Bograd**¹, Sukyung Kang² and FUTURE SSC¹ NOAA Southwest Fisheries Science, Center, Monterey, CA, USA. E-mail: steven.bograd@noaa.gov² Fisheries Resources Management Division, National Institute of Fisheries Science, Busan, R Korea. E-mail: sukyungkang@korea.kr

‘Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems’ (FUTURE) is an integrative Scientific Program undertaken by the member nations and affiliates of PICES to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders and the public. Since its inception in 2009, the FUTURE program has contributed significantly to advancing our understanding of how marine ecosystems respond to natural and anthropogenic forcing and how marine ecosystems will change in the future, although challenges remain. Here we provide an overview of the FUTURE program, highlighting recent research advances, identifying critical gaps in our understanding, and providing an assessment of the Program’s capacity to forecast climate-driven marine ecosystem changes. Advances in the understanding of climate impacts on marine ecosystems, and a broad dissemination of this information, is essential for preserving a healthy and sustainable North Pacific for FUTURE generations.

S11: FIS/POC Session**Environmental variability in Arctic and Subarctic ecosystems and impacts on fishery management strategies****September 28****11:00 (S11-12195)****Large zooplankton abundance as an indicator of walleye pollock recruitment in the southeastern Bering Sea**Lisa B. **Eisner**¹, Ellen Yasumiishi² and Alex Andrews²¹ NOAA, Alaska Fisheries Science Center, Seattle, WA, USA
E-mail: lisa.eisner@noaa.gov² NOAA, Alaska Fisheries Science Center, Juneau, AK, USA

Interannual variations in large zooplankton abundance (sum of the most abundant large taxa, typically important in age-0 pollock diets) were compared to age-1 and age-3 walleye pollock (*Gadus chalcogrammus*) abundance for year classes 2002-2012 and 2014 on the southeastern Bering Sea shelf. Data were collected on BASIS fishery oceanography surveys during mid-August to late September for warm (low sea ice) and cold (high sea ice) climate stanzas. A positive significant linear relationship was found between mean abundance of large zooplankton during the age-0 stage of pollock and estimated abundance of age-1 and age-3 pollock. Increases in sea ice extent and duration were associated with increases in large zooplankton abundances, increases in large copepods and euphausiids in pollock diets, and increases in age-0 pollock lipid content. Our results suggest that increases in the availability of large zooplankton prey during the first year at sea were favorable for age-0 pollock overwinter survival to age-1 and recruitment into the fishery at age-3. If the relationship between large zooplankton and age-1 (age-3) pollock remains significant, the index may be used to predict future recruitment success of pollock one (age-1) to three (age-3) years in advance. This provides support for the revised oscillating control hypothesis that suggests as the climate warms, reductions in sea ice (and reduced availability of ice-associated algae, an early spring food source) could be detrimental to large crustacean zooplankton and subsequently to the pollock fishery in this region.

11:20 (S11-12245)**Assessing biodiversity patterns of fish resources in the Eastern Bering Sea**Irene D. Alabia¹, Jorge Garcia Molinos¹, Sei-Ichi **Saitoh**¹, Takafumi Hirata², Toru Hirawake³ and Franz J. Mueter⁴¹ Arctic Research Center, Hokkaido University, Sapporo, Japan
E-mail: irenealabia@arc.hokudai.ac.jp² Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan³ Faculty of Environmental Science, Hokkaido University, Sapporo, Japan⁴ University of Alaska Fairbank, Juneau, AK, USA

One of the important aspect of community ecology is describing the spatio-temporal patterns in biodiversity, as these in turn, affect the capacity of the system to respond to environmental changes. Here, we explored the beta-diversity of fish and invertebrate assemblages in the Eastern Bering Sea from June-July, 1993-2016. Beta-diversity index was computed using the outputs from the ensemble habitat models generated for each taxa. The ensemble habitat models were constructed using species occurrence data from the NOAA summer bottom trawl surveys and pertinent set of environmental factors (depth, winter sea surface temperature, and winter sea ice concentration). From this analysis, we subsequently examined the spatial beta-diversity patterns to identify areas in the Eastern Bering Sea that exhibit substantial variation in species identities. High beta-diversity suggests considerable heterogeneity in communities and likely reflects habitat heterogeneity as well. This has important implications on setting up fishery management and conservation priority, as regions of heterogeneous habitat could host a variety of species and can also represent essential biogeographic transitions.

11:40 (S11-12047)

Changes in recruitment of Pacific cod in the northwestern Bering Sea and their relation to climate variations in the Northern Hemisphere

Andrei Krovnin, Boris Kotenev, Nikolai Antonov and George Moury

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Though Pacific cod in the northwestern Bering Sea has a large importance for the Russian fishery (with annual catches up to 92,000 t), its long-term fluctuations and their relation to changes in environmental conditions and, in a broader sense, with climate, are not well-studied. The analysis of data on cod recruitment for the 1962-2016 period has showed a pronounced decadal variability, with maxima in the first half of the 1960s, second half of the 1970s, early 1990s and early 2010s. The decadal variations of cod recruitment were closely related to similar fluctuations of PC EOF1 of winter (January-March) heat content in the 0-200 m layer of the Bering Sea, which were largely determined by longitudinal shifts of the Aleutian Low. These shifts, in turn, are controlled by the large-scale climatic processes in the Atlantic-Eurasian and Arctic sectors of the Northern Hemisphere. In this study, we will analyze those changes in the winter large-scale atmospheric patterns over Eurasia and Arctic, which contributed to formation of favorable conditions for successful reproduction of Pacific cod in the northwestern Bering Sea, and will make a projection of the stock state for the next 10-15 years.

12:00 (S11-11996)

Climate variability on arctic fish growth rates: Empirical evidence for biophysical coupling and its effect on harvest policies

Thomas E. Helser, Mary Elizabeth Matta and Paul Spencer

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Evidence for a functional response between climate variability and arctic fish growth is emerging, particularly when such a response is seen across diverse taxa under the influence of physical processes in a given ecosystem. In this study, we evaluated the functional response between short- and long-term climate variability on the growth rates of several long lived rockfish (*Sebastes* spp.) in the Bering Sea. Exactly dated growth increment data, which spanned nearly 80 years, were analyzed using a nonlinear Bayesian hierarchical growth model that included covariates such as age, annual sea surface temperature (SST), upwelling and the Pacific Decadal Oscillation (PDO). Both SST and PDO entered the model as covariates explaining significant variability in growth across both several fish taxa. Once the effects of age on growth-increment data were removed, growth variability correlated positively with SST on an inter-annual basis while PDO accounted for longer term growth rate trends that were particularly evident between the pre- and post-1976 productivity regimes in the North Pacific. Accounting for the climate-induced growth response before and after the regime shift in population models had a significant impact on management reference points, indicating that harvest policies will need to account for non-stationary trends climate-growth coupling.

S12: BIO Topic Session**Seasonal and climatic influences on prey consumption by marine birds, mammals and predatory fishes****September 26****14:10 (S12-12207)****Increased prey consumption by groundfish during the 2014-2015 marine heat wave and the potential for competition with seabirds**Stephani G. **Zador**¹ and John F. Piatt²¹ Alaska Fisheries Science Center, NOAA, Seattle, WA, USAE-mail: Stephani.zador@noaa.gov² Alaska Science Center, U.S. Geological Survey, Anchorage, AK, USA

This talk will address how changes in water temperature during the recent marine heat wave in the Gulf of Alaska could have increased prey consumption by large predatory groundfish (e.g., arrowtooth flounder *Atheresthes stomias*, Pacific cod *Gadus macrocephalus*) through increased metabolic requirements. Increased food demand by ectothermic fish due to increased temperature has been demonstrated in modeling and experimental studies. We combine empirical data with previously-established bioenergetic parameters to estimate total prey consumption during warm years relative to cold years. We estimate total prey consumption for endothermic seabirds based on previous studies and discuss how increased food demand by groundfish may have depleted prey resources for seabirds. We find that a significant increase in prey resources by groundfish during the marine heat wave may have been a contributing factor in the widespread seabird die-offs observed during 2015-2016 in the Gulf of Alaska.

14:30 (S12-12275)**Climate and prey consumption by Rhinoceros Auklets and Japanese Cormorants breeding in Teuri Island, Hokkaido, Japan**Jumpei **Okado**¹, Motohiro Ito² and Yutaka Watanuki¹¹ Graduate School of Fisheries Sciences, Hokkaido University, JapanE-mail: s02119172c@gmail.com² Department of Applied Biosciences, Faculty of Life Sciences, Toyo University, Japan

When climatic regime shift occurs the distribution and abundance of forage fish change dramatically. These changes affect prey of seabirds and consequently their consumption. In Japan, cold to warm regime shift occurred in 1989, then return to a cold regime was suspected to recently occur. We monitored population and chick diet of Rhinoceros Auklets (*Cerorhinca monocerata*) and Japanese Cormorants (*Phalacrocorax capillatus*) at Teuri Island, Japan Sea in northern Japan. We estimated prey consumption of these two species using simple bioenergetics models. Population of the auklets increased from 1980s to 2010s, while that of cormorants increased from 1980s to 2000s, then decreased. After cold-warm regime shift in 1989, auklets changed diet from cold water species (sardine, sand lance) to warm water species (anchovy). The cormorants fed both on demersal fish and epipelagic fish during warm regime, while they fed almost on demersal fish (rock fish) during warm-cold regime shift in recent years when warm water epipelagic fish were not available. We found significant impact of climate change on prey consumption. In addition, it is known that, in auklets, diet for parents and that for chicks are often different. Using the samples of stomach contents of adults and bill-loads for chicks that were collected in 2004 – 2005 (warm regime) and 2014- 2015 (presumed cold regime), we estimated the prey consumption by parents and by chicks, separately, and we found that the parent's diet is key for estimating prey consumption.

14:50 (S12-12117)**Breeding phenology and diet shift of seabirds in South Korea**Miran **Kim**¹, Youngsoo Kwon¹, Mijin Hong², Ho Lee¹, Hong-chul Park¹ and Na-yeon Lee¹¹ Korea National Park Research Institute, Wonju, Kangwondo, R Korea
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Breeding timing is important to match peak food availability with the nutritional requirements of chicks. In this study, we monitored breeding phenology of Black-tailed gulls *Larus crassirostris* using automatic timelaps cameras in two breeding colonies of South and West Sea of South Korea. Initiation of breeding had been monitored on Hongdo islet for 7 years and on Nando islet for 2 years between 2003 and 2017. Breeding timing of Black-tailed gulls in Hongdo islet at the South Sea of Korea tended to be advanced comparing to 2003 except 2013. Black-tailed gulls in Nando islet also arrived at breeding colony 2 days earlier in 2017 than gulls in 2016. We analyzed carbon and nitrogen stable isotopes of chick body feathers on Hongdo islet to investigate annual change of diet from 2002 to 2016. Carbon and nitrogen stable isotope values tended to increase. It may reflect marine environmental change in South Korea. Sea Surface temperature of South Korea had been slightly increased last 40years.

15:10 (S12-11980)**Integrated study of marine mammals: An update of the regional project in the Southeast Asia**Xuelei **Zhang**¹, Kongkiat Kittiwatanawong² and Saifullah Arifin Jaaman³¹ Marine Ecology Research Center, First Institute of Oceanography, SOA, 6 Xianxialing Road, Qingdao 266061, PR China
E-mail: zhangxl@fio.org.cn² Phuket Marine Biological Center, P.O. Box 60, Phuket 83000, Thailand³ Institute of Oceanography & Environment (INOS), Universiti Malaysia Terengganu (UMT), 21030 Kuala Terengganu, Malaysia

Marine mammals migrate between their habitats. To account for the environmental impacts, such as those arising from prey availability and seasonal/climatic changes, it is critical to conduct sufficient observation of the migration of marine mammals. Traditionally, the region relies on labor intensive methods to observe/study/protect the endangered marine species. These methods cannot meet increasing demand for higher efficiency, objectivity and repeatability, which can be empowered with modern science and technologies such as telemetries using bioacoustic sensors, satellites, unmanned aero vehicles and boats, molecular analysis, etc. Marine mammals are components of the marine ecosystem. Thus, for sound science and toward effective conservation measures, we also need to conduct concert research into the system's productivity, oceanography and coastal anthropogenic activities therein. Some methods and preliminary results will be presented, from the regional research efforts jointly funded with the China-ASEAN Maritime Cooperation Fund and partners' cofinancing.

15:50 (S12-12036)

Bioenergetic requirements of migrating eastern North Pacific grey whales in the face of climate change

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Unusually high mortalities of grey whales (*Eschrichtius robustus*) observed in 1999 and 2000 along the migration route between Mexico and the Arctic have been attributed to starvation resulting from reductions in prey availability likely due to climate change. However, relatively little is known about minimum energetic requirements to sustain the annual grey whale migration and the associated effect of climate change on the ability of grey whales to meet minimum energy requirements for migration. We addressed this knowledge gap by constructing an age-structured bioenergetics model to predict the energy requirements of each migrating cohort of whales and estimated a minimum threshold of daily prey consumption during the summer that would be necessary for them to avoid nutritional stress during the annual migration. Inputs included age, sex, and reproductive state and the model assumed a range of annual energetic requirement thresholds—from 96% of daily requirements (below which pregnant females would not successfully give birth or wean a calf) to 58-60% (below which adults would die). We thus derived daily food requirements (e.g., kg of amphipods, mysid shrimp, etc.) for all age classes of grey whales and predicted future mortality rates as a function of varying prey densities due to climate change. Our results are useful for managers and policy makers to assess and anticipate the likelihood of climate-induced mortality events occurring.

16:10 (S12-12314)

Estimation of prey consumption by cetaceans in the western North Pacific-Update to Hunt *et al.* (2000)

Tsutomu **Tamura**

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Hunt *et al.* (2000) estimated prey consumption for 135 species of seabirds and 47 species of marine mammals in the PICES region. They estimated energy requirements of sea birds and mammals using simple equations that scaled energy requirements as a function of body mass. In 2016, S-MBM in PICES recommended that the Hunt *et al.* (2000) report be updated with data collected over the past 2 decades to answer the overarching question, “how much do marine mammals consume.” The general approach proposed was to treat the Hunt *et al.* (2000) report as a living document. The assessment of prey consumption was based on 1) recently available abundance estimates of cetaceans (after 2000), 2) daily prey consumption rates of cetaceans estimated, 3) estimated biomass of cetaceans by use of average body weight and abundance, and 4) composition of prey species of cetaceans. The annual prey consumption of cetaceans was estimated for the PICES regions. However, more information is needed on the abundance, body weight and prey composition of cetaceans to address a more realistic strategy for fisheries management and the conservation of cetaceans in future.

16:30 (S12-12182)

Spatial estimation of prey consumption by sei whales in the western North Pacific during the summers of 2008 – 2009: Density surface model approach

Hiroko **Sasaki**¹, Tsutomu Tamura², Takashi Hakamada², Koji Matsuoka², Hiroto Murase¹ and Toshihide Kitakado³

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The BIO workshop on “Consumption of North Pacific forage species by marine birds and mammals” recommended undertaking detailed analysis of prey consumption of sei whales. To estimate prey consumption in a spatial context, a reliable estimation of spatial abundance as a function of environmental covariates with an appropriate spatiotemporal scale is required. This year, the authors applied a density surface model (DSM) to sighting data of sei whales to estimate abundance in a spatial context. The data were obtained in JARPNII conducted in 2008 and 2009. The DSM consisted of two levels. At the first level, detection function (probability of detecting a school of sei whales given its distance from the transect) was modeled with visibility and Beaufort scale as covariates. Density surface (i.e. spatial abundance estimation) was estimated using a generalized additive model (GAM). Daily water temperature rather than monthly mean was used as a covariate of the GAM. The data were derived from an ocean forecast system developed by the Japan Fisheries Research and Education Agency based on the Regional Ocean Modeling System (FRA-ROMS). Depth was also used as a covariate. As in the previous year, the amount of prey consumed by individual sei whales was estimated by GAM using the same environmental covariates mentioned above. The product of the DSM and individual consumption models yielded the spatial pattern of prey consumption in the survey area.

16:50 (S12-12151)

Simple models to predict daily energy requirements and prey consumption by marine mammals in the North Pacific

Andrew W. **Trites**

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In general, smaller species of marine mammals have higher mass-specific energy requirements than bigger species (e.g., 4-5% for dolphins and 2-3% for large whales). However, closer inspection of energetic requirements of different sized species reveals disconnects between body size and energy requirements in a number of them due to some marine mammals having higher metabolisms and higher functioning musculature that require more prey to fuel their needs. This implies that the simple models currently used to determine daily rations are ineffective to estimate the food requirements of marine mammals, and that new means are required to yield better estimates of prey consumption. I reviewed all existing estimates of energy requirements for marine mammals to identify species that have well supported estimates—which I then used to derive generalized equations that predict the energy requirements of all pinnipeds and cetaceans as a function of body mass. These new equations are superior to existing generalized equations that have been used in the past to estimate energetic needs, and can be used to derive estimates of prey consumption for species of marine mammal with unknown energy requirements in the North Pacific.

S13: BIO Topic Session**Joint PICES-ICES Session on Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services****September 26****11:00 (S13-12132)****Localized high abundance of Marine group II archaea in the subtropical Pearl River Estuary: Implication for their niche adaptation**

Chuanlun **Zhang**¹, Wei Xie², Haiwei Luo³, Senthil K. Murugapiran⁴, Jeremy A. Dodsworth⁴, Songze Chen², Ying Sun³, Brian P. Hedlund⁴, Peng Wang², Huaying Fang⁵ and Minghua Deng⁵

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Marine group II (MGII) archaea are widely distributed in global oceans and dominate the total archaeal community within the upper euphotic zone of temperate waters. However, factors controlling the distribution of MGII are poorly delineated and the physiology and ecological functions of these still uncultured organisms are elusive. In this study, we investigated the planktonic MGII associated with particles and in free-living forms in the Pearl River Estuary (PRE) over a 12-month period. The average abundance of particle-attached MGII was 10-fold higher than that of the free-living counterparts, demonstrating their preference for particle attachment. The results also showed that the abundances of MGII were positively correlated with phototrophs, including both algae and *Cyanobacteria*, when the salinity is higher than 10‰, and that MGII in the surface water were negatively correlated with monthly photosynthetic active radiation (PAR) during the sampling period. A nearly complete genome of PRE_MGIIa, which represented the most abundant operational taxonomic unit (OTU) of MGII in surface waters, was recovered using metagenome binning methods. Comparing with other published MGII genomes, PRE_MGIIa contained unique genes annotated as catalase and high-affinity inorganic phosphate transporter, which might be pivotal for their adaptations to PRE that was heavily impacted by anthropogenic activities. Our study presents a comprehensive analysis of the potential ecological interactions between MGII and other microorganisms, particularly phototrophs and other archaea, and provides insight into microbial niche adaptation in the estuarine ecosystem.

11:20 (S13-12230)

Anthropogenic blue carbon: Assessing the contribution of seaweed aquaculture for carbon uptake and storageM. Robin **Anderson**¹ and Richard B. Rivkin²¹ Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, St. John's NL, Canada

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Blue carbon is a component of the pool of biological produced carbon that can be stored in a form that is relevant for climate mitigation. However quantification of the fate, export and potential sequestration of blue carbon is complex. The production and fate of carbon derived from the extensive naturally-occurring and managed (i.e. farmed) kelp beds and other macroalgal systems is rarely assessed and complicated by physiological adaptations of seaweed, specifically their ability to store organic carbon under nutrient limited, high light conditions. Thus models which use average carbon conversion factors will introduce a large and unpredictable bias. Kelp and other seaweed aquaculture is rapidly expanding with an annual (2014) global harvest of $\sim 30 \times 10^6$ tonnes. Although biomass yields are relatively well quantified, losses due to fragmentation and sloughing are not. As a result of the poorly constrained carbon conversion factors and gross biomass production, the potential for carbon capture and storage or the eventual sequestration is difficult to calculate. Here we examine the potential for seaweed aquaculture to capture and store carbon and identify the data gaps that need to be filled to adequately quantify this potential.

11:40 (S13-12211)

Viruses, carbon sequestration and the biological pumpCurtis A. **Suttle**

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Viruses are major agents of mortality, and through cell lysis are estimated to kill $\sim 20\%$ of the biomass in the ocean daily. The cellular constituents released via lysis comprise a complex mixture of dissolved and particulate organic matter (DOM & POM) that includes labile components such as nucleic and amino acids, as well as recalcitrant components such as cell-wall material. Consequently, viruses play a major role in global nutrient and carbon cycling. The labile DOM and POM is rapidly consumed by heterotrophic microbes in a process called the *Viral Shunt*, which releases nitrogen, phosphorus and iron-rich components, fueling primary productivity and more carbon sequestration. However, the recalcitrant components accumulate, in what has been termed the *Microbial Carbon Pump* (MCP). In the process, recalcitrant carbon-rich DOM and POM are accumulated, skewing the composition of the viral lysates to be carbon-rich relative to the elemental stoichiometry of the cells from which they were derived. Hence, the relative amount of C will exceed that of the Redfield Ratio (106C:16N:P1). Export of this carbon-enriched material from the surface to the deep ocean will increase the efficiency of the Biological Pump. Hence, the viral shunt and the MCP working in unison result in more carbon sequestration in the oceans than would be the case if viruses were not part of the system.

12:00 (S13-12016)

Climate change, phytoplankton export and carbon equestration

Uta **Passow**

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Large phytoplankton blooms may form rapidly sinking aggregates that settle to below 1000 m, leading to the sequestration of carbon, e.g. its removal from the atmosphere for > 100 years. This mechanism is an important pathway of the biological carbon pump (BCP). To date, the deep ocean has sequestered about ¼ of the human produced carbon, largely due to the activity of the BCP. How will rising temperatures and ocean acidification influence the mechanisms driving the BCP, and specifically the settling of phytoplankton? Transparent exopolymer particles, TEP, which form abiotically from substances released by microbes, play an important role for the formation of fast sinking aggregates.

Experiments suggest that TEP production may be increased due to rising temperatures, and other work implies that increased TEP may lead to a decrease in export flux. This presentation will describe results from experimental work, field studies and theoretical considerations trying to evaluate the effect of changing temperature and carbonate chemistry on phytoplankton settling and carbon sequestration.

12:20 (S13-12223)

A model simulation of future biogeochemical conditions along the British Columbia Continental Shelf

Angelica **Peña**, Isaac Fine and Diane Masson

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The British Columbia shelf is at the northern end of the California Current System and is influenced by summer coastal upwelling, mesoscale eddies, and freshwater inputs. A regional coupled circulation-biogeochemical (ROMS) model of this region has been developed to gain a better understanding of the potential impact of climate variability and change on lower trophic levels and the biogeochemistry of the region. In particular, the model is used to evaluate changes in nutrient fluxes, primary production and the biological carbon pump. In this presentation we will discuss the approach used to investigate the effect of climate change on the biologically-driven carbon pump and present results on future ecosystem changes for the British Columbia contiin the west coast of Canada based on simulations of contemporary and future conditions.

14:10 (S13-12108)

Changes in plankton assemblages and role of microbial loop in biogeochemical carbon cycles associated with coastal upwelling in the Ulleung Basin, East Sea

Jung-Ho **Hyun**¹, Eun-Jin Yang², Jae-Hoon Noh³, Kyeong-Hee Kim⁴, Sung-Han Kim¹, Jin-Sook Mok¹, Dongseon Kim³ and Sinjae Yoo³

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The Ulleung Basin (UB) in the southwest of the East Sea is characterized by high plankton biomass and primary production. Wind-driven coastal upwelling has been known to be responsible for the enhanced biological production. However, upwelling-induced changes in plankton assemblages and the fate of primary production associated with the bacterial activities remain to be solved. We investigated the abundance of phytoplankton, heterotrophic bacteria and micro-zooplankton, and primary production (PP) and bacterial production (BP) to determine temporal and spatial variations of plankton assemblages and the quantitative role of heterotrophic bacteria in biogeochemical carbon cycles associated with the coastal upwelling in the UB. Phytoplankton assemblages changed from small-sized flagellates in early-upwelled and relatively stratified condition to larger diatoms in mid-upwelled condition. Abundance and production of each microbial group increased significantly ($p < 0.005$) in mid-upwelled condition compared to that measured in relatively stratified and early-upwelled condition. BP accounted for average 53% of PP in highly stratified condition, but decreased to 6% in mid-upwelled condition. Plankton assemblages dominated by smaller cell-size and higher BP to PP ratio during stratified condition suggested that a large amount of organic carbon is channeled via microbial loop, which ultimately diminishes export flux (i.e., function of biological carbon pump). Consequently, changes in the intensity and frequency of upwelling associated with climatic changes (i.e., increased sea surface temperature and decreased wind speed) that are in progress in the UB would significantly affect the carbon cycles associated with the fate of primary production and the role of the microbial loop.

14:30 (S13-12248)

Response of spring diatoms to CO₂ availability in the western North Pacific

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Due to massive spring diatom blooms, the western North Pacific, especially in the Oyashio region, has one of the greatest capacities for seasonal biological drawdown of partial pressure of CO₂ (pCO₂) in surface waters among the world's oceans. On the other hand, progressive increases in the seawater pCO₂ and the concomitant decreases in pH caused by anthropogenic CO₂ emissions have also been reported. However, it is still very unclear how spring diatom assemblages respond to CO₂ availability in this region. Here we report the impact of different CO₂ levels on spring diatoms in the Oyashio region as estimated from next-generation sequencing of the diatom-specific *rbcL* gene, which encodes the large subunit of RubisCO. We also examined the abundance and composition of *rbcL* transcripts in diatoms to assess their physiological responses to changing CO₂ levels. A short-term incubation experiment was carried out on-deck using surface Oyashio waters in spring under different pCO₂ levels (180, 350, 750, and 1000 μ atm). The transcript abundance of the diatom-specific *rbcL* gene decreased with an increase in seawater pCO₂ levels. These results indicate that CO₂ fixation capacity of diatoms decreased rapidly under elevated CO₂ levels. In the higher CO₂ treatments, diversity of diatom-specific *rbcL* gene and its transcripts decreased relative to the control treatment (350 μ atm), as well as contributions of Chaetocerotaceae, Thalassiosiraceae, and Fragilariaceae to the total population, whereas the contributions of Bacillariaceae increased. These results suggest that changes in CO₂ levels can also alter the community composition of spring diatoms in the Oyashio region.

14:50 (S13-12146)

Silicate weathering and CO₂ consumption rates: new insights from rivers of the Primorskii Krai (Russia)Galina Yu. **Pavlova**¹, Pavel Ya. Tishchenko¹, Pavel Yu. Semkin¹ and Elena A. Vakh^{1,2}¹ V.I. Il'ichev Pacific Oceanological Institute, Far Eastern Branch Russian Academy of Sciences, Vladivostok, Russia
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The interactions between water and rocks at the surface of the Earth release the most soluble ions that will end up in the ocean and lead to the consume atmospheric CO₂. Basalts play a major role in the carbon cycle. Many basaltic areas are located near the sea, so that only small rivers flow through these formations. As a rule small rivers are not taken into account in global budgets of weathering fluxes. However, even if individual river fluxes of dissolved material to the ocean are negligible compared to those of large rivers, these fluxes accumulated over the world-wide surface of volcanic provinces may not be negligible.

This study examined the chemical composition of river waters in basaltic environments in Primorskii Krai area to characterize the silicate rocks weathering and quantify the atmospheric consumption rates associated with basalt weathering. The Razdolnaya and Partizanskaya rivers were sampled and analyzed for their major elements in different seasons in 2011-2012. The drainage areas are 16430 and 4140 km², annual discharge – 2.27 and 1.32 km³/yr for Razdolnaya R. and Partizanskaya R., respectively. We use the well-established inverse method based on mass balance to apportion the river dissolved cations to rain and weathering input from evaporite, carbonate and silicate rocks.

The results of our calculation showed that silicate contribution to total dissolved cations predominates in all samples reaching above 50%. The CO₂ consumption rates of the Razdolnaya R. and Partizanskaya R. basins are calculated to be 7.6×10^4 and 21.2×10^4 mol·km⁻²·yr⁻¹, respectively.

15:10 (S13-12055)

Acidification of the interior of the Japan/East SeaPavel **Tishchenko**¹, Vyacheslav Lobanov¹, Dmitriy Kaplunenko¹, Tatyana Mikhajlik¹, Kyung-Ryul Kim² and Dong-Jin Kang³¹ V.I. Il'ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences, Russia
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The Japan/East Sea (JES) exhibits multiyear decreasing trend of dissolved oxygen (DO) concentration in deep and bottom water masses of the JES. Most of researchers suggested that changes in the intensity of vertical ventilation of deep and bottom water masses during the past few decades is the main cause of the observed changes in the DO concentrations. The goal of this study was to analyze the tendencies of variability of pH, pCO₂, DIC and related hydrochemical parameters such as DO and nutrients concentrations during last two decades. Hydrochemical data for two sections of the JES (along 132.3°E and 134°E) were chosen as most carefully sampled in the period 1999-2014. Our results demonstrate that pH and DO concentrations in the intermediate, deep and bottom water masses decreased with time. Opposite tendency was found for NDIC, pCO₂ and nutrients (silicates, phosphates and nitrates). Maximum rate of acidification corresponds to 750 m. For this depth, the annual rate of increasing of CO₂ partial pressure exceeds more than two times than atmospheric one. Maximal rates of annual variability of others hydrochemical parameters also correspond to 750 m depths. Observed variability of the hydrochemical properties can be considered as eutrophication of the JES.

15:50

Development and applications of high throughput metagenomics technologies to marine biogeochemistry

Jizhong **Zhou**

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 Earth and Environmental Division, Lawrence Berkeley National Laboratory, Berkeley, CA, USA
 School of Environment, Tsinghua University, Beijing, China

The rapid development of high-throughput metagenomic technologies over the past decade has greatly extended our understanding of complex microbial systems. Although remarkable advances have been made in the development of high-throughput functional gene arrays (FGA) for analyzing complex microbial communities, challenges still remain in their representation, specificity, sensitivity and quantitation. Here we developed a new generation of high-density FGA, GeoChip 5.0 based on Agilent platform, majorly covering probes from carbon (C), nitrogen (N), sulphur (S), and phosphorus (P) cyclings and energy metabolism probes, as well as antibiotic resistance, metal resistance/reduction, organic contaminant remediation, stress responses, pathogenesis, and virulence. GeoChip 5.0 contains 161,961 probes covering approximately 370,000 representative coding sequences from 1,447 functional gene families. These genes were derived from functionally divergent broad taxonomic groups, including bacteria (2,721 genera), archaea (101 genera), fungi (297 genera), protists (219), and viruses (167 genera, mainly phages). Both computational and experimental evaluation with perfect match (PM)/mismatch (MM) probes indicated that all designed probes were highly specific to their corresponding targets. Strong hybridization could be obtained with 100 ng DNA. Sensitivity tests revealed that as little as 0.05 ng of pure culture DNAs was detectable within 1 µg of complex background DNA. This is equivalent to 0.005% of a population within a complex community, suggesting that the Agilent platform-based GeoChip is extremely sensitive. Additionally, very strong quantitative linear relationships were obtained between signal intensity and pure genomic DNAs (about 99% of probes detected with $r > 0.9$) or soil DNAs (about 97% of the probes detected with $r > 0.9$) within at least three orders of magnitudes. We applied the designed FGAs to analyze the two-years time series samples from Station ALOHA. Our results indicated that the community taxonomic, phylogenetic and functional gene diversity all statistically differed among the three investigated depths, but no clear temporal patterns were detected during the two-year investigation. Moreover, the observed community diversity patterns were significantly different from randomly permuted communities, suggesting that the bacterial communities at Station ALOHA are most likely governed by deterministic processes rather than stochastic factors. All meta-analyses collectively indicated that the spatial and temporal turnovers of bacterioplankton communities at Station ALOHA were significantly affected by depth-dependent environmental factors, particularly the vertically different temperature. Our study not only enhances our understanding on the assembly mechanisms of ocean bacterioplankton, but also provides new insights into the community assembly of other planktonic groups.

16:10 (S13-12193)

Microbes and ocean biogeochemical processes

Richard B. **Rivkin**¹ and M. Robin Anderson²

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About 50% of global primary production (~105 Gt/y) occurs in the ocean and <1% of this production sinks, via the biological carbon pump (BCP) below the depth of sequestration. The microbial carbon pump (MCP) lengthens the residence time of dissolved organic carbon (DOC) through the production of recalcitrant DOC (RDOC), and the magnitude carbon it sequesters may be similar to that of the BCP. Bacteria and Archaea assimilate DOC which is either transferred to the food web via protistian grazing or released via inefficient ingestion and viral lysis, leading to the progressively transformed of labile DOC into RDOC. Quantifying the spatial and temporal the importance of BCP and MCP will depend largely on structure, dynamics and environmental regulation of the microbial food web. Here we have assembled and analyzed a comprehensive database on bacterial processes, protistian bacterivory, and associated environmental variables for the World Ocean. We find that depending on region and season, that 40-75% of contemporaneous bacterial production is channeled through the food web. With an estimated global oceanic heterotrophic prokaryote production of 3-4 Gt/y, this sets an upper limit a RDOC production of 1.5-2 Gt/y. The climate implications will be discussed.

BIO Contributed Paper Session**September 29****09:00 (BIO-P-12271)****Geographical variation of community structure of bacillariophyceae (diatom) in the western North Pacific Ocean**Kazuaki **Tadokoro** and Tsuyoshi WatanabeTohoku National Fisheries Research Institute, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
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Bacillariophyceae (diatom) is one of the important primary producers in the ocean ecosystems. There is many large size species (bigger than 20 micrometer), and they play important role in the classic food web that flow energy from primary producers to mesozooplankton. However, its geographical variation of community structure has not been well studied. We studied the geographical variation of community structure and biodiversity of bacillariophyceae in the western North Pacific Ocean from equatorial to subarctic by using the species composition data collected by Japan Meteorological Agency from 1950 to 1990. In this study, 271 species (including form and variety) of bacillariophyceae was appeared. We averaged species composition data by month and latitude and longitude 1° degree grid, and used cluster analysis to classify geographical variation of community structure. We classified 4 communities. The two groups were considered to be subarctic group because they mainly appeared north of 40°N, and other two groups were considered to be subtropical group because they mainly appeared south of 40°N. Appeared species number was relatively high in the north of 40°N and coastal area. On the other hand cell number of diatom was relatively high in the subtropical area.

09:20 (BIO-P-11985)**Feeding impact of the planktonic copepod *Calanus sinicus* on phytoplankton in the northern East China Sea in late spring**Garam **Kim** and Hyung-Ku KangKorea Institute of Ocean Science & Technology, Ansan, Korea
E-mail: garamkim@kiost.ac.kr

The distribution and feeding of *Calanus sinicus* were studied in June 2015 on the 12 sampling stations spread from the southern coast of Korea to the northern East China Sea, to better understand an ecological role of *C. sinicus* in the research area. Ingestion rate, daily ration as percentage body weight and feeding impact of copepodite stage CIV to adults were estimated using the gut pigment method. Density of overall *C. sinicus* was varied from 2 to 1,387 inds. m⁻³ by stations. CV copepodite was the most abundant with the density of 273.7 inds. m⁻³ and CIV was next, followed by adult female and male. The gut pigment content of the copepodites of *C. sinicus* ranged from 3.2 to 5.5 ng chl. ind⁻¹ with the highest value in the adult female. Although the gut pigment content and ingestion rate of adult female were higher than other developmental stages, the highest value of daily ration as percentage body weight was found at CIV copepodite. These results confirm that the feeding of copepodites of *C. sinicus* is more active than that of adults. Mean feeding impact of the copepodites of *C. sinicus* on phytoplankton biomass, in terms of chlorophyll *a* concentration, ranged from 0.1 to 2.6% with the highest value in the copepodite CV. No significant correlations was found between density, ingestion rate and feeding impact of *C. sinicus* and the environmental factors such as temperature, salinity or chlorophyll *a* concentrations.

09:40 (BIO-P-12160)

Identification of gene markers associated with starvation in female *Calanus sinicus* Brodsky (Calanoida: Copepoda)

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Calanus sinicus is an abundantly distributed copepod in the coastal waters of the subtropical western North Pacific, and physiological states of *C. sinicus* is a possible indicator for biological conditions of marine ecosystems. Food availability in the ocean is highly variable temporally and spatially. Then, it may lead to starvation of copepods, however, which is difficult to identify under *in situ* environment by conventional methods. In this study, we aimed to develop a method to evaluate starvation of female *C. sinicus* by identifying differentially expressed genes under starvation. First, we conducted culturing experiments with two treatments: feeding (FED) and starvation (STV) for 24 hour. The expressed genes were comprehensively revealed by RNA-seq, and total 16 genes showed significantly different expression patterns between FED and STV. From the function of the homologue of these genes, Vitellogenin (Vg) gene for a precursor of egg yolk protein was suggested as useful maker involving in a starvation response. We then measured temporal changes of Vg expression levels by quantitative real-time PCR, using specimens cultured under different fasting time. As a result, expression of Vg greatly decreased at fasting 12 h, and then it remained at a very low level. Although no clear decreasing tendency of the egg production rate was observed at fasting 12 h, most individuals did not lay eggs after fasting time of 24 h. These results suggest that the expression level of Vg can be a one of indicators of starvation and useful for predicting egg production of female *C. sinicus*.

10:00 (BIO-P-12179)

Egg sizes and life histories of the two planktonic copepod families Eucalanidae and Calanidae

Shinji **Shimode**¹, Kazutaka Takahashi², Minamo Hirahara³, Mana Mikawa¹, Tomohiko Kikuchi¹ and Tatsuki Toda³¹ Graduate School of Environment and Information Sciences, Yokohama National University, Kanagawa, Japan

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It has been well known that egg sizes of marine planktonic copepods are different between two spawning strategies, namely broadcast-spawners that release their eggs freely into the water and sac-spawners that carry their eggs until hatching. Broadcast-spawners are considered to produce relatively smaller eggs, compared with sac-spawners. In this study, egg sizes of the most dominant planktonic families in the open oceans, Eucalanidae and Calanidae, are examined to investigate whether there are no differences in egg sizes within broadcast-spawners. We conducted egg size measurements and egg production rate (EPR) experiments on 12 Eucalanidae and 9 Calanidae species collected from Sagami Bay, Japan. In addition to the 21 species, egg sizes and EPR of 2 Eucalanidae and 12 Calanidae reported in previous studies were included in the analysis. Our result clearly indicates that egg diameters (ED) relative to prosome lengths (PL) of adult females were different between the two species groups: 1) tropical and subtropical surface species (ED > ca. 7% of PL) and 2) ontogenetic vertical migration (OVM) species (< ca. 7%). In contrast, EPR of the former species group (*Subeucalanus*, *Cosmocalanus*, *Nannocalanus*, etc.) were relatively lower than the latter group (*Eucalanus*, *Calanus*, *Neocalanus*, etc.). Our result suggests that the subtropical and tropical surface species of the two families are “K” reproductive strategists, i.e., larger egg sizes and lower EPR, while the OVM species are “r” reproductive strategists, i.e., smaller egg sizes and high EPR.

10:20 (BIO-P-12270)

Seasonal variation of arrow-worm (Chaetognatha: Sagittidea) assemblages and impact of small copepods in the south-central South China Sea

Lianggen **Wang**, Feiyan Du, Xuehui Wang, Yafang Li, Jiajia Ning and Lei Xu

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Arrow-worms are mesozooplankton common to all regions of the world oceans and prey largely on copepods. The arrow-worm abundance distribution and impact factors were analyzed using net data obtained during 2013 and 2014. Twenty-four taxa were identified, low abundance (4.29 ± 3.40 individuals m^{-3}) were observed compared with coastal zones, which was similar with other oceanic zones in the western Pacific Ocean. Abundance and distributions changed seasonally along with the surface current, which was driven by a monsoon reversal. The dominant taxa were *Flaccisagitta enflata*, *Serratogitta pacifica*, *Mesosagitta minima*, *Ferosagitta ferox*, *Pterosagitta draco* and *Krohnitta pacifica*. *F. enflata* abundance contributed to 58.0% of the arrow-worm abundance was 2.47 ± 2.27 individuals m^{-3} and other five dominant taxa abundances contributed to 36.1%. The result of a generalized additive model (GAM) analysis showed that *F. enflata* abundance was affected by *Mecynocera clausi*, *Calocalanus pavoninus*, *C. plumulosus*, *Clausocalanus minor*, *C. arcuicornis*, *Farranula gibbula* and *Oithona similis*, which made up 20.9% of all copepods caught by individual number. Therefore, we suggest that rich and various food help *F. enflata* to be the dominant taxa in the tropical oceanic zones.

11:00 (BIO-P-12320)

Understanding of mutualistic interaction between marine phytoplankton (*Tetraselmis striata*) and bacteria (*Pelagibaca bermudensis* and *Stappia* sp.) in phycosphere

Jungsoo **Park** and Myung-Soo Han*

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Effective sustainable algal cultivation techniques are essential for mass production of the marine microalga *Tetraselmis* for biofuel and array of co-products. The phycospheric communities affect the microalgal growth and metabolism through various allelochemical and nutrient interactions; hence, their potential to affect the quantity and quality of both biomass and bioproducts is significant. In the present study, we have screened the phycospheric communities of biofuel producing *Tetraselmis striata* (KCTC1432BP). A total of 26 bacterial strains were isolated and identified from the phycosphere of *T. striata* mass culture. Then, each bacterial strain was tested in co-cultivation conditions with *T. striata* for evaluating its growth promoting

and inhibitory effects. Among these all strains, two promising strains (*Pelagibaca bermudensis* KCTC 13073BP and *Stappia* sp. KCTC 13072BP) were selected because of their maximum growth promoting effects and mutualistic interactions. The growth rate, biomass productivity, lipid contents, and fatty acids were analyzed during their combined growth in O3 media and compared with axenic growth of *T. striata*. Later, growth promoting mechanisms in the co-cultivation environment were investigated for these promising bacterial strains under replete and limited conditions of nutrients (nitrate, phosphate, and vitamin B12). The growth promoting potential of *P. bermudensis* was illustrated by the two fold enhancement in biomass productivity. These bacteria are promising for microalgal cultivation without any negative effects on the native seawater bacterial communities, as revealed by next generation sequencing analysis. This study represents, to date, the first report highlighting the role of phycospheric growth promoting bacteria of promising biofuel feedstock *T. striata*.

11:20 (BIO-P-12201)

A comparative study of nematode assemblages associated with *Sargassum muticum* in its native range in South Korea and as an invasive species in the English Channel

Hyeong-gi **Kim**¹, Lawrence E. Hawkins¹, Jasmin A. Godbold¹, Chul-Woong Oh², Hyun Soo Rho³ and Stephen J. Hawkins¹

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Canopy forming algae are important habitat providers in coastal ecosystems. Several canopy forming species are invasive and spread to outside their native geographic range. We explored the role these invasive algae play in providing habitat for meiofaunal species. The nematode assemblages living in the intertidal algae *Sargassum muticum* in Europe where it is an invasive species and South Korea within its native range were compared. *Sargassum muticum* is a native species in East Asia and is a successful invasive species in North America and on European coasts. A nested survey design was used with two regions in each country, replicate shores in each region and three patches on each shore. The composition of the nematode assemblages was compared in British Isles and Korea. Significant differences among each spatial scale (patches, shores, regions and countries) were found in nematode assemblages. The species density and diversity was higher in Korea than British Isles. Despite different assemblage structure between countries, some cosmopolitan nematode species were appeared in both countries. These nematode species possibly come from Korea to British Isles with *S. muticum*. Further molecular studies are required to understand whether those species have invaded with *S. muticum* from Korea to British Isles.

11:40 (BIO-P-12291)

Environmental predictors of habitat suitability and spatial distribution of Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) in Jeju waters

Soeon **Ahn**¹, Sinjae Yoo¹ and Hyun Woo Kim²

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The Indo-Pacific bottlenose dolphin population in Jeju waters is resident in the region and its size is estimated to 100-110 individuals. To conserve this endangered species, the urgent challenge is to understand their habitat range and habitat preference well enough to maintain this population in the face of the pressures resulting from environmental changes. The aim of this study is to use species distribution models to investigate the distribution of *Tursiops aduncus* and the effects of environmental variables on the habitat suitability of this species. We compiled interannual dataset (2004-2016) comprised of annual cetacean sighting data from Cetacean Research Institute and Jeju National University. We selected environmental variables such as mean SST, salinity, pH and water depth which are likely to be primary drivers for dolphin distribution and these were obtained from Bio-Oracle global environmental data packages (5 arcmin) and the General Bathymetric Chart of the Oceans (GEBCO) dataset. The result indicated that water depth was a main driver to affect the distribution of Indo-Pacific bottlenose dolphin. Therefore, the area of northern part of Jeju coast waters was predicted to be a highly suitable habitat. Maxent model generated for *Tursiops aduncus* returned the area under the ROC curve (AUC) values higher than 0.9.

12:00 (BIO-P-12302)

Capturing Non-AIS vessel data in Southern Resident Killer Whale (SRKW) Critical Habitat

Lauren McWhinnie, Patrick D. **O'Hara**¹, Norma Serra-Sogas, Leh Smallshaw and Rosaline Canessa

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Southern Resident Killer Whale (SRKW) exposure to vessels is expected to increase due to planned port expansions and new marine terminal construction on Canada's Pacific coast. Vessel movement can be captured and assessed through the use of Automatic Identification Systems (AIS), however the volume of smaller non-AIS vessels is not currently quantifiable or being assessed. For this reason, models based on AIS data would underestimate vessel related stressors such as noise. Here we describe a system - the Photographic Observation Study (POS) AIS camera - designed to capture both non-AIS vessels and SRKW as well as AIS data. POS is positioned to capture both non-AIS vessels and SRKW within Boundary Pass; a significant bottlenecked area for both whales and vessels. POS is complementary to acoustic data collected concurrently at this site. This talk will present a description of the development and installation of the POS unit as well as initial findings from the early analysis work undertaken to date. We also describe an automated target detection scheme for image analysis. The information obtained from these images is particularly important when assessing the level of vessel exposure SRKW are subjected to. Noise exposure estimates often rely on whale vocalizations to determine whale presence, yet evidence suggests whales reduce vocalizations in the presence of vessels, leading to underestimated noise exposure. Therefore, POS enables the collection of data that will help to correct this exposure underestimate by improving our whale presence estimate in Boundary Pass.

FIS Contributed Paper Session

September 29

09:00 (FIS-P-12240)

Multiple-trait genetic evaluation of the Pacific white shrimp *Litopenaeus vannamei* in China

Jie **Kong** and Sheng Luan

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As the primary cultivated species in the world, the Pacific white shrimp *Litopenaeus vannamei*, has accounted for more than 80% of the total shrimp production in China. A genetic improvement program was performed to increase the production and profits of *L. vannamei* culture in China. The target traits included body weight and survival at different temperatures and different densities, resistance to ammonia nitrogen and low temperature, feed efficiency, meat yield and reproductive efficiency. First, a base population of *L. vannamei* was established in 2011, and genetic relationships of several hundred founders were reconstructed using SSR markers by the maximum likelihood method. Genetic evaluation showed that heritabilities of body weight, survival, ammonia nitrogen tolerance, cold tolerance, feed efficiency, meat yield and reproductive efficiency were 0.19-0.45, 0.05-0.19, 0.08-0.154, 0.03, 0.17-0.51, 0.12 and 0.06-0.19, respectively. As the most interesting trait, body weight exhibited a low genetic correlation with survival (-0.008), high negative genetic correlation with cold tolerance (-0.77), high positive genetic correlation with ammonia nitrogen tolerance (0.83) and moderate genetic correlation with meat yield (0.32). In addition, a low genotype by environment interaction (G×E) for body weight ($K < 0.5$) and a high G×E for survival ($k > 0.5$) were found in *L. vannamei*. The results show that there was substantial additive genetic variance for body weight, survival, resistance, feed efficiency and meat yield in the Pacific white shrimp that can be exploited through multiple-trait selective breeding.

09:20 (FIS-P-12013)

Growth and survival of jack mackerel *Trachurus japonicus* juveniles in the Tsushima Warm Current

Motomitsu **Takahashi**¹, Chiyuki Sassa¹, Satoshi Kitajima¹ and Youichi Tsukamoto²

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We examined growth trajectories of jack mackerel *Trachurus japonicus* juveniles in relation to a survival index (recruitment per spawning biomass: RPS) of the Tsushima Warm Current stock during 2011 – 2015. Juvenile *T. japonicus* were collected using a subsurface trawl during May – June. Body length (BL) of the juveniles ranged from 20 to 50 mm. Daily somatic growth rates were estimated for each individual fish based on otolith daily increments. Hatch dates ranged from February to May with peaks in April. Mean back-calculated BLs at 40 days post hatch (dph) ranged from 20.4 mm in 2011 to 25.6 mm in 2014. Interannual variations in mean daily somatic growth rates during 10-day intervals from hatching to 50 dph were related with RPS during the survey period. Mean growth rates during 20-30 dph and 30-40 dph positively correlated with RPS, suggesting that year classes with faster growth rate during late larval and early juvenile stages have higher survival rate than those with slower growth rate. Interannual variations in mean water temperature at 50 m measured at the fish collection showed comparative trends in mean growth rates during the significant period (20-40 dph) in addition to those during 5 days prior to the fish collection. Meanwhile, no comparative trend was found between the growth rates and abundance of prey organisms, copepodites and adults of Paracalanidae, measured at the fish collection. These results indicate that water temperature rather than food availability affects growth and survival rates during late larval and early juvenile stages in the Tsushima Warm Current region.

09:40 (FIS-P-12243)**An overview of the culturing and breeding of *Fenneropenaeus chinensis* in China**Xianhong **Meng**, Jie Kong, Qingyin Wang, Kun Luo, Sheng Luan, Qiang Fu and Xiaoli ShiYellow Sea Fisheries Research Institute, QingDao, PR China
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Fenneropenaeus chinensis, distributed along the North-western coast of Pacific Ocean, has been one of the most important fishery resources in the marine economy in China. Its farming history in China has been about 60 years long according to the earliest written records from related research in 1952. In 1959, research on artificial rearing and inshore cultivation was initiated. Techniques for large-scale industrial seed-stock production were developed in 1981, resulting in its farming peak period from 1987 to 1992 with total farming yield around 200,000 mt and its primary position in the mariculture field. Considerable attention was also focused on the development of more efficient culture modes such as industrialized culture and multi-trophic integrated culture since 1959. China made new shrimp varieties selected for faster growth and greater disease resistance a priority especially after the outbreak of white spot syndrome in 1993. The first new variety, Huanghai No.1, was produced in 2003 after seven generations of selective breeding incorporating biotechnology approaches. Multi-trait selective breeding based on BLUP estimation was applied to another new variety, Huanghai No.2, in 2008, and more varieties have been bred and well received by farmers. Development of modern molecular techniques will greatly promote further shrimp breeding, as we have developed abundant SNPs to construct high-density genetic maps for further QTL analysis and genome selection, and can precisely detect the viral load using a TaqMan real-time PCR method. These innovative approaches will unquestionably provide the necessary technical and theoretical support for the industry development of *F. chinensis*.

10:00 (FIS-P-12258)**Gonadal abnormalities in walleye pollock *Theragra chalcogramma***Kristina **Zhukova** and Andrey M. PrivalikhinRussian Federal Research Institute of Fisheries and Oceanography (VNIRO), Moscow, Russia
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In recent years, analyses of large-scale annual commercial catches have detected a constant presence of walleye pollock with abnormal gonads: intersexuality, total or partial atresia and filiform gonads. Most members of this species are gonochoristic, but rare cases of bisexual walleye pollock have been observed by chance in the field. In such gonads, both male and female reproductive tissues were present, but they were separated from each other by connective tissue. Filiform gonads occurred in adult walleye pollock specimens with no sign of gonad development. Microscopic examination revealed intensive growth of the connective tissue and the presence of primary growth oocytes or spermatogonia. In some cases, the germ cells were absent. The occurrence of individuals with ovotestes and filiform gonads was less than 1%. Total and partial atresia serves an adaptive function by regulating fecundity on an individual and population level. The number of females with total oocyte resorption varied in different areas: 0.9-11.1% in the Bering Sea, 0.2-14.6% in the Okhotsk Sea, 4.6-12.6% in Peter the Great Gulf, 2-2.4% in Avacha Bay and 0.8 in the Gulf of Alaska. Total atresia was observed in females and males and led to spawning omission. Partial atresia affects the part of current year's oocytes generation and decreases individual absolute fecundity. The proportion of females with partial atresia varied from 23.4% to 61.9% in the Bering Sea, from 43.4 to 58.2 % in the Okhotsk Sea and from 29.0 to 33.8 % in the Sea of Japan/East Sea.

10:20 (FIS-P-12218)**Scales of variability in forage fish populations: Comparing interpretations of ichthyoplankton and sedimentary records**Ryan R. **Rykaczewski**¹, Brendan D. Turley¹ and Rebecca G. Asch²¹ University of South Carolina, Columbia, SC, USA. E-mail: ryk@sc.edu² East Carolina University, Greenville, NC, USA

Populations of forage fishes exhibit substantial changes in biomass with severe consequences for industries and ecological communities that depend upon them. Understanding the importance of climate-induced variability for these fishes has long been a concern of fisheries oceanographers. For anchovy and sardine, modern observations of changes in population sizes and landings have cultivated the hypothesis that changes in oceanographic conditions have opposing impacts on each taxon, stimulating out-of-phase alternations in biomass. Analyses of fish scales preserved in anoxic sediments challenge this idea. Deposition rates of anchovy and sardine scales have been interpreted to indicate variability in population sizes that are inconsistent with relationships in observational records. However, the assumption that scale-deposition rate is indicative of population size is questionable, and controversy remains as to whether the sediment record offers sufficient evidence to discount paradigms from the modern era. We use a spatially resolved ichthyoplankton record to explore relationships between estimated population biomass and the presence of sardine and anchovy eggs in a coastal location coincident with the area of the paleo-oceanographic fish scale record. We find that the spatially limited sampling leads to an inadequate (and, at times, opposite) impression of population variability. Fish spatial distribution varies with population size, and change in the abundance of fish at one nearshore location is not indicative of similar changes in population biomass. The limitations of short, observational records deserve wider appreciation. However, the sediment record of scales can be subject to over interpretation producing misleading results regarding population variability in forage fishes.

11:00 (FIS-P-12059)**Ichthyoplankton succession and assemblage structure in the Bohai Sea during the past 30 years since the 1980s**Xiaodong **Bian**^{1,2}, Xianshi Jin^{1,2} and Ruijing Wan^{1,2}¹ Key Laboratory of Sustainable Development of Marine Fisheries, Ministry of Agriculture, Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao, PR China. E-mail: jin@ysfri.ac.cn² Function Laboratory for Marine Fisheries Science and Food Production Processes, Qingdao National Laboratory for Marine Science and Technology, Qingdao, PR China

Ichthyoplankton succession and assemblage structure in the Bohai Sea was studied based on a pooled analysis of historical data of fish eggs and larvae sampled from horizontal trawl surveys during oceanographical expedition cruises over the past 30 years, and combined with field surveys of current fish habitat conditions. By using multivariate statistical analysis this study aimed to investigate the seasonal and interdecadal variations in the species diversity and the key species, and the collaborative change rules between the dominant species and important species in the succession process. The analysis results show that the current number of fish species in early stages is only half of the 1980s, and the density only one tenth of the 1980s. During the investigation period, species replacement in the early life stages of fish was obvious, otherwise, the replacement rate was significantly accelerated in recent years. The dominant species of fish eggs did not change significantly at the same season in each investigation period, however, the dominant species of the fish larvae has changed from small continental shelf pelagic-neritic fish to small continental shelf demersal fish. Meanwhile the dominance of the commercial continental shelf demersal fish communities decreased sharply. Temperature adaptation studies on the spawning stock during the same season in each investigation period showed that species number in each temperature adaptation type decreased significantly. However the seasonal or annual percentage of each type remained stable. Habitat studies on the spawning stock at the same season in each investigation period also showed that species number in each habitat type decreased significantly. Annual percentage of the continental shelf pelagic-neritic fish increased, the continental shelf demersal and benthopelagic fish decreased. Under multiple sources of exogenous interference factors, irreversible changes have taken place to every key link of the recruitment process in the early life stages of the fish with habitat loss or fragmentation in the Bohai Sea in the past 30 years. Stressors such as overfishing and climate change promote multidimensional niche disturbance in the fish community and structural decline in fishery resources, while succession and assemblage structure of the fish eggs and larvae is the embodiment of this development.

11:20 (FIS-P-12097)

Development of a growth prediction model for Japanese scallop along the Okhotsk coast of Hokkaido, Japan using RS and FRA-ROMS

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The Okhotsk coast of Hokkaido is the largest Japanese scallop producing region in Japan. Scallops landings have been about 300,000t annually using the sowing culture method. However, the production of Japanese scallop varied both temporally and spatially in recent years. Here we develop a growth prediction model for Japanese scallop using the following data including both observation and model assimilation: 1. Monthly in situ observations of scallop growth (Total weight) at the Saroma Lake station from 2004 to 2014. 2. Monthly buoy observation data at 4m water depth from the Saroma Lake station, including sea temperature, chlorophyll-a (Chl-a), and salinity. 3. Satellite remote sensing data from MODIS, including spatial Chl-a. 4. Seabed water temperature and salinity data from a 1/50° high-resolution ocean model based on an operational ocean forecast system that is called FRA-ROMS. A generalized additive model (GAM) was applied to station observation data, satellite data and 1/50° model data to reveal the influence of environment factors (Chl-a, temperature, salinity) on the growth of scallop, and develop a growth prediction model for Japanese scallop in the Okhotsk sea. The results revealed that GAM is an effective model to predict the vertical growth of scallop, the predict results were well verified by in-situ data ($r^2=0.95$). The key factor affecting scallop growth was water temperature and Chl-a concentration, which was highly related with Soya Warm Current and sea ice.

11:40 (FIS-P-12312)

Long-term dynamics of the greenland halibut population in the Okhotsk Sea

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Variations of greenland halibut abundance in the Okhotsk Sea was examined with data from bottom trawl surveys in 1990-2010s. Each year-class in all areas of the sea was assessed by these surveys at least twice. The age group 9+ was the most abundant in the trawl catches and the abundance of the older age groups decreased exponentially corresponding to natural mortality, so the number of 9-years-old specimens was assumed to be an index of year-class strength. This index was determined for all year-classes hatched in 1984-2004 directly or re-calculated from the number of older age groups using an exponential model. Year-to-year changes of the year-classes in all the main areas (at West Kamchatka, Kuril Islands, and East Sakhalin) were similar, evidence of their common origin from spawning grounds located over the continental slope at West Kamchatka. They were numerous in the 1980s and gradually decreased later, reflecting the dynamics of the whole population. However, the year-class strength of the stock in the northern Okhotsk Sea, originated from the same spawning grounds, had the opposite variation, interpreted as the influence of water circulation change. Geostrophic circulation in the Okhotsk Sea provided transport of halibut eggs and larvae from the spawning grounds to the southern areas until the late 1980s, but to the northern area recently. Recently halibut was concentrated mostly in the northern Okhotsk Sea where its commercial stock reached $50 \cdot 10^6$ ind. Possible reasons for population depression were analyzed.

12:00 (FIS-P-12316)

Seasonal distribution of commercial concentrations of saffron cod (*Eleginus gracilis* (Til.)) on the shelf of West Kamchatka

Olga **Novikova**

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Saffron cod, no matter what is the state of general stock abundance and biomass, demonstrates several areas of stable commercial concentration on the shelf of West Kamchatka. The areas are situated within three water masses in the south-west, central and north parts of the shelf, and this distribution coincides with the distribution of the main forage organisms. Winter observations revealed density increases near the Second Kuril Strait (50°30' - 51°30' N) and between 52°00' - 53°00' N and 54°00' - 55°00' N. In spring and summer saffron cod aggregated near the strait, migrated northward and then reaggregated there in the area between 51°30' and 52°00' N. Two areas of dense saffron cod concentration also appeared on the shelf in the southwestern (52°30' - 53°30' N) and northwestern (54°00' - 55°00' N) parts. Analysis of the vertical distribution of the catches of saffron cod revealed that the most dense aggregations in winter occurred at depths from 50 to 100 m and that the principal catches (70-80%) in spring and summer occurred at depths <50 m.

MEQ Contributed Paper Session

September 29

09:00 (MEQ-P-12021)

Yessotoxins: History, existence, risk and warning

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Yessotoxins (YTXs) is a group of disulfated polyether toxins produced by marine dinoflagellate which was first separated from *Patinopecten yessoensis* of Japanese Mutsu Bay in 1986. Until now, Norway, Italy, New Zealand, Chile, Japan, Russia, Ireland, America, China and other countries have also detected YTXs in shellfish and algae. There are reports on YTXs which can cause damages to cells, cardiac muscle, liver and pancreas and neuronal tissue. YTXs accumulate in shellfish and have high acute toxicity to mice by intraperitoneal injection of lipophilic extracts, and YTXs have been found to be potent cytotoxins. Although there are no dead events recorded for YTXs, and a quite high regulatory level of 3.75mg YTX equivalents/kg in shellfish has been established in Europe and some countries. But it is safe for people and marine ecosystem existing YTXs although no death and under the threshold value? Are there potential risks? Some discussion and warning were done base on the study of the existence and distribution of YTXs for past years in China coast.

Keywords: Yessotoxin; *Protoceratium reticulatum*; shellfish; existence and distribution

09:20 (MEQ-P-12037)

Monitoring of marine bioresources safety in the Far Eastern Seas

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Marine bioresources of Far Eastern Seas are the abundant and diverse source of protein food for the population of Russian Federation and neighboring East Asian countries. It is obviously, that growing population, economic development, increase of industrial and agricultural production in the region of North-Eastern Pacific contribute to environmental condition of marginal seas, and the safety of seafood for human health is an objective of high priority.

Due to the initiative of Fisheries Agency of Russian Federation, ecological monitoring of bioresources safety and environmental quality of Far Eastern Seas is developing in TINRO-Center. During 2011 - 2016 screening researches are carried out to provide the determination of aliphatic hydrocarbons, microelements, chlorinated pesticides, PAHs, and PCBs in sea water, bottom sediments, marine bioresources on the different levels of food chain from seaweed and invertebrate to commercial fish and mammal species from fishing areas of Far Eastern Seas – Japan/East, Okhotsk and Bering Seas.

It was indicated, that organic pollutants demonstrates rather low concentrations in the marine environment of coastal areas, excluding petroleum hydrocarbons. Crabs and shrimps, involving in the benthic food web accumulate arsenic to high level of concentrations. Fish feeding mammals intensively accumulate mercury in the pristine environmental condition, but some mammalian species e.g. gray whale showed very low mercury concentration in tissues due to benthos feeding. These findings are to provide information of the marine bioresources safety and to predict the quality of marine environment of Far Eastern Seas.

09:40 (MEQ-P-12096)

Environmental evolution of Fukushima-derived ^{134}Cs in the Northwest PacificWu **Men**¹, Wen Yu, Yusheng Zhang, Jianhua He, Fenfen Wang, Yiliang Li, Feng Lin, Fangfang Deng and Jing Lin¹ Laboratory of Marine Isotopic Technology and Environmental Risk Assessment, Third Institute of Oceanography, State Oceanic Administration, 184 Daxue Road, Xiamen 361005, China. E-mail: menwu@tio.org.cn

Fukushima Daiichi Nuclear Accident (FDNA) aroused a worldwide anxiety and concern. To understand the transport of the radioactive contaminants released from FDNA in the northwest Pacific, 12 monitoring cruises were performed by the State Oceanic Administration of China from 2011-2016. More than 500 stations were monitored. This paper reports the monitoring results of the 12 cruises and their demonstrated environmental evolutions of ^{134}Cs in seawater and marine organisms.

Generally, the level of ^{134}Cs in the seawater decreased with the time, the highest activity of ^{134}Cs decreased from 756Bq/m^3 in June of 2011 to 0.92Bq/m^3 in September of 2016. In order to obtain more detail information on the environmental evolutions of ^{134}Cs , the study areas were divided into 4 area, including the open sea area of east of Japan, open sea area of southeast of Japan, open sea area of southeast of Taiwan Island, northeast area of south China Sea and East China Sea. The different variations of ^{134}Cs in these areas were controlled by the complicated physical oceanography characteristic including sub-tropic mode water, Kuroshio Current, meso-scale eddy and their interactions.

As for the marine organisms, we analyzed plenty of squid samples and shark samples. The levels of ^{134}Cs in these samples and the variations were obtained. To link the radioactivity pollution to possible harm, the radiation dose was assessed. It revealed that the dose rates absorbed by marine organisms following the release of Fukushima-derived ^{134}Cs were much lower than the ERICA ecosystem screening benchmark of $10\ \mu\text{Gy/h}$. It is no need to worry about the radiation impacts on the marine organisms in the broad Northwest Pacific.

10:00 (MEQ-P-12145)

Sediment accretion and carbon sequestration in tidal flat of Liaohe estuaryJinqiu **Du**^{1,2}, Daoming Guan^{1,2}, Ziwei Yao², Guangshui Na², Hui Gao² and Chuanlin Huo³¹ Department of Marine Chemistry, Ocean University of China, Qingdao, P.R. China
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Estuarine wetland has high sediment accretion rate and carbon sequestration capacity, it plays an important role in maintaining the stability of the coastal zone and the mitigation of climate change. This study focuses on Liaohe estuary, sediment core samples were collected in July 2016 at reed beach and intertidal mudflat, content and distribution of TOC, TC, TN and radionuclides were analyzed, and the effect of vegetation on sediment accretion and carbon sequestration were discussed. The results showed that the content of TOC is higher in reed beach affected by vegetation than that of intertidal mudflat, while their ratios of C/N are basically the same, so they should have the same source of sedimentary organic carbon; the average sediment accretion rate was calculated to be $1.92\text{ cm}\cdot\text{a}^{-1}$ at reed beach by ^{210}Pb method, and to be $3.67\text{ cm}\cdot\text{a}^{-1}$ at intertidal mudflat; the accumulation rate of sedimentary organic carbon at reed beach surface is $92.9\text{ g}\cdot\text{m}^{-2}\cdot\text{a}^{-1}$, while it is $158.9\text{ g}\cdot\text{m}^{-2}\cdot\text{a}^{-1}$ at intertidal mudflat surface. In conclusion, sediment accretion rate of intertidal mudflat was significantly higher than that of reed beach, this resulted in that accumulation rate of sedimentary organic carbon in the low TOC content intertidal mudflat to be higher than that of reed beach, thus showing the high sediment accretion rate of estuarine wetland is conducive to the accumulation of sedimentary carbon.

POC Contributed Paper Session

09:20 (POC-P-12116)

Recent reduction of dissolved oxygen in the North-western Pacific and Japan Sea

Dmitry **Kaplunenko**¹, Vyacheslav Lobanov¹, Pavel Tischenko¹, Sergey Sagalaev¹, Sho Hibino², Toshiya Nakano², Shi Xuefa³ and Liu Yanguang³

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The recent activity and collaboration of V.I. Il'ichev Pacific Oceanological Institute (POI), Japan Meteorological Agency (JMA) and First Institute of Oceanography (FIO) have allowed to obtain high accuracy data on the vertical distribution of oceanographic parameters (temperature, salinity, oxygen concentration) in the water basins of Japan Sea (POI and JMA) and the North-western Pacific (POI and FIO). The field work in the Japan Sea were conducted by the R/V *Keifu Maru* and R/V *Akademik M.A. Lavrentyev* with two coupled CTD sections covering the central part of the sea and located in Japanese (PM-line transect) and Russian (134E section) EEZs. This work started in the Japan Sea in 2011 as a part of a North East Asian Regional Global Observing System (NEAR-GOOS) activity. The survey in the North-Western Pacific were held by R/V *Akademik M.A. Lavrentyev* with joint Russian-Chinese cruises, and are part of a project that studies paleo and modern climate of marginal North East Asian seas and North-Western Pacific, started in the 2010. The aim of this study is to characterize the variability of observed parameters during the last 7 years, and to compare our results with other existing data (e.g. eWOCE atlas of Schlitzer, 2000). The calibration equations for CTD-units, obtained during the NEAR-GOOS PM-line execution were applied later in the next cruises of R/V *Akademik M.A. Lavrentyev* for measurements in the North-Western Pacific. Our results demonstrate a significant decrease in dissolved oxygen concentration in both the North-western Pacific and Japan Sea. The most dramatic reduction was observed in the North-western Pacific at the depth over 750 m.

09:40 (POC-P-12174)

Evaluation of climatological mean surface winds over the Korean Waters simulated by CORDEX regional climate models

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Surface wind over the ocean not only influence climate change through air-sea interactions but also coastal erosion through changes in wave height and direction. A reliable projection of future changes in surface winds is thus important, and it is necessary to perform an assessment of their representation in climate models that are widely used for future projections. This study aims to evaluate the climatological mean surface winds over the Korean Waters simulated by five Coordinated Regional Climate Downscaling Experiment for East Asia (CORDEX-EA) regional climate models. Compared with the ERA-interim reanalysis data, the CORDEX regional models, except for the HadGEM3-RA model, produce a stronger wind speed over most area of the Korean Waters both in summer and winter. Unlike the other models, HadGEM3-RA, without spectral nudging, underestimates the amplitude of the seasonal mean wind speeds. When examining the wind direction, three out of the five models realistically simulates the observed seasonal reversal of winds (northwesterly in winter and southeasterly in summer) while the other two models show southerly in summer. Our results suggest that large-scale flow information, downscaled to regional models by means of spectral nudging, can significantly affect the surface winds on a regional scale.

10:00 (POC-P-12252)

Timing of unprecedented climate in Korea: A linear projectionHo-Jeong Shin¹, Chan Joo **Jang**^{1,2} and Il-Ung Chung³¹ Korea Institute of Ocean Science and Technology, Ansan, Gyeonggi-do 15627, R Korea. E-mail: cjang@kiost.ac.kr² University of Science and Technology, Daejeon 34113, R Korea³ Gangneung-Wonju National University, Gangneung, Gangwon-do 25457, R Korea

Recent extreme weather events worldwide combined with the emergence of the highest surface temperatures recorded since the emergence of human life on Earth raise the question if such extreme climate events will occur more frequently and become normal in the future. This study aims at identifying the timing of emergence of a statistically unprecedented climate state over Korea with special focus on its regional footprints. In this study, we use an in-situ observational data from weather stations of annual-mean surface air temperature in Korea from 1973 to 2015 and estimate the timing of unprecedented climate using a linear regression method. Based on the in-situ data, unprecedented climate in Korea is projected to be statistically significant (above the 95% confidence level) by 2043 in Cheongju at first and by 2168 in Haenam at last. The 125-year gap in the timing indicates that a regional difference in the timing of unprecedented climate is considerably large in Korea. Despite the sensitivity of the linear estimation to the data period, our findings of large regional differences in the timing of unprecedented climate can provide insight to develop policies for mitigation and adaptation to climate change, not only to the central government but to provincial governments.

10:20 (POC-P-12319)

Regional variation of heat transfer to deep sea during the recent warming hiatusYong **Lin**¹, Peifu Cong and Shuxi Liu¹ National Marine Environmental Monitoring Center (NMEMC), SOA, Dalian, Liaoning, China, PR. E-mail: ylin@nmemc.org.cn

The heat transfer to the deep sea (HTDS) has been identified as the main driver of the recent warming hiatus in previous studies. However, large inconsistencies exist on the role of the ocean because of biases in model simulations of changes in oceanic heat content (OHC) and problems with the OHC data quality. We propose a novel approach to solve these problems by assuming that the long term changes of HTDS leave an imprint on sea surface temperatures (SST), which are considered to be more reliable. Based on the rate of change and amplitude of SST, we show that the recent warming hiatus is mainly related to the Southern Hemisphere (SH), especially the tropical latitudes, the Pacific and Indian Oceans rather than the Atlantic Ocean.

11:00 (POC-P-12062)

Increasing Pacific decadal variability under greenhouse forcingGiovanni **Liguori** and Emanuele Di Lorenzo

Georgia Institute of Technology, Atlanta, Georgia, USA. E-mail: giovanni.liguori@gmail.com

Decadal changes in Pacific climate impact long-term transitions in marine ecosystems and influence the statistics of weather including ocean and atmosphere extremes such as strong droughts, hurricanes and marine heatwaves. Using observational analyses of basin-scale sea surface temperatures (SST) we show that the variance of the El Niño-like decadal variability is increasing in the period 1940-2016 by ~30% and its coupling (e.g. lag correlation) with major climate modes of the Pacific is intensifying. The significance of these trends, and their link to greenhouse forcing, is confirmed by examining an ensemble of 30 simulations of the Community Earth System Model (CESM-LE) over the period 1920-2100 forced with the RCP8.5 radiative forcing scenario. In the CESM-LE, we find that a significant trend in the strength of the winds-evaporation-SST (WES) thermodynamic feedback leads to an intensification of the low-frequency variance of the North Pacific Meridional Mode (NPMM), which in turn energizes the El Niño-like Pacific decadal variability through its El Niño precursor thermodynamics and dynamics. The stronger SST anomalies associated with the NPMM also reinforce the coupling with El Niño and the climate coupling between tropics and extra-tropics. This suggests that an important fraction of the observed and modeled trends in ENSO variance under greenhouse forcing may be caused by stronger thermodynamics coupling to meridional modes in the North Pacific.

11:20 (POC-P-12115)**The influence of seasonal upwelling and downwelling on a coastal fjord: An example from Rivers Inlet, Canada from 1951 to 2017**Jennifer M. **Jackson**¹, Brian P.V. Hunt^{1,2} and Frank Whitney³¹ Hakai Institute, Victoria, BC, Canada
E-mail: jennifer.jackson@hakai.org² University of British Columbia, Vancouver, BC, Canada³ Fisheries and Oceans Canada, Sidney, BC, Canada

Rivers Inlet is a 45 km long, 3 km wide fjord situated in British Columbia's mainland central coast. At the surface, the circulation of Rivers Inlet is dominated by estuarine and atmospheric forcing (Hodal, 2011). Once home to the second largest sockeye salmon run in British Columbia, salmon stocks crashed in 1999 to less than 1% of their historical level and have shown few signs of recovery. Physical (temperature, salinity, and oxygen) data have been collected in Rivers Inlet since 1951 and biological data (chlorophyll, zooplankton, nutrients, etc.) have been collected since about 2000. From 2008 to 2010 and from 2013 to present, the University of British Columbia and the Hakai Institute have been collecting year-round data in Rivers Inlet, with about 10-15 cruises per year. Here we examine this 66 year physical dataset in the context of seasonal upwelling and downwelling to understand i) the seasonal cycle, ii) interannual variability, and iii) climatic scale changes.

11:40 (POC-P-12324) (Cancelled)**Simulation of river runoff in Siberia and the propagation of this fresh water in the Arctic**Viktor **Kuzin**, Gennady Platov and Natalya LaptevaInstitute of Numerical Mathematics & Mathematical Geophysics Siberian Division, Russian Academy of Sciences, Novosibirsk, Russia
E-mail: kuzin@sscc.ru

The temporal variability of river runoff is modeled for eleven Siberia rivers: Ob, Taz, Pur, Yenisei, Khatanga, Anabar, Olenek, Lena, Yana, Indigirka and Kolyma. The model is a linear model of reservoirs with the surface, underground and river runoffs. Conditions of runoff formation were verified based on the results of the reanalysis. For comparison, we examined data from GMAO MERRA. The results show an increase in runoff for the last decades, which is consistent with observations. We also examine changes during the 21st century using output of ten selected models from the CMIP5 under the radiative scenario RCP8.5. In the numerical experiments, we find differences between individual models, however, the overall tendency across models exhibits a positive trend in runoff.

The spread of the Siberian river runoff water masses in Arctic was examined with a model of the ocean and the sea-ice of the Arctic Ocean. The simulation results, based on calculated transport of Siberian rivers, for six IPCC models were compared with the results, obtained using mean climatological seasonal variation of their runoff. The specifics of how river water anomalies propagate in the Arctic Ocean have been studied. It is shown that river water plays an important role in regulating the fresh water balance in the Arctic. Significant changes of the balance is linked to changes in the sign of the Arctic Ocean Oscillation index.

12:00 (POC-P-12121)

Characterizing the shelf ecosystem status using heat, momentum, and energy fluxes in the near-bottom layers over the continental shelf

Vadim Navrotsky, Valeriy Liapidevskii, Elena Pavlova and Fedor Chrapchenkov

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Geographically and physically the continental shelf is the boundary between the coastal zone and the open ocean. It is the site of the most active physical, chemical, biological, and bio-geomorphologic interactions between land and ocean, thus controlling key ecological processes that are societally relevant (e.g. ocean productivity). The goal of this study is to examine the effects of hydrodynamic processes on the state of shelf ecosystems. One of the main controlling factor for biological processes and the oceanic food web is the supply of nutrients, which in shelf regions is realized mainly through land discharges and near-bottom dynamic processes that lead to re-suspension and mixing of bottom nutrient-rich sediments. Results from experiments carried out in the shelf zone of the Peter the Great Gulf, Sea of Japan, show that fluxes of heat, momentum, and energy in the near-bottom layers exhibit important seasonal differences. During the warm period, stratification internal wave motion are much greater than during the cold season, which is characterized by homogeneous vertical structure. Corresponding differences in spatial structure of chlorophyll concentration, which we use as an indicator of the ecosystem state, are discussed.

W1: MONITOR/TCODE Workshop

The role of the northern Bering Sea in modulating the arctic II: International interdisciplinary collaboration

September 23

09:10 (W1-12257) Invited

Flow of pacific water in the Chukchi Sea: Results from RUSALCA expeditions

Maria N. Pisareva¹, Robert S. Pickart², Michael A. Spall², G.W. Kent Moore³, Katrin Iken⁴, Elizaveta A. Ershova^{1,4,6}, Jacqueline M. Grebmeier⁵, Lee W. Cooper⁵, Bodil A. Bluhm^{4,6}, Russell R. Hopcroft⁴, Carin J. Ashjian² and Ksenia N. Kosobokova¹

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Chukchi Sea is an important transition zone for the Pacific-origin water that flows northward through Bering Strait and influences the interior Arctic Ocean. As it carries large amounts of freshwater and heat and is also a significant source of nutrients, phytoplankton and zooplankton to the region, it is crucial to study its properties and transformation on the Chukchi shelf.

Here we present results from three shipboard biophysical surveys in 2004, 2009 and 2012, that sampled both the US and Russian sides of the Chukchi shelf as part of international interdisciplinary collaboration - RUSALCA program, complimented with various atmospheric and biological fields. The hydrographic characteristics and pathways of Pacific-origin water masses as well as their relation to the patterns of benthic fauna and zooplankton are investigated.

In some respects the spatial distributions of these water masses are as would be expected based on information from the historical World Ocean Database, but there were significant differences. Most notably, twice the warm fresh Alaskan coastal water was diverted from its normal coastal pathway northwestward through Herald Canyon and in September 2009 the two main summer waters entering the Chukchi Sea were transposed in Bering Strait. It is argued that this was the result of atmospheric forcing. The flow speed map is constructed based on hydrographic data, while patterns of benthic fauna coincide with different flow regimes. For the most part, benthic epifaunal and macrofaunal suspension feeders are found in high flow regimes, while deposit feeders are located in regions of weaker flow.

09:30 (W1-12221)**Modeling the sympagic-pelagic-benthic coupling processes in the St. Lawrence Island Polynya region, northern Bering Sea**Zhixuan **Feng**¹, Rubao Ji¹, Carin J. Ashjian¹, Jinlun Zhang², Robert G. Campbell³ and Jacqueline M. Grebmeier⁴¹ Woods Hole Oceanographic Institution, Woods Hole, MA, USA. E-mail: zfeng@whoi.edu² University of Washington, Seattle, WA, USA³ University of Rhode Island, Narragansett, RI, USA⁴ University of Maryland Center for Environmental Science, Solomons, MD, USA

The Pacific Arctic Ocean is experiencing significant changes in atmosphere, sea ice, and ocean that may alter the marine ecosystem. The St. Lawrence Island Polynya (SLIP) region in the northern Bering Sea is one of the major biological hotspots. The highly productive benthic communities provide abundant prey for benthic-feeding mammals and seabirds, particularly the endangered spectacled eiders. Yet, major ecosystem shifts are occurring in the SLIP region, such as the observed declining trend in the percent biomass of the medium-sized nuculanid bivalves. Historical hydrographic and biogeochemical measurements and ice-ocean-ecosystem model outcomes are synthesized to elucidate the relationships between wind, sea ice, hydrography, nutrients, and production processes in this high-latitude continental shelf system. The model captures the annual cycles and seasonal patterns of the water column physical structure, nutrients, and primary production, and export production. In the wintertime, the mixing process brings high nutrients from the bottom water to the surface. A spring bloom occurs when light becomes available for photosynthesis and is typically associated with the formation of wind-driven polynyas. In the summertime, a two-layered water column is built up mainly due to thermal stratification. Nitrate and ammonium are gradually depleted in the surface water and concurrent high zooplankton grazing results in low phytoplankton standing stock. Meanwhile, nutrients are accumulated in the bottom water due to benthic remineralization. With later ice advance in recent years, a fall bloom may become more prevalent. The analyses of bottom-up forcing and sympagic-pelagic-pelagic coupling will facilitate the prediction of the persistence or relocation of benthic hotspots and also the development of management strategies to mitigate detrimental effects from climate change in the Pacific Arctic Ocean.

W2: HD Workshop**Coastal ecosystem services in the North Pacific and analytical tools/methodologies for their assessment****September 22****14:00 (W2-12249) Invited****Integrating the value of marine ecosystem services into decision making: A case study of Xiamen, China**Benrong **Peng**

College of Environment and Ecology, Xiamen University, A 107, Huansheng Bld., Xiang'an Campus, Xiamen University, Xiamen, Fujian, PR China. E-mail: brpeng@xmu.edu.cn

Wellbeing of coastal communities and toward sustainable development are vitally dependent on the goods and services provided by the marine ecosystems. But while demands for the marine ecosystem services such as food and raw materials and ocean space are growing, human actions are diminishing the capability of many marine ecosystems to provide these services, which jeopardize the sustainable development of coastal communities with high density population. Valuing the marine ecosystem services and integrating these values into decision-making are effective and efficient approach to balance the economic development and coastal ecosystem conservation.

This study presented some concrete examples of integrating marine ecosystem services' value into decision-making in Xiamen, including regional development and environmental protection programme, coastal reclamation planning, and internalizing the externality of human activities through ecological damage compensation. This presentation also discussed the role of scientist in instilling value of ecosystem services, and providing the support for the decision making related to the coastal development and protection.

14:30 (W2-12082)**Valuing the loss of ecological benefits of wetland reclamation in Jiaozhou Bay based on choice experiments**Jingmei **Li** and Qi Chen

School of Economics, Ocean University of China, Qingdao, PR China
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This paper aims to evaluate the loss of ecological benefits caused by wetland reclamation, based on choice experiment method in Jiaozhou bay. By reviewing literature and consulting experts, we divide the wetland restoration attributes into four parts: wetland area, vegetation cover rate, water quality and biodiversity in the wetland. By sampling 293 residents in Jiaozhou bay at random, also evaluate the willingness to pay about different wetland restoration attributes in Jiaozhou bay: the willingness to pay is RMB 321.78 per year in order to restore each attribute to the baseline level. Then we can figure out that the loss of ecological benefits caused by wetland reclamation in Jiaozhou Bay is RMB 767 million per year. The result further shows that the change of wetland area is the first most important concern of local residents, while the improvement of water quality is the second most important concern. Therefore, the government should make a proper restoration policy in which enlarging the wetland area should be the key point.

Key words: Loss of Ecological services; Reclamation; Choice experiments; Willingness to pay; Jiaozhou Bay

15:00 (W2-12233)

Marine ecosystem services assessment methods

Shang **Chen**, Wei Liu, Tao Xia and Linghua Hao

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Concepts and assessment frameworks of marine ecosystem services are developed. The marine ecosystem services includes four groups of services, i.e. the provisioning, regulating, cultural and supporting services. Provisioning services are material products provided by marine ecosystem, including food production, raw material production, oxygen production and genetic resources provision. Regulating services are the benefits obtained from the regulation of ecosystem processes, including climate regulation, waste treatment, disturbance regulation and biological control. Cultural services are the nonphysical benefits obtained from ecosystems, including: leisure and recreational activities, scientific services, cultural activities. Supporting services are those that are necessary for the production of all other ecosystem services, including primary production, nutrient cycling and biodiversity maintenance. They are different from provisioning, regulating and cultural services in that their impacts on people are often indirect or occur over a very long time. The procedures and methods for identification, quantification and monetization of marine ecosystem services are established. Moreover the procedure for mapping and overlap of spatial distribution map of the value of each services are established too.

Keywords: marine ecosystem services; assessment; value; methods.

15:50 (W2-12127)

What influences people's value of marine ecosystem services: A case study of Japan

Kazumi **Wakita**¹, Hisashi Kurokura², Taro Oishi³, Zhonghua Shen⁴ and Ken Furuya²

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⁴ LDWC International Business Support Co. Ltd., Tokyo, Japan

Marine ecosystem services are crucial to sustain people's lives, and how to sustain its healthy ecosystem is one of the major policy agenda for all countries. Understanding people's value of marine ecosystem services and their motivation for conservation is an important first step towards successful conservation of marine ecosystem services. This study takes interdisciplinary approach that combines environmental economics and social psychology in examining relationships between people's value of marine ecosystem services and factors which influence their value, using a questionnaire conducted to receive 945 responses from residents in Japan. The analysis reveals that the groups of respondents with a higher WTP to conserve marine ecosystem services have higher public spirit and stronger connections with other people and invisible things such as spirits. On the other hand, the groups of free riders who have no WTP to conserve marine ecosystem services have lower public spirit and weaker connections with others, both humans and non-humans. The percentage of free riders were 17%, whereas that of positive payers were 14%. People's degree of support for theory of global warming caused by increase of carbon dioxide and that for future forecast of increase of carbon dioxide do not seem to influence their WTP. Considering that scenario provided to the respondents was about status of marine ecosystem services in 100 years later, the respondents' WTP is interpreted as representing a kind of people's altruism.

16:15 (W2-12177)

Development of a relative coastal vulnerability index for climate change adaptation and environmental changes in the North Pacific coastal zone

Meenu **Rani**¹ and Pavan Kumar²

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The degree to which society is potentially vulnerable to the impacts of climate change can be expressed through an assessment of either the biophysical (external) or social (internal) elements at risk. The research work has utilized Remote Sensing and GIS techniques for assessing vulnerability of the Trivandrum coast, India due to predicted sea level rise. Multi-sensor satellite data has been interpreted using on-screen visual interpretation techniques to generate coastal thematic information followed by ground truth data collection and validation. Geospatial models for carrying out regional coastal vulnerability assessment of the entire Trivandrum coast. A new approach of integrating physical variable has been developed and demonstrated in GIS environment. Coastal Vulnerability Index (CVI) has been computed for entire Trivandrum coast based on integration of eight physical variables, those are: relative sea level, coastal geomorphology, regional elevation and coastal slope, rate of shoreline change, coastal accretion and erosion, significant wave height, land use land cover and suspended sediment concentration in GIS environment. The results show that 42 % of the Trivandrum coast is under high to very high risk category and 54 % of the Trivandrum coast is under Moderate to Low risk category due to the threat of predicted sea level rise. The area under very high risk category is along north-western part of the Trivandrum coast and the area under high risk category is in southern part of the coast. The integration of eight physical variables have made it possible to assess the coastal vulnerability more realistic for prioritizing the coastal segments for planning remedial actions while preparing integrated coastal zone management plans. The major parameters affecting vulnerability are dynamic of sea level, slope and coastal erosion. Sea level rise is a realistic approach with the coastline geometry. Obviously, sea level change solely affects the configuration of the coastal areas other factors and also play a major role in hammering the west coastal environment of Trivandrum. Therefore, the analysis of coastal vulnerability to sea level rise has many advantageous sights. The vulnerability analysis provides valuable information that helps to priorities major issues which need to be addressed.

Keyword: CVI, Relative sea level, Climate change, Geospatial modeling, Vulnerability analysis

W3: FIS Workshop

Linking oceanographic conditions to the distribution and productivity of highly migratory species and incorporation into fishery stock assessment models

September 22

09:00 (W3) Invited

Challenge and opportunity for fisheries stock assessment in changing environments

Yong **Chen**

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The complex, nonlinear and dynamic human-natural interactions in fisheries hinder full understanding of fisheries population dynamics, causing management decisions to be made in the face of large uncertainty. Climate change has further increased the level of complexity and uncertainty in ecosystems. As a result, we are often unsure of fish population dynamics and possible consequences from management regulations. To reduce the likelihood of unintended damages to marine ecosystems, we need to reduce the uncertainty associated with our understanding of dynamics of target fish populations and their ecosystems. In this presentation, I will discuss possible challenges facing fisheries stock assessment in changing environments and identify some of the opportunities we have to improve our understanding of fisheries dynamics. In particular, I will discuss the use of environmental data to improve stock assessment. Drawing from research conducted in previous studies, I will show how we can identify research avenues to address some of the challenges facing fisheries stock assessment in an uncertain climate.

09:40 (W3-12231)

Consequences of environmentally driven uncertainty in productivity for management of North Pacific Albacore tuna

Desiree **Tommasi**¹, Barbara Muhling¹, Steven Teo² and Gerard Di Nardo²

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Changes in ocean conditions are known to affect the productivity (recruitment, growth, survival) of many valuable marine fish, including highly migratory species like Albacore tuna (*Thunnus alalunga*). Both climate variability and change are expected to alter North Pacific Albacore tuna (NPALB) productivity, with implications for fisheries management. To maintain resilience of the NPALB population under climate change and limit sociological and economics impacts, future fishery management advice needs to be robust to uncertainty in productivity. Here we outline a Management Strategy Evaluation (MSE) framework based on the Stock Synthesis software and designed to assess the consequences of uncertainty in NPALB productivity for achieving NPALB management objectives. We show preliminary results highlighting how temperature-driven, time-varying growth and non-stationarity in the stock-recruitment relationship affect NPALB management performance metrics in the context of future climate projections.

10:05 (W3-12198)

Dynamic ocean management applications for the Drift Gillnet fishery in the California CurrentElliott L. **Hazen**^{1,2}, Kylie L. Scales^{1,2}, Heather Welch^{1,2}, Dana K. Briscoe^{2,3}, Steven J. Bograd^{1,2}, Heidi Dewar⁴, Suzy Kohin⁴, Scott Benson⁴, Tomo Eguchi⁴, Larry B. Crowder³, Rebecca Lewison⁵ and Sara Maxwell⁶¹ NOAA Southwest Fisheries Science Center, Environmental Research Division, 99 Pacific St. #255, Monterey, CA, 93940, USA
E-mail: Elliott.hazen@noaa.gov² UC Santa Cruz, Department of Ecology and Evolutionary Biology/Institute of Marine Sciences, 100 Shaffer St., Santa Cruz, CA, 95060, USA³ Stanford University, Hopkins Marine Station, 120 Ocean View Blvd, Pacific Grove, CA 93950, USA⁴ NOAA Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA, 92037, USA⁵ San Diego State University, Department of Biology, 5500 Campanile Dr, San Diego, CA 92182, USA⁶ Old Dominion University, Department of Biology, 5115 Hampton Blvd, Norfolk, VA 23529, USA

Managing for economic and ecological sustainability in marine fisheries often requires novel approaches. Current spatial management approaches use large-scale seasonal closures to avoid bycatch, but here we present an ecoinformatic tool termed *dynamic ocean management* that provides management targets aligned with ocean features in space and time. Such targeted management approaches require mechanistic or statistical models of how distribution and likelihood of catch varies with the oceanic environment. Data on top predators are often sparse and collected using multiple platforms, e.g. fisheries catch, fisheries independent surveys, and telemetry studies, an approach that synthesizes across data type would provide a more holistic understanding than a single approach alone. Here we explore the California Drift Gillnet fishery that targets swordfish, thresher shark, and mako shark, but also catches a number of species as bycatch including but not limited to sea lions, sea turtles, and blue sharks. This tool is built in R Shiny and uses habitat models and risk weightings to estimate catch / bycatch ratios as a function of management concern in near time. Anomalous ocean conditions such as recent marine heatwaves can change species distribution patterns, thus we can use this tool to examine how predicted patterns in catch and bycatch change. Dynamic ocean management approaches could be applied to other migratory species for which data are available, and this example emphasizes the utility in integrating multiple data types for marine conservation and management.

10:50 (W3-12093)

Optimal harvest strategies of sandfish based on a stage-structured model in the East SeaGiphil **Cho**¹, Sukgeun Jung² and Il Hyo Jung¹¹ Pusan National University, Busan, R Korea. E-mail: giphil@pusan.ac.kr² Jeju National University, Jeju, R Korea

We propose optimal harvest strategies using a stage-structured fishery model with impulsive system. The economical objective is to maximize the profit of fishing in fisheries management. Fishing effort used to harvest is used as a control to investigate the optimal utilization of the resource in economic sense. We analyze the economical optimal harvest strategy of sandfish caused by monthly price change. The optimal control problem is solved numerically using forward backward sweep method. Simulation results show the difference of the harvest strategies of the sandfish with and without considering monthly price. We expect that maximum sustainable yield of the sandfish can be increased by approximately 13.5% due to the optimal harvest strategies. The parameters of reproduction rate and growth equation of the sandfish in the model were derived from data of otolith and gonad analyses of female sandfish collected from 2005 to 2008. And we estimated the age-specific natural mortality of the sandfish assuming natural mortality as an inverse function of total length.

11:15 (W3-12105)

Differences in biological characteristics of Pacific cod (*Gadus macrocephalus*) between the East and the Yellow Sea, Korea

Kyunghwan **Lee** and Sukgeun Jung

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Pacific cod (*Gadus macrocephalus*) is one of the important commercial fish in the western North Pacific. In the Korean waters, habitats of Pacific cod are largely divided into the Yellow and the East Sea. To compare the growth and maturation characteristics of Pacific cod between the two seas, a total of 261, 322 cod samples were collected in the East Sea from January to December 2003, January to February 2007, and 682 samples in the Yellow Sea from January to December 2007. The regional differences in von Bertalanffy growth equation were compared by Kimura's likelihood ratio test and Wald test. The probability of spawning by adult cod was estimated by logistic regression equation. Significant regional differences were detected in 1) relationship of total length and body weight 2) von Bertalanffy growth equation and 3) median maturity length. The East Sea cod showed a higher growth rate than the Yellow Sea cod and female cod showed a higher growth rate than male cod. The estimated median maturity lengths suggested that the Yellow Sea cod (male: 2.3 yr, female: 2.6 yr) matured earlier than the East Sea cod (male: 3.9 yr, female: 4 yr) for the both sexes. We hypothesized that these differences in growth and maturation of cod are attributed to the regional differences in the marine environment between the two seas.

11:40 (W3-12143)

Individual-based model of chub mackerel (*Scomber japonicus*) covering from larval to adult stages to project climate-driven changes in their spatial distribution in the western North Pacific

Sukgeun **Jung**

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I projected the effects of warming ocean on the transport, recruitment and spatial distribution of chub mackerel (*Scomber japonicus*) covering from the larval to the adult stages up to age 3 yr by developing and applying individual-based models (IBM) based on a regional ocean circulation model for the western North Pacific and a biological model for predicting the growth-dependent mortality and the passive and active movement of mackerel. Under two climate change scenarios, my IBMs tentatively suggested that the larval and juvenile mackerel in the Korea Strait, the Japanese coastal areas and the Kuroshio extension areas are mostly transported from the East China Sea where they were hatched. Despite the greater uncertainty, the preliminary results of my IBMs projected that, by the 2050s, the strengthened Tsushima warm current in the Korea Strait and the East Sea, driven by global warming, will shift the young-of-the-year mackerel biomass distribution north to the East Sea, and adult mackerel biomass north, especially in the Yellow Sea. To improve the model performance, international cooperative researches among the regional countries are required, especially for extensive ichthyoplankton surveys in the East China Sea.

12:05 (W3-12053)

Oceanographic influences on the spawning and recruitment of Pacific bluefin tuna

Barbara A. **Muhling**^{1,2}, Desiree Tommasi^{1,2} and Gerard DiNardo²

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Pacific bluefin tuna (*Thunnus orientalis*) migrate throughout most of the North Pacific ocean, and are occasionally found as far south as New Zealand. Despite this very broad range, they are only known to spawn in two small areas in the western North Pacific: the Taiwan and Nansei Islands area during boreal spring, and the Sea of Japan during summer. As a result, environmentally-driven variation in larval survival within these small spatiotemporal windows can determine annual recruitment strength for the entire population. In this study, we show how basin-scale processes influence each spawning ground differently, and how distinct oceanographic temperature regimes are linked to recruitment variability. We also consider the potential mechanisms driving spawning season length, and suitability of oceanographic conditions for larval survival. The potential predictability of annual recruitment strength using forecast models is also briefly discussed.

12:30 (W3-12247)

Development of methodology for analyses of larval ambient water temperature of Pacific bluefin tuna using SIMS

Yulina V. **Hane**¹, Shingo Kimura¹, Yusuke Yokoyama¹, Yosuke Miyairi¹ and Takayuki Ushikubo²

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Pacific bluefin tuna (PBT), *Thunnus orientalis*, is among the most commercially valuable species in Japan. Their primary spawning grounds are located in the waters off eastern Taiwan and Ryukyu Islands in the south of Japan and in the Sea of Japan with spawning temperature to be approximately 26–27°C and 24°C respectively. However, recent seawater temperature rise due to the climate change may be causing their spawning grounds to be shifted northward, possibly leading to declining survival rates of larvae and juveniles. Otolith oxygen isotope ratio ($\delta^{18}\text{O}$) is a proxy for estimating water temperature experienced by fish. Previous study has proposed an equation for estimating water temperature experienced at the larval stage from PBT otolith $\delta^{18}\text{O}$ using bulk samples with isotope ratio mass spectrometry, though specific temperature experienced by larvae has not been revealed due to their small size. This study investigates temporal changes in spawning temperature by analyzing otolith core $\delta^{18}\text{O}$ of giant PBT caught off the waters around Japan. The SIMS (Secondary Ion Mass Spectrometry) techniques, a high sensitive surface analytical method with a spatial resolution of sub- μm to 10 μm , will be used to measure $\delta^{18}\text{O}$ of otolith core. As obtaining stable beam of $\delta^{18}\text{O}$ strongly depends on the surface condition and chemical composition of samples, it is crucial to establish a sample preparation protocol before SIMS measurement to assure the data quality. This talk introduces our recent efforts in developing the preparation protocol to obtain a mirror-surfaced thin section containing multiple otolith cores for the SIMS analysis.

HAB-S Meeting

September 23

11:15 (HAB-S-11989)

2016 Red Tide in China

Hao **Guo**, Dongmei Li, Yubo Liang and Chunjiang Guan

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About 68 events of marine red tides with an affected area of 7,500 km² were witnessed along Chinese coastline. The occurrences and affected area of red tides were markedly increased compared with a year earlier. The bloom threshold concentrated during April to August. The sea areas where the marine red tides occurred frequently were mainly distributed in East China Sea, about 37 red tide events with an affected area of 5,700 km². The most cases of blooms caused by *Noctiluca scintillans*. A new record red-tide-species, *Gyrodinium impudicum*, break out in Bohai Sea from 27th, Aug. to 29th, Sep. In addition, the distribution area of green tide, *E. Prolifera*, is the largest in recent 5 years.

14:00 (HAB-S-12333) (July 27, updated, after accepted edits)

An analysis of dynamic factors influencing the 2013 giant jellyfish bloom near Qinhuangdao in the Bohai Sea, China^{1*}

Lingjuan **Wu**¹, Jia Wang², Song Gao¹, Xiangrong Zheng³, and Rui Huang¹

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The explosive growth of *Nemopilema nomurai* occurred near the coastal waters of Qinhuangdao in July 2013. However, it did not take place in 2012. In this paper, the dynamic factors of wind, ocean currents, and sea temperature on the giant jellyfish bloom in 2013 are analyzed more comprehensively than in the past. The numerical experiments are based on a trajectory model of the jellyfish particles, which are released into the waters from Feiyan Shoal to mouth of the New Yellow River, speculated as the most likely remote source of the Qinhuangdao jellyfish bloom. The results show that in surface layer, the jellyfish drift is jointly driven by the surface winds and surface currents. In the northeastern Bohai Bay, the giant jellyfish moved northwestward in the surface layer with a westward wind and current anomalies during the second half of May 2013. This bloom approached the south of Jingtang Port by early June, and accumulated near Qinhuangdao in early July. The scenario in 2012 during the same period was quite different. The simulated jellyfish particles influenced by waters near Qinhuangdao decreased with depth and there were few(no) particles influencing Qinhuangdao in the middle (bottom) layer due to weak anticyclonic residual circulation in Bohai Bay. The sea temperature of potential jellyfish source waters was more suitable in 2012 for a jellyfish bloom than in 2013, but only if there was adequate jellyfish prey present. Hence, the specified direction of wind and current pattern in the Bohai Sea in the surface layer (especially in the northeastern Bohai Bay during the second half of May) was more important for the initiation of jellyfish bloom near Qinhuangdao than sea temperature in that source region.

Keywords: Giant jellyfish; bloom; Qinhuangdao; dynamical factors, Bohai Sea

14:25 (HAB-S-12043)**Ultrastructure and phylogenetic position of a kareniacean dinoflagellate collected from Japanese coast**

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The unarmored dinoflagellates of the family Kareniaceae are mainly composed of the genera *Karenia*, *Karlodinium* and *Takayama*, and some of the members are responsible for fish killing red tides. We examined morphology and phylogeny of a small unarmored dinoflagellate isolated from Japanese coast, based on SEM, TEM and molecular phylogeny inferred from LSU rDNA sequences. The species has the small epicone, and chloroplasts mainly situated in the large hypocone. The straight apical groove could be observed under SEM. TEM revealed the typical organelles of dinoflagellates, i.e., a dinokaryotic nucleus located in the hypocone, mitochondria with tubular cristae, and trichocysts. Chloroplasts contain three appressed thylakoids and stalked pyrenoids surrounded by a starch sheath without any insertion in the matrix. An eyespot, located at the sulcal region and containing a single layer of osmiophilic globules is the characteristic feature, which has not been reported from any kareniacean dinoflagellates. Molecular phylogeny showed the small species is positioned in the family Kareniaceae, but not closely related to the clades of well-known genera, *Karenia*, *Karlodinium* and *Takayama*.

14:50 (HAB-S-12224)**An under-ice phytoplankton blooms in Peter the Great Bay: Are they controlled by environmental factors?**

Tatiana Y. **Orlova**¹, Polina A. Kameneva¹, Vladimir M. Shulkin² and Alexander Lazaryuk³

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Long freezing time (3-3.5 months) is a peculiarity of Peter the Great Bay, East/Japan Sea situated as south as at 42N. Phytoplankton bloom under ice is also feature of this area discovered more than 30 years ago. Diatoms were the dominant species of winter blooms at that time. According to the last two decades observation at the Peter the Great Bay some shift in the winter blooms timing and composition of the phytoplankton community was registered though exact reasons of it are not revealed. This talk will present the results on be-weekly variability of the phytoplankton and hydrochemical characteristics at winter time in the inner part of the Peter the Great Bay in 2009-2016. Relationship of phytoplankton's composition and biomass with hydrological conditions during and before winter blooms was studied. The freezing process controls the dynamic of diatom phytoplankton growth under ice in the middle of winter through the support of vertical advection. End of freezing in March leads to the blooms of non-diatom phytoplankton with significant accompanying hydrochemical anomalies due to destruction of produced biomass. Possible reasons of the phytoplankton community composition and biomass variability in the inner part of Peter the Great Bay coastal area in winter will be discussed.

W4: MEQ Workshop**Long-term changes in HAB occurrences in PICES nations; the Eastern vs. Western Pacific****September 22****09:00 (W4-12283) Invited****Long-term monitoring of the toxic dinoflagellate *Alexandrium tamarense* and environmental factors in Osaka Bay, eastern Seto Inland Sea, Japan: History of invasion and expansion of toxic blooms**Keigo **Yamamoto**¹ and Ichiro Imai²¹ Marine Fisheries Research Center, Research Institute of Environment, Agriculture and Fisheries, Osaka Prefecture, Tanigawa, Tanigawa, Misaki-cho, Osaka 599-0311, Japan. E-mail: YamamotoKeig@mbox.kannousuiken-osaka.or.jp² Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido 041-8611, Japan

The expansion of the toxic blooms by the dinoflagellate *Alexandrium tamarense* in Osaka Bay, eastern Seto Inland Sea, Japan, was examined by monitoring at 13 or 20 sampling stations from 2002 to 2016, together with long-term monitoring of environmental factors from 1975 to 2016. In Osaka Bay, paralytic shellfish poisoning (PSP) was first detected from bivalves in the spring of 2002. Since then, the occurrences of *A. tamarense* blooms and the resultant PSP contamination of bivalves have been observed every year. *A. tamarense* blooms were mainly observed from March to May in Osaka Bay, at a temperature of 15 °C or lower and the salinity approximately 30. High cell densities were observed at lower nutrient conditions, especially low phosphate. Dissolved inorganic nitrogen (DIN) declined from the 1980s, as a long-term trend, and the decreasing trend became conspicuous since the 2000s. Phosphate drastically declined until the 1990s, thereafter it is kept at a low level. *A. tamarense* blooms in Osaka Bay increased in scale from the 2000s and thereafter. Long-term trends in the dynamics of *A. tamarense* populations were considered to be negatively related to both the concentration of DIN and the cell densities of the dominant diatoms in Osaka Bay. Seasonal blooms of *A. tamarense* in Osaka Bay are considered to be induced by declines in phosphate concentrations. However, the long-term expansion of *A. tamarense* appears to be related to a declining trend in DIN concentrations and subsequent decrease in spring blooms of the dominant diatoms, especially of *Skeletonema* spp.

09:45 (W4-12122) Invited**Observed climatic and oceanographic variations related to harmful algal blooms: Comparisons between the western and eastern North Pacific**Nicholas A. **Bond**Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, P.O. Box 354925, Seattle, WA, 98195-4925, USA
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The North Pacific Ocean features considerable variability in physical conditions on time scales of months to decades. A notable recent example is represented by the northeast Pacific marine heat wave of 2014-16, which has been implicated in a harmful algal bloom (HAB) of unprecedented scope and intensity along the west coast of North America. The present study uses atmospheric and oceanic reanalyses to document the character of major climate and oceanographic events, and long-term trends, along the western and eastern margins of the North Pacific Ocean during the last ~50 years. The focus is on physical environmental variables known or suspected to be related to HABs. The objective is to help establish the extent to which particulars in the climate forcing and upper ocean response can be linked to the presence (or absence) and severity of HAB outbreaks in the historical record.

10:50 (W4-12083)

Trends of HAB occurrences and related environmental parameters in the NOWPAP region

Takafumi **Yoshida** and Genki Terauchi

CEARAC (Special Monitoring and Coastal Environmental Assessment Regional Activity Centre), NOWPAP (Northwest Pacific Action Plan), 5-5 Ushijimashin-machi, Toyama City, Toyama, 930-0856, Japan. E-mail: yoshida@npec.or.jp

NOWPAP CEARAC published the first Integrated Report on Harmful Algal Blooms (HAB) for the NOWPAP Region in 2005 and the second Integrated Report in 2011 in order to share information on HAB occurrences among the four NOWPAP member states (China, Japan, Korea and Russia). In these reports, information on HAB occurrences is available from 1990s to 2008 even though the exact periods of data are different among the member states. According to the collected data, 50–60 HAB events were observed every year in the NOWPAP region; however, there was no clear trend on HAB occurrences.

In 2010, CEARAC started an activity on assessment of the eutrophication status in the NOWPAP region. At first, parameters that indicate the degree and direct and indirect effects of nutrient enrichment were collected for the assessment, and ‘the number of red tide events’ was included as one parameter. In addition, in the 2014-2015 biennium, CEARAC carried out trial application of the screening procedure of the NOWPAP Common Procedure for eutrophication assessment and collected long term data on three parameters (COD, red tide and hypoxia events, and satellite derived chlorophyll-*a* concentration) in the NOWPAP region. Relationship between HAB occurrences and environmental conditions were being studied.

11:10 (W4-12170)

Temporal changes in *Cochlodinium polykrikoides* ribotypes and environmental factors in Korean coastal waters

Tae-Gyu **Park** and Weol-Ae Lim

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We surveyed temporal changes in *C. polykrikoides* blooms and environmental factors (temperature, salinity and inorganic nutrients) from 2010 to 2016. Temporal changes in ribotypes of *C. polykrikoides* for the last 10 years were also surveyed using ribotype specific real-time PCR. *C. polykrikoides* blooms mostly initiated offshore (30 to 50 meters in depth) and were advected inshore by coastal currents. Whereas the blooms have not occurred in closed bay in Korea. The blooms occurred in 2012 to 2015 at 500-15,000 cells mL⁻¹ whereas did not occurred in 2010, 2011 and 2016. We compared environmental factors between bloom occurring years and non-bloom years. There were no significant differences in temperature and inorganic nutrients between bloom (average 23.25±1.78°C, DIN 0.032±0.023 mg L⁻¹) and non-bloom years (average 23.3±2.28°C, DIN 0.039±0.024 mg L⁻¹). The blooms tend to occur at high salinity waters (salinity 32-34) but occurred at low salinity (30.63-31.18) in 2014 at maximum cell density of 2000 cells mL⁻¹. Two ribotypes were detected by real-time PCR during 2007 to 2016. East Asian type was detected in every year, whereas Philippines type was detected in 2007, 2009, 2011 and 2016. The cell density of East Asian type occupied more than 99% compared with Philippines type. The blooms lasted average 20 days when Philippines type was detected, whereas the blooms lasted average 54 days when East Asian type was only detected.

11:30 (W4-12264)

Can large scale of *Karenia* blooms in China coastal waters be linked to climate (weather) signals?

Douding **Lu**¹, Xinfeng Dai¹, Pengbin Wang¹, Ping Xia¹ and Weibing Guan¹, Haiyan Huang² and Leo Chan³¹ Second Institute of Oceanography, SOA, Hangzhou 310012, PR China. Email: doudinglu@sio.org.cn² National Marine Data and Information Service, Tianjin, 300171, PR China³ State Key Lab of Marine Pollution, City University of HongKong, PR China

Karenia mikimotoi bloom was first recorded in HongKong waters 1980 in China. The second record was probably in Xiamen Harbor, 1986. However, over 120 blooms caused by this species occurred in China coastal waters since 1998. Particularly, the massive bloom of *K. mikimotoi* in the South China Sea in 1998, 2016 and in the East China Sea in 2005, 2012 resulted in the heavy loss of fish and shellfish farming industry. These four large scale HAB events seemed corresponding to climate, El Nino, signal. Generally, there is more rainfall in the east and south coastal areas in China during El Nino years. Air and sea water temperature in winter time are lower than the mean level. Our results show that water temperature in March 2005, 2012 was obviously lower than that of normal years in Zhejiang and Fujian coastal sea especially in nearshore region of coastal waters compared to the same period of other years. Special meteorological and sea conditions (low air temperature and strong northern monsoon, more rainfall and feeblish Taiwan Warm Current) were observed from January to March. Warming rate of temperature was relatively fast in April and May. These special conditions might provide a well physical, biological and chemical environment for the growth of *K. mikimotoi* to compete with other species. In the case of 2005, *K. mikimotoi* became dominant late April in an offshore subsurface layer after a diatom bloom. This led to the development of the first large-scale bloom of *K. mikimotoi* recorded in the ECS which caused severe damage to farmed caged fish in inshore waters in late May and early June. There is a strong need to better identify long-term trends for this HAB organism in the context of climate change pressures.

11:50 (W4-12205)

Long-term trend of harmful algal blooms and environmental factors in the Seto Inland Sea of Japan

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The Seto Inland Sea is the largest enclosed coastal sea in Japan and is also a major fishing ground including aquacultures of fishes, bivalves and seaweeds. In 1960s and 1970s, red tide incident had markedly increased in frequency and scale with serious eutrophication in the sea, and the maximum 299 incidents per year was recorded in 1976. In 1973, governmental regulations regarding eutrophication was enforced based on laws, then the red tide incident decreased around 100 incidents per year with decreasing DIN from about 10 μM in the 1970s to ~ 5 μM in the late 1990s to the present, and large scale of red tide reduced. In Harima-Nada, eastern part of the Seto Inland Sea, a long-term monitoring of raphidophyte *Chattonella* spp. has been carried out from 1973, along with environmental factors and other phytoplankton compositions. The data shows that nutrient levels exhibited a decreasing trend and it is thought that *Chattonella* cannot form large-scale bloomings under the present conditions. In addition, after the mid 1990s, the occurrence period of *Chattonella* cells have been several weeks earlier than that of the 1970s and early 1980s, and *Chattonella* blooms have peaked at the time of rainy season mainly in early July. Due to the earlier occurrence, the bloom frequency has increased in the northern coastal area of Harima-Nada, where most of the large-rivers discharge into Harima-Nada, although the cell density and the spatial scale of the distribution have become lower and smaller than those in the 1970s and early 1980s.

12:10 (W4-12294)

Decadal time series tell a story about climate and HABs

S. Morgaine **McKibben**¹, Angelique E. White², William P. Cochlan³ and Vera L. **Trainer**⁴

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In 2015, a massive bloom of the marine diatom *Pseudo-nitzschia*, stretching from central California to northern British Columbia, resulted in severe damage to coastal resources and marine life. It is the largest bloom in at least the past 15 years, and concentrations of the toxin, domoic acid, in seawater, some forage fish, and crab samples were the highest ever reported for this region. Marine mammal and bird mortalities were reported in multiple states, with domoic acid poisoning the cause of impaired health or a strong contributing factor to compromised marine animal health. While domoic acid events have been reported on the U.S. west coast since 1991, it has been difficult to determine the environmental controls promoting the most severe events until now, after more than 2 decades of data are available for analysis. These data show that the most severe domoic acid events coincide with or follow anomalously warm phases of the Pacific Decadal Oscillation and the Oceanic Niño Index as well as the 2015 warm anomaly, known colloquially as the Blob. These decade-long datasets illustrate the need to assess environmental conditions prior to as well as during these HABs to better understand the sequence of factors that may promote blooms. For example, *Pseudo-nitzschia* may survive for long periods of time under nutrient stress, then respond quickly to rapid influxes of nutrients, allowing for successful competition with other phytoplankton for resources needed for growth. The data types needed to accurately and completely tell the story about HABs and their relationship to climatic factors will be discussed.

14:00 (W4-12279)

Species composition and long-term dynamics of potentially toxic dinoflagellate species in benthic assemblages of Peter the Great Bay, Sea of Japan

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The species composition and the seasonal and long-term changes in benthic dinoflagellate assemblages remain poorly studied. Like planktonic forms, benthic dinoflagellates can produce toxins causing the death of fish and various types of poisoning of warm-blooded animals and humans. A total of about 30 species of the benthic dinoflagellates which can produce various types of toxins and bioactive chemical compounds are known to date. Of particular interest is the study of seasonal phenomena in the flora and fauna of temperate seas, especially shallow waters, where the annual cyclicality of environmental conditions is the most pronounced. The long-term dynamics of the species composition and abundance of toxic species in epiphytic and sand-dwelling dinoflagellate communities of the upper subtidal zone were studied in Russian waters of the Sea of Japan. Five potentially toxic species were found: *Amphidinium carterae*, *A. gibbosum*, *A. operculatum*, *Ostreopsis* cf. *ovata*, and *Prorocentrum foraminosum*. Two species are the constant components of the summer-autumn community of epiphytic dinoflagellates. Among them, *Ostreopsis* cf. *ovata* reaches a high density and prevails in autumn. The *P. foraminosum* density was significantly lower, but the species was observed in the epiphytic community for a longer period. Significant interannual variations in the density of these species were noted. In contrast to the epiphytic assemblages, the population density of all the potential toxic species in coastal sand was very low.

14:20 (W4-12126)**Long-term trends in abundance and impacts of *Cochlodinium fulvescens* M. Iwataki, H. Kawami & K. Matsuoka (Gymnodiniales, Dinophyceae) in British Columbia, Canada, from the Harmful Algae Monitoring Program time series**Nicola **Haigh**Harmful Algae Monitoring Program, Microthalassia Consultants, 3174 Rock City Rd., Nanaimo, BC, Canada
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The Harmful Algae Monitoring Program has been collecting data on phytoplankton species diversity and abundance, with a focus on species that are harmful to finfish, in coastal British Columbia (BC), since 1999. In 1999 blooms of *Cochlodinium fulvescens* killed farmed salmon in BC, but during the past 18 years we have seen a decrease in abundance, and associated economic and environmental impacts, of this species. The area with the most frequent *C. fulvescens* blooms is Clayoquot Sound, on the west coast of Vancouver Island. In the period of July – September, from 1999 to 2009, *C. fulvescens* was present in an average of 69% of weekly samples sent from this area; from 2010 to 2016 it was only present in an average of 37% of weekly samples. Bloom concentrations of *C. fulvescens* were seen in 1999 – 2002, 2004, 2006, 2009, and 2012; in 1999 – 2001 and 2006 for 33 – 50% of the July – September period, and for the other years only 8 – 17 % of the time. No significant fish kills have been reported from *C. fulvescens* in BC since 1999. This decrease in *C. fulvescens* does not appear to correlate with any environmental parameters or climate patterns.

14:40 (W4-12007)**The bloom species succession and related potential alien species in East China Sea**Jinhui **Wang**^{1,2}, Yutao Qin^{1,2} and Hong Cheng³¹ East China Sea Branch, SOA, Shanghai, 200137, PR China, E-mail: wangjinhui@189.cn² Key Laboratory of Integrated Monitoring and Applied Technology for Marine Harmful Algal Blooms, SOA, Shanghai, 200137, PR China³ Ocean University of Shanghai, Shanghai, 201306, PR China

The tendency of harmful algal blooms (HAB) and related alien species in the East China Sea was analyzed since the 1990s. Recently, changes in the biogeography of harmful dinoflagellates (*Heterocapsa circularisquama*, *Prorocentrum dentatum*) and raphidophytes (*Heterosigma akashiwo*, *Chattonella marina*) have been detected along the Chinese coast. Strong northward shifts in the spatial distribution of *Phaeocystis globosa* and *Karenia mikimotoi* blooms have been documented.

Some new species formed bloom in different part of China which never been found before, species introductions including issues of anthropogenic sources (e.g. ballast water) or natural systems (e.g. species range extension) will be analyzed based on geographical distribution and long series monitoring data. These blooms can have detrimental effects on macrofauna, diatoms, macrophytes and may threaten Sustainability. The degradation of the chemical equilibrium induces the break-down of the biological balance in the ecosystem and can become troublesome. An alternance between free-floating seaweed proliferations and phytoplankton blooms indicate the higher levels of eutrophication.

15:00 (W4-12244)

Long-term changes in HAB occurrences in Amursky Bay, Russia

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The results of long-term changes in microalgae communities as well as analysis of HABs species dynamics in Amursky Bay (East/Japan Sea) during the period 1970-2016 were summarized. A total number of 43 potentially toxic and bloom-forming microalgae have been identified. Several species of potentially toxic haptophytes, dinoflagellates and diatoms are reported for the first time in the study area. The revealed changes and trends in the composition and distribution of microalgae communities are as follows: long-term changes in microalgae communities are observed; there is a decreasing of diatom component of microalgae communities which substituted by the non-diatom component; new bloom-forming species were detected for the study area and new toxin producing species were revealed. The species richness increased; there are species-specific changes in the abundance and seasonal dynamic of HAB taxa like *Pseudo-nitzschia*, *Karenia*, *Ostreopsis*, *Prorocentrum*, *Dinophysis*, *Heterosigma*, *Pseudohaptolina*); a list of species causing blooms in the bay was expanded. For the last two decades some species of harmful algae (e.g., toxic dinoflagellates and haptophytes benefiting water column stratification, warm water benthic dinoflagellates and cyanobacteria responding to increased water temperatures) became more common. Possible reasons of HABs occurrences in Amursky Bay are discussed.

This study was supported by the Russian Foundation for Basic Research (projects 17-04-01394 and 15-04-05643a).

15:20 (W4-12128)

Oceanographic conditions that lead to large *Pseudo-nitzschia* blooms in coastal waters

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Pseudo-nitzschia blooms periodically have resulted in massive toxic events along the eastern boundary of the Pacific, threatening marine ecosystem and human health, and causing substantial economic impacts. By contrast, toxic *Pseudo-nitzschia* blooms are rare along the western margin of the Pacific, even though low abundances of toxic *Pseudo-nitzschia* species occur commonly within coastal phytoplankton communities. The recent massive bloom along the California and British Columbia coast during 2015, and an anomalous toxic bloom in the Gulf of Maine during 2016, present useful comparisons that may explain the founding factors for large *Pseudo-nitzschia* blooms. Pennate diatoms of the genus *Pseudo-nitzschia* demonstrate unusually efficient macronutrient and iron uptake capabilities that help these species persist under prolonged low nutrient conditions, which helps to explain the widespread presence of this genus in coastal and offshore waters. Combined with a strong ability to regulate cell sinking rates, seen by their ability to form thin layers in surface waters, these physiological attributes would facilitate greater competitive success and retention of *Pseudo-nitzschia* in stratified, low nutrient surface waters. We explore the significance of these unique characteristics in explaining the different prevalence of toxic *Pseudo-nitzschia* blooms in the eastern vs. western Pacific, and how climate change may increase the frequency of these toxic events in both regions in the future ocean.

16:00 (W4-12235)

Blurred lines: Multiple freshwater and marine algal toxins at the land-sea interfaceMelissa B. **Peacock**¹, Corinne Gible², David B. Senn³, James E. Cloern⁴ and Raphael M. Kudela⁵¹ Salish Sea Research Center, Northwest Indian College, Bellingham, WA, USA
E-mail: mpeacock@nwic.edu² California Department of Fish and Wildlife, Office of Spill Prevention and Response,³ Marine Wildlife Veterinary Care and Research Center, Santa Cruz, CA, USA⁴ San Francisco Estuary Institute, Richmond, CA, USA⁵ United States Geological Survey, Menlo Park, CA, USA⁶ Ocean Sciences Department, University of California Santa Cruz, Santa Cruz, CA, USA

The California Current spans nearly 3,000 km, from Southern British Columbia to Baja, California. Over the last few years, there have been multiple, dramatic algal toxin events within the California Current, including the 2015 Amnesic Shellfish Poisoning event, the emergence of Diarrhetic Shellfish Poisoning in the Pacific Northwest, and freshwater microcystin poisoning of California sea otters. These events have led to broad public, management, and scientific interest in algal toxins. Current management practices separate freshwater and marine harmful algae, and sample organisms or toxins that “should” be present, or have been historically problematic in water bodies. Here we look at San Francisco Bay, CA, USA, a region that has been monitored for harmful algae for more than 20 years, but historically has been assumed not to have harmful algal bloom problems. From 2011–2016 we used particulate, dissolved, and shellfish sampling to identify that multiple toxins are present nearly all the time, and that at least four toxins are present simultaneously in 37% of our sampled shellfish, including domoic acid, microcystins, Paralytic and *Dinophysis* Shellfish Toxins. Here we discuss what chronic or acute toxin exposure means, and ask the question: is broader monitoring necessary to protect non-commercial shellfish harvesters? These findings are put in the context of ecological drivers using seasonal and multi-year trends, and explore improved monitoring and management efforts to deal with the simultaneous presence of multiple toxins.

16:20 (W4-12225)

The effects of ocean acidification and temperature on the growth and toxicity of *Pseudo-nitzschia australis* from the California Current upwelling systemWilliam P. **Cochlan**¹, Charles J. Wingert¹, Christopher E. Ikeda¹ and Vera L. Trainer²¹ Romberg Tiburon Center for Environmental Studies, San Francisco State University, Tiburon, CA, USA
E-mail: cochlan@sfsu.edu² Marine Biotoxins Program, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, USA

Two critically important alterations of the coastal waters of the California eastern boundary upwelling system (EBUS) - increased temperature and elevated CO₂ levels, were examined in controlled laboratory studies of the impactful toxigenic diatom *Pseudo-nitzschia australis* Frenguelli. Our results demonstrate the adaptive capability of this pennate diatom to grow and produce the potent neurotoxin, domoic acid (DA), as a function of these abiotic factors during their nutrient-replete, exponential growth phase and their nutrient-depleted, stationary growth phase. Non-axenic strains of *P. australis*, isolated from Monterey Bay, CA during the massive West Coast 2015 bloom of this species, were exposed to a range of temperatures (5, 7, 9, 11, 13, 15, 17 and 19 °C) using a custom-build incubator, and to four pH levels (8.1, 8.0, 7.9 and 7.8) regulated by direct injection of compressed CO₂/air mixture into culture flasks. Laboratory findings demonstrate that this diatom species reaches maximal growth rates at ~17–18 °C with specific growth rates increasing by ~3-fold from 5 to 17 °C. Stationary cells increased domoic acid production as the partial pressure of CO₂ (*p*CO₂) increased, and particulate DA was 3-fold greater at pH 7.8 compared to pH 8.1. However, exponential growth rates were not affected until a critical pH of 7.8 was reached when growth rates declined by 30%. These laboratory results reveal the capability of *P. australis* to rapidly increase its growth potential in warm waters, and to become increasingly toxic in more acidic waters - environmental conditions expected in the California EBUS due to CO₂-induced ocean acidification and greenhouse warming.

W6: BIO Workshop**Advantages and limitations of traditional and biochemical methods of measuring zooplankton production****September 22****09:10 (W6-12203) Invited****Revising our traditions: An overview on method and results of growth and production estimates for zooplankton**Andrew G. **Hirst**^{1,2}¹ School of Biological and Chemical Sciences, Queen Mary University of London, Mile End Road, E1 4NS, UK² Centre for Ocean Life, National Institute for Aquatic Resources, Technical University of Denmark, Kavalergården 6, 2920, Charlottenlund, Denmark. E-mail: ag.hirst@qmul.ac.uk

Estimating growth and production rates of zooplankton, and copepods in particular, is important in describing flows of material and energy through pelagic systems. Quantifying the major patterns and limits to growth rates is also important in understanding what may control these fundamental physiological and fitness terms. In advancing our understanding we have developed and utilised a range of ‘traditional’ techniques in order estimate the rate of accumulation of mass in growing copepods, this is a body of work which now spans over 50 years and hundreds of publications. Over the past decade we have made some important mathematical and methodological improvements to the approaches. The aim of this talk is critically explore our current position regarding the range of traditional methods we have at our disposal, describe improvements on these methodologies, and to review the published results and explore their implications. Finally, we will make recommendations for best practice in future, and how we may best place ourselves in order to address the questions and challenges that face us.

9:50 (W6- 12286)**A comparison of zooplankton secondary production in a high nutrient low chlorophyll (HNLC) and seasonally productive regions in the North Pacific**Lian E. **Kwong**¹ and Evgeny A. Pakhomov^{1,2}

Presented by Natalie Mahara on behalf of Lian E. Kwong

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Zooplankton play a pivotal role in the World’s oceans, directly linking phytoplankton to fisheries productivity. Zooplankton secondary production (ZSP) is defined as the rate of increase in biomass through time, and incorporates zooplankton growth (somatic and reproductive) and mortality. Because marine ecological processes are strongly size dependent, rates of ZSP can be measured from normalized biomass size spectra (NBSS). Zooplankton net samples, multi-frequency acoustics, and chlorophyll-a data collected in collaboration with Fisheries and Oceans Canada (DFO) during two monitoring voyages (Line P and La Perouse) covering three seasons (winter, summer and fall) over a 20-year period (1995-present) were combined to produce NBSS. Three methods of quantifying secondary production (i.e., chitobiase [Sastri and Dower, 2006, 2009], point observations of size spectra [Basedow et al. 2014], size spectra time series [Edvardson et al., 2002]) are compared using the Saanich Inlet, BC, time series (biweekly sampling from 2015-2017). Calculated ZSP rates using the three time series will provide a direct comparison of secondary production in high nutrient low chlorophyll (HNLC/iron-limited) regions and seasonally productive regions within the North Pacific. It is envisioned that these estimates of ZSP will be included in future food-web and biogeochemical models. Preliminary estimates of ZSP over the past two decades will be presented.

10:00 (S5/W6-12261)

Zooplankton communities in the coastal northeast Pacific Ocean: A comparison of a highly productive region and a light-limited high nutrient, low chlorophyll region

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Zooplankton have long been recognized as an important link between primary producers and higher trophic levels. The Discovery Islands (DI) and Johnstone Strait (JS) regions along the northeastern side of Vancouver Island, BC remain vastly understudied biologically. JS has been proposed as a trophic gauntlet where zooplankton limits higher trophic levels due to environmental conditions, highlighting the need for a better understanding of local zooplankton communities. Preliminary data suggest JS is permanently well-mixed with low temperatures, high surface nutrient concentrations, and low chlorophyll biomass throughout the spring and summer months. In the DI, stratified stations have productive surface waters, whereas well-mixed stations have low primary productivity similar to conditions found in JS. This suggests that environmental conditions directly influence primary productivity, however the same link has not been demonstrated in the connection with zooplankton communities. Vertical zooplankton tows were conducted at 9 sites throughout the DI/JS region from mid-April until early-July in 2015 and 2016. Data suggest that zooplankton community composition is >55% dissimilar between JS and DI sites. Cluster Analysis suggests that within the DI, community similarity depends on a combination of seasonality and stratification, with zooplankton composition being >65% dissimilar in some cases. In Johnstone Strait, zooplankton communities before mid-May appear to be approximately 50% dissimilar to those after mid-May. Understanding the drivers behind spatial and temporal changes in zooplankton communities along the BC coast may lead to a better understanding of trophic dynamics in marine ecosystems.

10:20 (W6-12256)

Coupling crustacean zooplankton production and primary production rates to estimate trophic transfer efficiencies in the NE Pacific

Theresa A. **Venello**¹, John F. Dower¹ and Akash R. **Sastri**^{1,2}

Presented by Akash R. Sastri on behalf of Theresa A. Venello

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Crustacean zooplankton production rates were measured off the west coast of Vancouver Island and along Line P to Ocean Station Papa during 2015-2017 using the chitobiase method. Various methods were also used to measure primary production rates. By coupling measures of crustacean zooplankton productivity and primary productivity we are able to directly estimate trophic transfer efficiency (TTE). Although generally assumed to be 10%, we have found TTE to vary both spatially and temporally, ranging from 0 to 22%. Off the west coast of Vancouver Island in May 2016, sampling stations on the continental shelf had an average TTE of 9.3%, while stations located off the shelf averaged 4.9%. Along Line P, nearshore stations had an average TTE of 6.2% in February, 13.9% in June, and 8.7% in August, whereas offshore stations had averaged 8.6% in June and 11% in August. The routine coupling of crustacean zooplankton production rates and primary production rates to estimate TTE provides insight into how much energy is actually being transferred at the base of the marine food web. Additionally, quantifying spatiotemporal variability in TTE (i.e. instead of simply assuming 10%) will help to better parameterize and constrain ecosystem models.

POSTERS

S1-Paper Session

S1-P1

Influence of temperature changes on the bottom marine biota in the western part of Tatar Strait

Alexander A. Dulenin and Polina A. Dulenina

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The spatio-temporal macrobenthos changes in the western Tatar Strait (the most cold-water area in the Sea of Japan) on the example of the two dominant groups - macroalgae and bivalves, are presented. The studied area is 600 km. Currents form the temperature inversion: average summer water temperature in the north of the area is 1°C higher than in the south (11.7 vs 10.7 °C, respectively.) The temperature increased by 2°C in the last 40 years - from 10 to 12°C.

The macrophytes average relative biomass grows from 4 kg/m² in the southern to 6.2 kg/m² in northern part. Temporal changes are examined by the relative stock of a commercial species *Saccharina japonica*. For 18 years, it has grown 2 times (from 125 to 250 tons/km).

The bivalves species composition changes are found: 19 species have expanded their habitat areas to the north. The ratio of thermophilic species among them (9 species, 47%) is much higher than in the whole regional fauna (21%), while cold-water ones are presented only by 2 species (11%).

An analysis of the species composition of the two faunistically representative bays (Sovetskaya Gavan in the south and Chikhacheva in the north) showed that the thermophilic species proportion increases northerly (15 and 34%, respectively). At present, commercial clusters (up to 20 kg/m²) of a subtropical-low-boreal species *Crassostrea gigas* has appeared in the north. In the 80-s of the last century only the sparse settlements were noted.

So, the macrobenthos abundance and composition correspond to the temperature dynamics. The study results are statistically significant, these data are used for natural resources management and fishery forecasting.

S1-P2

Forecast for 4 anadromous fish stocks status in the rivers of the mainland part of Tatarsky Strait (Sea of Japan) to the end of the 21st century

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For four anadromous fish that are significantly different from each other, by biological cycles and the environment, the dynamics of their productivity is analyzed according to the materials of their catches in the 20th and 21st centuries. All of these species are reproduced in the rivers of the mainland coast of the Tatarsky Strait and go to the feeding grounds in the Sea of Japan. The main threat to their populations in this area is considered poaching. Secondary threats: logging and forest fires. Areas of reproduction of these fish is sparsely populated and all rivers are not blocked by dams.

Pink salmon *Oncorhynchus gorbuscha* – abundant commercial fish. The peaks of industrial fishing (up to 13,000 MT) were recorded in 1926 and in 2016. Masou salmon *Oncorhynchus masou* – abundant commercial fish. Masou salmon, unfortunately, was listed without justification in the regional Red book.

Sakhalin taimen *Parahucho perryi* – not abundant species. Inhabits rivers, and feeds in the estuary part of the river, rarely entering sea. Valuable trophy fish for anglers. Sakhalin sturgeon *Acipenser mikadoi* is a really rare protected species (Red book of the Russian Federation, IUCN).

Presentation makes a forecast for 4 anadromous fish stocks status and possible ways for its using to the late 21st century.

S1-P3**The directivity of the ecosystem processes in the spawning-nursery lake and the optimal spawning escapement**

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The climate changes in the North Pacific bring some effects on ecosystems of sockeye salmon spawning-nursery lakes and abundance of local stocks there. Kuril Lake (Southern Kamchatka) is the spawning and nursery site for the biggest in Asia sockeye salmon (*Oncorhynchus nerka*) stock named "Ozernovskoye". Since 2000 the stock and the catches on the shores have been increased, The spawning escapement to the lake was not fixed and varied in a wide range behind the optimal 1,5 million spawners. The escapement was set stable (optimal) from 2008. In terms of the stable sockeye salmon spawning escapement until 2014 the weight of 2+ smolts was higher than a longterm average. At the same time the conditions of juvenile feeding characterized by the biomass of plankton crustaceans (PC) were favorable as the PC density was 70 mg/m³ what is higher than a threshold value. A sharp decrease (2 g less) of the 2+ smolt weight has been observed since 2014, what coincided with abrupt decrease of zooplankton biomass to extremely low level typical for cold 1990s. The directivity of the ecosystem processes was analyzed. Possible drivers of worsening conditions of sockeye salmon juvenile feeding (decreasing zooplankton biomass) were figured out. Possibility and necessity in changing the optimal escapement was analyzed as a method of sockeye salmon juvenile forage base regulation.

S1-P5**Methane fluxes in the North Western Pacific Region**

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The spatial distribution of methane content and fluxes in the Sea of Japan and in the near-Kuril water areas of the Sea of Okhotsk and open Pacific was studied during the expeditions in 2005, 2010, and 2011. The study of the distribution of methane fluxes enables supposing that the high values of methane concentration in the surface layer of sea water are caused by the influx of methane from underwater sources. The surface waters with the anomalous concentration of methane are spread by currents in a mosaic way in the water areas of the Sea of Japan, Sea of Okhotsk, and near-Kuril Pacific under study.

The effect of pulsating emissions of methane is observed: if wind speed is low and there is a methane flux from the underlying deep waters, an increase takes place in the concentration of methane in the surface water due to its transport. Methane concentration dramatically drops to the equilibrium values as wind speed increases because the methane flux from deep horizons does not have time to compensate the methane out flow from the surface. In the case of intense methane flux to the sea surface, for example, in the zone of gas flares, the real concentrations of methane exceed the equilibrium values and provide the high rate of methane emission to the atmosphere.

The methane flux to the bottom surface from deep rock horizons through the fault zones increases during the period of seismic and tectonic activity.

The research was carried out in the framework of the project "The Computation of the Fields of Currents, Transport, and Transformation of Pollutants and Environmental Hazards in the Russian Far East" following the program of the Presidium of Russian Academy of Sciences No. 43 "Fundamental Problems of Mathematical Modeling."

S1-P6

The Accident Fukushima's radionuclides in the northwestern Pacific in the summer of 2012Vladimir **Goryachev**, Vyacheslav Lobanov, Alexander Sergeev and Nataliy ShlykV.I. Il'ichev Pacific Oceanological Institute (POI), Russian Academy of Sciences, Vladivostok, Russia
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The cruise on the board of R/V "Professor Gagarinsky" (12.06.2012-10.07.2012) was conducted with the aim to collect data on the distribution of artificial radionuclides half years after the accident on Fukushima NPP (Nuclear power plant) in Japan Sea, Sea of Okhotsk and adjacent areas of the Northwest Pacific. Surface and deep water samples were collected along the cruise track. Samples of plankton, squid and fish were taken at some stations. ^{137}Cs concentrations in the Japan Sea and Okhotsk Sea surface water 1.4-2.3 and 1.5-1.9 Bq/m³, accordingly, do not exceed pre-accident level. ^{137}Cs concentrations of all samples in the western subarctic Pacific and the Kuroshio-Oyashio transition zone (154°E, 38°48'N - 155°E, 44°03'N) are in the range of 1.8-21 Bq/m³. All surface water samples collected in the Pacific contain ^{134}Cs (0.2-11.9 Bq/m³). Samples taken to the north of the Kuroshio warm eddy show subsurface ^{134}Cs , ^{137}Cs concentrations with a maximum between 100-300 m. Near the eddy center, the cesium vertical distribution is mostly homogeneous and the penetration depth was greater than 500 m. Almost all biological samples, collected in the transition zone, contain ^{137}Cs with concentrations 0.03-1.9 Bq/kg wet weight. ^{134}Cs concentrations 0.27 Bq/kg and $^{110\text{M}}\text{Ag}$ 1 Bq/kg wet weight is found in the zooplankton samples. Squid and fish contain ^{134}Cs in the range of 0.03-0.8 Bq/kg, $^{110\text{M}}\text{Ag}$ 0.04-5.1 Bq/kg wet weight. For biological samples the average ratio of $^{134}\text{Cs}/^{137}\text{Cs}$ is 0.55, whereas at the time of accident, this value was equal to 1. This decrease corresponds to partial cesium disintegration in 15 months.

S1-P7 (CANCELLED July 24)

Impacts of climate change on Pacific North America's small-scale fisheries catchesMelanie **Ang**^{1,2}¹ Institute for Resources, Environment and Sustainability, University of British Columbia, Canada² Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada
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Climate change will have significant implications for marine ecosystems and fisheries in the North Pacific, however the ability of small-scale fisheries to cope with these impacts remain relatively unknown. Globally, small-scale fishers form 90% of total employment in the fishing industry. Yet, research and policies on small-scale fisheries are often marginalized by efforts that largely focus on industrial operations. Comprehensive understanding of small-scale fisheries under climate change will contribute positively to resource management, and consequently, help alleviate poverty, ensure sustainable livelihoods and food security. In this research, we address this knowledge gap by integrating fisheries catch data from Fisheries and Oceans Canada and the Sea Around Us with climate change projection models on species distributions. Our results will illustrate the predicted spatial and temporal changes in Pacific North America's small-scale fisheries catch amount and taxa composition. Further, our study will anticipate the impacts on biological resources and ecosystem services to fisheries and communities in the Pacific North America region and will be useful in informing fisheries management in the region.

S1-P8

Central Arctic Ocean challenge; An emerging opportunity to view the changing North Pacific from above

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Rapid loss of sea ice cover has opened up the Central Arctic Ocean (CAO) for potential fishing opportunities. Debate and policy initiatives have been launched for regulating fisheries in the area that has not even started yet. Scientific research in the CAO, however, remains too scarce to inform and support policy decisions and to facilitate the establishment of proper governance in the region. Indeed, records of research vessel traffic and survey intensity show that CAO remains largely a region of sparse scientific data. Data on the distribution and abundance of harvestable species are generally lacking, let alone information on dependent and related species and on the nature of the interactions among them and the environmental control. Timely and adequate science will help ground the development of a management scheme in solid, quantitative rationale. Currently there are a number of national research programs that support regular expeditions in the Arctic Ocean, most of which come from PICES member states. These studies can provide information to meet the CAO challenge but also to better understand the linkage between the Arctic and North Pacific. Preliminary analysis of sea ice retreat, biological production and bottom topography greatly assisted our attempt to identify priority areas for observation and monitoring and to draft a research plan. Connectivity between the North Pacific and the Arctic as well as the leadership as a key regional marine science organization place PICES in a position to play a role, even for its own good.

S2 MEQ Topic Session

Microplastics in marine environments: Fate and effects

S2-P1

Ecotoxicity effects of microplastic to the early life stages of large yellow croaker

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Plastics are persistent synthetic polymers that accumulate as waste in marine environment. Microplastic (MP) particles, which defined as plastic particles smaller than 5 mm, derived from the fragmentation of larger debris or enter the environment directly as microscopic fragments. MP pollution in the world's oceans has been recently estimated at over 5 trillion floating particles, corresponding to 270,000 tons. However, the consequences of MP for marine ecosystem still remain unknown. Early life stages (ELS) are of primary importance to fish population dynamics due to the intense mortality during the embryonic and larval periods. Fish embryos and larvae are particularly sensitive to natural and anthropogenic origin stressors including mercury exposure. To our knowledge, there is little literature about the responses of ELS of marine fish species to MP, especially about the mechanism underlying MP's toxicity. In this manuscript, the distribution, quantity and type of MP will be investigated in a typical semi-enclosed bay—Xiangshan Bay. Moreover, we will investigate the toxicological effects of MP exposure on the development and growth of large yellow croaker embryos and larvae.

S2-P2

Abundance, composition and distribution of microplastics on Korean Beaches

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Microplastics are widespread and ubiquitous in the marine environment. Especially, beach is the most important location of microplastics accumulation. Spatial distribution within a beach is, however, not well addressed yet. In addition, major factors influencing on pollution levels and spatiotemporal distribution of microplastics on beach are still unclear. Multiple lines across a beach (backshore; B, strandline; S, middle; M, and water-edge; W) and two seasons (before and after rainy seasons) were investigated to evaluate spatiotemporal distribution of microplastics in twenty beaches along the coast of Korea in 2016. The relationship of microplastic abundance with environmental and potential source related factors influencing their spatial distribution were evaluated. The median value of microplastic abundances at each sampling line was in order of B > M > S > W. The mean abundance was significantly higher in B line than M and W lines. The mean abundance of large microplastic (L-MP) in after rainy season was 10 times significantly higher than that in before rainy season. L-MP distribution demonstrated significant positive correlation with small microplastic (S-MP), beach width, population, and proximity to the city among the factors tested, on the other hand none of significant correlations were obtained between S-MP and all the factors other than L-MP. In this study, significant increase of L-MP abundance after rainy season and correlation with the land-based sources imply their main input source is allochthonous. Main input source of S-MP may be considered as autochthonous because of significant correlation with L-MP and none of correlation with the land-based sources.

S2-P3**Changes of carbonyl and vinyl index of three plastics by outdoor exposure**Young Kyoung **Song**^{1,2}, Soeun Eo^{1,2}, Sang Hee Hong^{1,2} and Won Joon Shim^{1,2}¹ Korea Institute of Ocean Science and Technology, Geoje, R Korea
E-mail: wjshim@kiost.ac.kr² Korea University of Science and Technology, Daejeon, R Korea

Three polymer types [low-density polyethylene (LDPE), polypropylene (PP) and expanded polystyrene (EPS)] were exposed to outdoor sun light in Korea for 12 months. The exposed polymers were sub sampled in every month and measured the carbonyl index (CI) and vinyl index (VI) which used to characterize the degree of photo-oxidation of polymer by FTIR-ATR. The CI and VI of PE showed a linear increase with UV exposure duration from 1.8 to 16.5 and 0.006 to 0.101, respectively. The CI of PP also increased, but has a jagged graph shape and the VI rapidly increased, reached a plateau after 3 months. In EPS, the CI increased until it reached at about 3 months (1.97), and then slowly increasing again. The VI of EPS increase to until it peaked at about after 6 months (2.67) and then slowly declined. When CI and VI was compared between outdoor and laboratory exposure, amount of outdoor sunshine is approximately 24% of UV chamber'. So the CI of PE (11.6), PP (0.76) and EPS (3.63) and VI of PP (0.16) and EPS (2.67) expose to UV in chamber for 4 months was similar to those (16.5, 0.70 and 2.97 for CI, and 0.13 and 2.33 for VI, respectively) in outdoor for 12 months. However, VI of PE exposed for 12 months in outdoor was 3.9 times higher than those in UV chamber for 4 months. CI and VI could be applied to field sample to assume that the degree of weathering of them in environment.

S2-P4**Development of efficient analytical method for microplastics in bivalves**Mi Jang^{1,2}, You Na **Cho**^{1,2}, Young Kyung Song^{1,2}, Won Joon Shim^{1,2} and Sang Hee Hong^{1,2*}¹ Korea Institute of Ocean Science and Technology, Geoje 53201, R Korea
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As marine plastic debris breaks down to microplastics in the environment, it becomes available for ingestion by a wide range of small marine organisms. Among them, filter feeding bivalves can be an important monitoring species due to high accumulation of microplastics as well as sources of human microplastic consumption. There is, however, no standardized analytical method for microplastics in bivalve species. In order to develop an adequate and efficient pretreatment method, various types of digestion solution such as enzymes (Savinase+Lipase, Stainzyme plus, and Proteinase-K), base (KOH), acid (HNO₃), and hydrogen peroxide (H₂O₂), and density separation solution such as sodium chloride, sodium iodide (NaI), and lithium metatungstate (LMT) were compared in four species of bivalves (mussel, oyster, scallop, and clam). Digestion efficiency of biological materials and physio-chemical changes of polymeric materials were evaluated. The optimized protocol developed involves a digestion of tissue by 10% KOH solution at 40°C for one day, followed by density separation using LMT (1.6 g/ml) solution. This method can digest over 50 g of tissue (10 individual) at one time, without any surface change of the tested polymers with the exception of alkyd. The method was also found to have high microplastic recoveries in both high density and low density polymer (100% for polyethylene, 100% for expanded polystyrene, 93±6% for polypropylene, 93±6% for nylon, and 90±14% for polyester). This method is efficient for detection and quantification of microplastic in large amount of tissue samples, providing a method to monitor microplastic contamination in marine bivalves.

S2-P5**Bioaccumulation of microplastics in sheepshead minnow (*Cyprinodon variegatus*)**Jin Soo Choi, Youn-Joo Jung, Hong gil **Yun** and June-Woo Park

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As the small size of microplastics (MPs) can facilitate the ingestion of plastics into aquatic organisms, their toxicity in aquatic organisms has become an important issue. In this study, to evaluate the body uptake and release behavior of marine fish exposed to microplastic, 150 ~ 180 μm sized polyethylene micro plastic was selected as the evaluation target material and the marine fish Sheepshead minnow (*Cynoprionodon variegatus*) were used as test organisms. Exposure was carried out for 10 days at a concentration of 10 mg / L, and the depuration experiments was carried out for 4 days with the exposed fish being transferred to clean water. In order to determine whether there is a difference between the case where the food is not supplied and the case where the food is supplied in the actual environment, during the test period, exposure was carried out by dividing into feed and non-feed groups. By analyzing the fish exposed to microplastics by time and by organ, it was confirmed that a large amount of microplastics accumulated in the gills and digestive organs, and remained after the exposure period. Through this study, we evaluated the accumulation of microplastics in the organisms when they were exposed to microplastic present in the water and confirmed that the plastic particles introduced into the body are not easily discharged from the body. This result suggests that organisms exposed to microplastics for long periods of time may have an effect on organisms due to the microplastics remaining in the body.

S2-P6**Spatial characteristics of microplastics in the surface waters along the coast of Korea**Jung Hoon **Kang**¹, Oh-Youn Kwon¹, Minju Kim¹, Sang Hee Hong² and Won Joon Shim²¹ South Sea Environment Research Center, KIOST, Geoje, R Korea. E-mail: jhkang@kiost.ac.kr² Oil and POPs Research Group, KIOST, Geoje, R Korea

We investigated the occurrence of microplastics in the surface waters along the coast of Yellow and South Sea of Korea to examine the relation between the spatial patterns and the local characteristics. The studied area included six semi-enclosed bays consisting of special management and environmentally conservative areas designated by the government. Surveys were carried out in July after rainy season in 2015 and 2016 using a Manta-trawl with 330 μm mesh. Microplastic particles were counted and classified into fragment (expanded polystyrene; EPS, paint particles, fragment), sphere (EPS, sphere), fiber, film, and pellet in the Yellow and South Sea. And the size classes were selected as 0.33-0.5 mm, 0.5-1 mm and 1-5 mm. The average abundances of total microplastics ranged from 1.12-1.64 particles/m³ (Southern coast) in 2015 and from 1.70-2.79 particles/m³ (Western coast) in 2016. From all study areas, microplastics with size class of 0.33-0.5 mm numerically dominated compared to other size classes, except for Cheonsu bay, where microplastics dominated with size classes of 0.5-1 and 1-5 mm. Dominant types of microplastics were fibers (polyester, polypropylene and cotton) (33.3-58.7%) for all size classes in the Southern coast, while paint particles (alkyds) (16.5-49.4%) and fibers (polyester, polypropylene and cotton) (26.9-30.4%) dominated to the total microplastics in the Western coast. Exceptionally, EPS (39.1%) dominated to the total microplastics in the Cheonsu bay of Western coast. These results indicated that vulnerability of plankton or planktivores to numerically dominant fibers is likely to be high among microplastics rather than the regional specific occurrence of the microplastics in the study area.

S2-P7**Microplastics in freshwater river sediments in Shanghai, China: Case study of environmental risk assessment in mega cities**Guyu **Peng**¹, Pei Xu², Bangshang Zhu² and Daoji Li^{1*}

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Microplastics are plastics that measure less than 5 mm. Microplastics are widely distributed in water and sediments, and in marine biota. To understand the distribution and pollution of microplastics in urban rivers, we investigated river sediments in Shanghai. Six sampling sites covered most of city central districts. One sampling site was from a remote beach. Density separation, microscopic inspection and identification were conducted to analyze microplastic abundance, shape and color. It is found that granular microplastics were the most prevalent shape, followed by fibrous and fragmented microplastics. Transparent and white microplastics were the most common type in terms of color. White foamed microplastics were widely distributed in urban river sediment. Five types of microplastics were identified by micro-FT-IR analysis. Microplastics may enter marine environment via urban and industrial sewage effluent. Coastal rivers may be the source of microplastics, while the ocean being the largest sink of microplastics. Environmental risk assessment for microplastics in sediments was summarized. It is recommended to select the index, integrate the statistical data, follow the expert opinions extensively and construct the comprehensive evaluation method and ecological risk assessment system for microplastics.

S3: FUTURE Topic Session**Below and beyond maximum sustainable yield: Ecosystem reference points****S3-P1****Relationship between intrinsic rate of population increase and natural mortality in fish and invertebrates**Zuozhi **Chen**^{1,2,3}, Shijie Zhou³, Yimin Ye⁴, David Smith⁵ and Kui Zhang^{1,2}¹ South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, PR China² Key Laboratory of South China Sea Fishery Resources Exploitation & Utilization, Ministry of Agriculture, Guangzhou 510300, PR China³ CSIRO Oceans and Atmosphere, PO Box 2583, Brisbane, QLD 4001, Australia. E-mail: shijie.zhou@csiro.au⁴ Fisheries and Aquaculture Department, FAO, Rome, Italy⁵ CSIRO Oceans and Atmosphere, GPO Box 1538, Hobart, TAS 7001, Australia

The intrinsic growth rate (r) of a fish population is a key parameter in stock assessment and fishery management. Using r estimated from the Schaefer surplus production model for 189 fish and invertebrate stocks worldwide, we found empirical relationships between r and other life history parameters (LHPs) based on Bayesian hierarchical error-in-variables models that incorporate uncertainty in LHPs themselves. Among the various models tested, we found that r was strongly correlated with natural mortality (M), while other LHPs, such as the von Bertalanffy growth rate (k), asymptotic length (L_{∞}), maximum age (T_{\max}), length and age at maturity (L_{mat} and T_{mat}), add minor improvements to the relationship. The best model, selected based on the deviation information criteria (DIC) and Bayesian p -value shows: $r = 2.02 M$ for invertebrates (SD=0.21, n=28), $r = 0.76 M$ for elasmobranchs (SD=0.11, n=25), and $r = 1.73 M$ for teleosts (SD=0.08, n=136). These results can be used to improve the reliability of stock assessments and consequently management of a wide range of data-poor fisheries, which have only simple life history information available.

S3-P2**The application of Argo profile data and innovative methods in fisheries sciences**Peng **Lian**¹, Tao Tian² and S.J. Joung³¹ College of Fisheries, Ocean University of China, PR China. E-mail: lianpeng021@gmail.com² Center for Marine Ranching Engineering Science Research of Liaoning, Dalian Ocean University, Dalian, PR China³ Department of Environmental Biology and Fisheries Science, National Taiwan Ocean University, Taiwan, PR China

As a subfield of marine sciences, fisheries science is often focussed on climate warming. Based on open access data products from Argo Global Data Centers and Advanced Very High Resolution Radiometer, this study analyzes spatiotemporal variations of the monthly mean surface current, temperature and salinity between 20° and 40°N in Pacific. The thermohaline profiles are given by specific Argo buoys' data. Further, the vertical Akima interpolation and horizontal Kriging interpolation methods are employed to reveal Pacific temperature fields. Also the fisheries CPUE downloadable data from the international commission can be overlaid with the thermocline to demonstrate changes with time. The Empirical Cumulative Distribution Function (ECDF) can also be established. For evidence of global warming, Argo data gives us a broad picture. For analyses, available data included salinity and temperature data above the subsurface water, as well as fish distribution data, which were related to spatiotemporal factors. According to superposed figures, temperature, especially the vertical structure of the thermocline, is the principal factor affecting fish schooling, migration, and aggregations on fishing-grounds. At last, this paper discusses the phenomenon of chaos in density-dependence fisheries models, and introduces the wavelet analysis application in fishery science as well as finite element analysis application in fluid-structure interactions.

S4: MONITOR Topic Session**Adverse impacts on coastal ocean ecosystems: How do we best measure, monitor, understand and predict?****S4-P2****Studies on the bloom timing of moon jellyfish (*Aurelia aurita*) in the nearshore waters of the Hongyanhe River – an estuary of the Liaodong Bay**Chunjiang **Guan**, Guize Liu, Qing Yang and Jinqing Ye

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In recent years, the aggregation or outbreak of marine organisms can block the cold source water system of power plants, and increase risks to its normal operation. Aggregations include blooms of the moon jellyfish (*Aurelia aurita*) which is becoming a serious ecological disaster in the nearshore waters of the Liaodong Bay. Blooms of this jellyfish can jam the cooling system of power plants increasing the risk for closing of nuclear power plants. In order to ensure the normal operation of the nuclear power plant, we used an anchor drift net to monitor the relative density, bell diameter, wet weight of moon jellyfish every 3 days from June to August in 2015 and 2016 in the eastern part of Liaodong Bay. The results showed that the bloom timing of moon jellyfish ranged from early July to mid-August which represents a high risk period for the cold source water of nuclear power plants, also showed plaque distribution of moon jellyfish. The maximum relative density was up to 11,952 ind./net.h, bell diameter for 24cm, wet weight for 590g on 23rd July 2015, and on 14th August 2016 the maximum relative density was up to 16,667 ind./net.h, bell diameter for 18cm, wet weight for 360g. We urge the compilation of a risk cataloguing of marine organisms and a risk calendar of moon jellyfish blooms in order to guide early disposal strategies and ensure the safe operation of cold source water systems of nuclear power plants.

S4-P3**High-resolution monitoring of phytoplankton communities using spectral fluorescence signatures**Rikuya **Kurita**¹, Kenji Tsuchiya², Shinji Shimode³, Tatsuki Toda¹ and Victor S. Kuwahara¹¹ Graduate School of Engineering, Soka University, Tokyo, Japan

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The composition of phytoplankton communities is dependent on temporal and spatial variability of multiple environmental conditions. Traditionally, communities are investigated by analyzing bio-marker pigments from discrete water samples to identify specific phytoplankton classes. However, discrete water samples do not provide high-resolution data of the community distribution. The present study investigates the temporal (monthly) variability of the vertical distribution of bio-marker pigments coupled with high-resolution multi-excitation fluorescence (F^{λ}) from May 2016 to April 2017 to monitor phytoplankton community structure in the coastal waters of Sagami Bay. Mixed layer depth (Z_m) and 1% euphotic depth based on the light attenuation at 443 nm ($Z_{1\%}$) varied seasonally between 14 - 62 m and 25 - 70 m, respectively. Phytoplankton chlorophyll *a* ranged from 0.18 to 7.71 mg m⁻³, and showed a significant correlation ($r = 0.89$, $p < 0.01$, $n = 35$) with F^{470} . Quantitative coupling between the discrete water sample bio-marker pigments and F^{λ} were used to develop a new fluorometric-pigment model (F_{pigment}), revealing high-resolution pigment distribution. During the spring, $F_{\text{fucoxanthin}}$ increased in the surface layer with the development of the seasonal pycnocline, while $F_{\text{zeaxanthin}}$ increased with a shoaling of the Z_m during the early summer. From the summer to fall season, $F_{\text{peridinin}}$ and $F_{\text{alloxanthin}}$ increased below the Z_m , but above the $Z_{1\%}$ suggesting change in community distribution. Phytoplankton biomass and F_{pigments} were vertically uniform in distribution from the fall to winter. The results suggest the spatial and temporal distribution of phytoplankton communities are tightly controlled by light penetration and Z_m .

S4-P4

Plankton biodiversity, community structure and the physical and chemical environment of Izu-Oshima, Japan: A high resolution and multidisciplinary observational approach

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Marine ecosystems change at a myriad of time scales as a function of natural and anthropogenic agents. Classic problems in plankton ecology addressing communities' structure, function and its variance in time demand a high resolution and multidisciplinary observational approach. Here, we examine the interactions between the coastal environment and the plankton community of Izu-Oshima, Japan, focusing on systematic changes in plankton community structure, abundance and phenology. Combined with physical and chemical data, our cabled observatory system (OCEANS) includes a Continuous Plankton Imaging and Classification Sensor (CPICS) capable of resolving 20 taxonomic groups, non-living particles included. Our results showed a community shift between November and December 2014, through differences in diversity, major groups composition and in the physical environment itself. We identified the intrusion of a colder and more saline water mass possibly correlated to deep layers of the Kuroshio Current that was also scarce in chlorophyll-a content and predominantly composed by zooplankton. This factor indicated a local primary production limited by grazing. An enrichment in nitrate was associated with both a resupply through zooplankton excretion and an innate feature of the water mass. While the trophodynamics of the region remain to be fully understood, our project aims to extend the data analyses over a time frame of more than 2 years. Plankton monitoring programs, such as ours, are highlighted by many as sentinels to identify future changes in the marine environment, being an important tool for the validation of ecosystem models and the further understanding of regime shifts.

S4-P5

The effect of estuarine physicochemical conditions on antibiotic-resistant *E. coli* migration and competitive ability

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The increase in the number of resistant and multi-resistant strains of bacteria is a major concern for health officials world-wide. Estuary ecosystems are key areas for understanding the fate of antibiotic resistant bacteria during the process of their release into aquatic environments. In order to understand the effect of estuarine physicochemical conditions on antibiotic-resistant *E. coli* migration and competitive ability, 10 sulfonamide-resistant environmental strains were selected to investigate the effects of salinity, nutritional and antibiotic stress.

The results indicated that environmental factors significantly affected the distribution and migration of antibiotic-resistant *E. coli* in the estuary, but the contribution of antibiotics is very weak. Meanwhile, antibiotic-resistant *E. coli* exhibit a stronger adaptability to the environment via increased migration ability that is correlated with salinity and nutrition. In the oligotrophic environment, with salinity increased, the deviation degree of lag phase and generation time of antibiotic-resistant *E. coli* were relatively small. In addition, the selective pressure of low concentration antibiotics did not significantly increase the competitive advantage of antibiotic-resistant *E. coli*. In an oligotrophic simulation system, the deviation in lag phase between resistant and non-resistant strains was 13.8% (low antibiotics). The generation time change rate was reduced from 33.74% (without antibiotics) to 12.56% (low antibiotics).

S4-P6

Alpha, beta and gamma diversity of nematode assemblages in seaweeds from Korea the British Isles

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Nematodes inhabiting seaweeds in the English Channel and in Korea were compared to investigate the relationship between alpha and beta diversity to gamma diversity. The cosmopolitan genus *Corallina* and *Sargassum muticum*, a native of Korea and an invader in the British Isles were selected as algal habitat providers for nematodes. A hierarchical nested design have been used with regions in each country (3 for *Corallina*, 2 for *S. muticum*), 2 shores in each region and 3 patches on each shore. Four different alpha and beta nematode diversity relationships were measured using additive partitioning approach. All four alpha and beta relationships indicated alpha diversity contributed more than beta diversity to total gamma diversity in both macroalgae. Although the alpha diversity were dominant in nematode assemblages, the proportion of diversity component were varied in each spatial scale in each macroalgae. Estimated component variation in nematode assemblages also showed clear differences in each scale in each macroalgal host. This might suggest that alpha and beta relationship might be driven by different ecological processes. Nematodes can be a good ecological model for understanding diversity changes along the different spatial scale ranges.

S4-P7

Application GIMS- technology for the monitoring coastal and marine ecosystems

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Marine ecosystems and coastal zones are one of the important objects of geoinformational monitoring. Knowledge of microwave attenuation properties of coastal and marine ecosystems is needed in this respect since attenuation values and their dependence on frequency and biometrical features afford a basis for microwave remote sensing retrieving algorithms. One of the prospective approaches to the solution of the problems arising here is GIMS-technology (GIMS = GIS + model). The basic scheme of collection and processing of the information in geoinformation monitoring system (GIMS) recognizes that effective monitoring researched object is possible at complex use of methods of simulation modeling, collection and processing of the information.

Development of GIMS requires the decision of a set of problems related to the formation of data measurements flows to be solved.

S4-P8**Temporal variation in microbial community composition in Gadeok Channel, South Korea**

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Variations of bacterial community compositions in terms of temporal dynamics and vertical distributions in the Gadeok Channel, which is primary passage for exchange of waters and materials between the Jinhae-Masan Bay and the South Sea waters, have been analyzed from June to December 2016 using 16S rRNA gene sequencing. The resulting high quality reads (5,507,418) have clustered into 35,291 operational taxonomic units (OTUs) and classified with the phyla Proteobacteria (45.6%), Bacteroidetes (18.2%), Cyanobacteria (15.3%), Verrucomicrobia (5.9%), and Actinobacteria (5.8%). The bacterial community at each water column was highly diverse and varied among the seasonal dynamics. It has been found that the composition of bacterial communities in surface and middle water columns remains relatively similar, while that in bottom water column differs between temporal and hydrological dynamics. Alphaproteobacteria (28%) was the most abundant bacterial class, followed by Falvobacteriia (16%) and Gammaproteobacteria (13%) in all water columns. However, dominant groups from this class at the order level showed a significant difference among the samples. Furthermore, principle coordinates analysis based on OTU data indicated that bacterial communities in surface column were more spatially variable than the bottom and middle columns. The dynamics of physicochemical and hydrologic conditions over the water column are decisive factors in shaping the pattern of bacterial communities in Gadeok Channel.

S4-P9**Fluorescence to chlorophyll a ratios on the central coast of British Columbia – Data quality control and spatial-temporal variability across a diverse and optically complex environment**

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Since 2012, the Hakai Institute has collected year-round high frequency chlorophyll a (chl) samples from Niskin bottles and in-situ chl fluorescence profiles at multiple sites on the central coast of British Columbia. These sites span a diverse and bio-optically complex region, from the headwaters of a coastal fjord (Rivers Inlet) to the shelf waters of Queen Charlotte Sound. The length of this timeseries and the range of observed conditions provides an ideal dataset for the investigation of coastal fluorescence to chl ratios (fl:chl), which are important for deriving accurate in-situ chl biomass estimates and investigating phytoplankton dynamics. The span of observed fl:chl is greater than expected with many values exceeding those found in comparable research (> 10). It is unclear whether these values are a natural phenomenon. Additional aspects of fl and chl data quality control are discussed, including tracking of fluorometer instrument drift using dark current values collected at deep water sites (> 250 m), and the development of thresholds and corrections for surface fluorescence data affected by non-photochemical quenching.

S5: FIS Topic Session

Coastal ecosystem conservation and challenge

S5-P1

The effect of the lights on reproduction of sea urchin

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The experimental studies of lights influence on development of sea urchin gametes showed that effects of red and green lights quite different. Light with a wavelength 720 nm at a constant temperature of +4 C have a positive effect on the reproductive process: mass of gonads increased on 2.0 g, number of parietal oocytes increased on 20% and free oocytes increased twice in comparison with the control. Light with a wavelength of 520 nm inhibits development of gonads sea urchins and decreased volume of acinus in 1,5 times, and of spermatocytes by 10% in comparison with control. The lowest fecundity of sea urchins - 23.0 million oocytes observed where the animals were kept under the influence of green light and highest fecundity - 31 million oocytes observed under influence red light according to experimental data. The minimum deviations from normal development (8%) at early ontogenesis was observed in embryos from gametes obtained from sea urchins maintained under illumination with light of a wavelength 720 nm.

S5-P2

Improvement of coastal use fee and levy system based on the marine ecosystem in Korea

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The marine environment budget was about 200 billion KRW in 2015, but the annual collected amount of the marine environmental levy was only 8 billion KRW (by the income of the fisheries development fund in 2014). The levy of coastal users is significantly lower than the negative external effects (such as environmental damage) caused by marine use. Marine quasi-taxation* is one of economic incentives that allow a person using the marine environment and resources to pay social costs. However, the current marine quasi-taxation standard(rate) is not able to account the value of marine ecosystem services and the impact of use. (*Quasi-tax is a term that encompasses the burden of imposing taxes other than taxation from the perspective of the company. However, in this study, the marine quasi-taxes are limited to the charges related to sea use and development, such as coastal use fee and levy) Therefore, it is necessary to improve a quasi-taxation system that can contribute to the socially desirable marine utilization level and secure the management finance of governments. In this study, we analyze the problems of current marine environmental quasi-taxes in Korea through the case studies over 10years and suggest advanced alternatives based on ecosystem services. The results of this study can be a fine alternative for the improvement of the present coastal use fee and levy system.

S5-P3

Changes on the ecological Carrying Capacity of fleshy prawn (*Fenneropenaeus chinensis*) in the Bohai Sea

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The Bohai Sea provides important spawning grounds and nursery habitats for some of the fishing species found in the Bohai and Yellow Seas, and marine stock enhancement of the fleshy prawn (*Fenneropenaeus chinensis*) has been developed over the past decades in this area. Overstocking of fleshy prawn combined with environmental changes may cause mass mortalities and severe consequences for the ecosystem. Accordingly, the rigorous assessment of the carrying capacity of fleshy prawn underpins responsible marine fisheries enhancement. Using two trophic food web models in 1982 and 2015, the trophic impact relationship in fleshy prawn with other groups and ecosystem was explored and the changes in the ecological carrying capacity for fleshy prawn in Bohai Sea were analyzed. Results suggest that the fleshy prawn carrying capacity was respectively 1.365 t·km⁻² and 0.978 t·km⁻² in Bohai Sea in 1982 and 2015. Compared with respectively current biomass, the fleshy prawn had a great potential for continued enhancement. Exceeding fleshy prawn biomass levels of 1.365 t·km⁻² and 0.978 t·km⁻² may cause other functional groups biomasses to fall, and the ecosystem will become unbalanced. Results of this study will provide some references for the science implementation of stock enhancement and the sustainable development of fisheries resources in the Bohai Sea.

S5-P4

Real-time detection of the red tide dinoflagellate *Akashiwo sanguinea* using a newly developed ultrasonic acoustic technique

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Red tide, known as harmful algal bloom, is caused by the proliferation of a toxic or nuisance algae species and has been the focus of worldwide research communities for several decades. Until recently, the techniques available for red tide detection were mainly microscopic and molecular techniques. However, these techniques are unable to detect in real time. Here, we have developed a technique for real-time detection of harmful algal blooms (HABs), focusing on ultrasonic acoustic backscattering properties. The developed detection system is mainly composed of a pulser-receiver board, signal processor board, control board, network board, power board, ultrasonic sensors (3.5 MHz), and environmental sensors. To evaluate the performance of the system, trials were performed in laboratory and field experiments. In the laboratory, the acoustic signal agreed with various levels of *Akashiwo sanguinea* (one of the HABs) densities. In field experiments (in Jangmok-Bay, South Korea), acoustic signals were not detected before blooms of *A. sanguinea* appeared. However, when *A. sanguinea* blooms appeared at density of over 3,000 cells mL⁻¹, the acoustic signals varied with red tide occurrence density and there was a good correlation between the acoustic signal and *A. sanguinea* densities. Therefore, the developed ultrasonic acoustic detection system for early detection of HABs was shown to be an effective system to monitor the occurrence of HABs in coastal regions.

S6: POC/FIS Topic Session**Interannual variability in marine ecosystems and its coupling with climate projections****S6-P1****Spatio-temporal distribution of the specific growth rate of *Prorocentrum donghaiense* related with SST**

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The specific growth rate of *Prorocentrum donghaiense* is calculated taking into account its dependence on water temperature; its spatial and temporal distribution is considered on the basis of satellite remote sensing data of sea surface temperature (SST) at the Pacific coast of China. Red tide events are determined. The peak of *P. donghaiense* harmful blooms is observed in April-June of every year, and the high incidence areas are located at the coasts of Zhejiang and Fujian provinces. A significant correlation was found between the specific growth rate and abundance of *P. donghaiense*. The possible influence of global climate change on red tides at Chinese coast is discussed.

Joined S8 / HD-Paper: HD Topic Session

Marine ecosystem health and human well-being: A social-ecological systems approach

S8-HD-P1

Research into marine ecological suitability assessment and zoning based on spatial analysis: A case study in Dongtou County

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The role of marine ecosystems, as critical elements of global life support systems, has gradually become recognized; marine ecosystems provide natural resources and environmental conditions necessary for human survival and socio-economic development. Meanwhile, human activities, including regional development, have exerted increasingly negative impacts on marine ecosystems and intensified the contraction of marine resources. Ecological suitability analysis can reflect the advantages of regional marine resources and the potential of socio-economic development while accounting for the complexity of marine ecosystems and the mobility of marine ecosystem components. Thus, ecological suitability analysis can contribute to scientific evidence for environmentally sound marine spatial planning for coastal cities. In this presentation, we report on research conducted in the island county, Dongtou. Our research used multi-temporal remote sensing data, field-research, interviews with local experts, the “3S” technology, statistics, indicators and other methods to construct a comprehensive evaluation model of ecological suitability of the region and to designate its ecological function areas. The results illustrate that, in the study area, marine resource utilization can be clearly divided into four categories: key protected zones, buffer protected zones, moderately developed zones, and optimized developed zones. The first two are always sensitive to the environment and thus are considered to be the important ecological restoration areas of the county, while the latter two are buffer areas for future marine resources utilization and marine engineering. This study has significant implications for resolution of conflicts between the marine resource conservation and exploitation, thereby balancing marine ecosystem integrity and sustainable of regional development.

Key words: Marine ecosystem; ecological suitability; spatial analyst; hemeroby

S8-HD-P2

Developing a global database on fishery conflicts

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Conflicts over fishery resources constitute a growing security concern, and experts expect that factors such as climate change will spark or exacerbate resource conflicts in the future. To better understand international conflict over fishery resources, and the role of climate change in stimulating conflict, we created a database of historical incidents of international fishery conflict on select commercial species, spanning the years 1970 to 2016. Among other things, the database is intended to: 1) descriptively explore global geographical patterns of international fishery conflict; 2) offer novel typological theories of international fishery conflict; and, 3) quantitatively assess the relationships between a wide range of biophysical, socioeconomic, and political factors and international fishery conflict.

S8-HD-P3

Fishing alternatives of a local stock of Coonstripe shrimp *Pandalus hypsinotus* for sustainability of the local communities in southern Hokkaido, JapanNaoki **Tojo**¹, Takaaki Mori² and Yasuzumi Fujimori³¹ Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan

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In Funka Bay, southern Hokkaido, Japan, Coonstripe shrimp *Pandalus hypsinotus* is highly regarded as a major fishing target. The fishery is managed through minimum size limits and the timing of open fishing periods. Since 1999, local shrimp fishermen have voluntarily released their catch of small shrimp caught during spring fisheries. However, annual catch is highly variable and these voluntary measures do not appear to have reversed downward trends in stock abundance. Here, we explore sustainable alternatives for the shrimp fisheries in the Funka Bay. We apply an integrative approach based on resource dynamics, expected returns, and fishers' perspectives. Predicted variables, such as biomass, derived from an age-structure model, were monetized. The values of additions and costs along the value chain were integrated to yield time series of predicted variables that were then used to develop estimates of net present values (NPV). Simulations were conducted for multiple scenarios of the fishery. Each scenario was simulated for 1000 iterations for two generations (40 years). The scenarios included preferences expressed in surveys and interviews of local fishermen. Corresponding NPVs were compared with risks based on the variability of the predictions. The results suggest that improvement of selectivity of the gear and investigation in the migration patterns of stock will be effective to sustain the economic returns. Increased product value was shown to arise under scenarios that shifted the timing of fisheries to enhance product freshness. The cumulated capital from the added returns may also contribute to the risk aversions in the given environmental dynamics.

S8-HD-P4

Seafood consumption and pesticide accumulation in humans in the Russian Far East (Primorsky Kray)Olga N. **Lukyanova**^{1,2}, Vasilii Yu. Tsygankov² and Margarita D. Boyarova³¹ Pacific Research Fisheries Centre (TINRO-Centre), Vladivostok, Russia

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Fish and seafood are important protein sources in the nutrition of population of coastal regions. Fish consumption per capita in Russia is 14-16 kg; in the Russian Far East, per capita fish consumption is 25 kg. Along with nutrients, people can absorb toxic substances accumulated by marine organisms. Concentrations of organochlorine pesticides (OCP) DDT and HCH were determined in adipose tissue of the residents from Primorsky Kray in post mortem analysis using gas chromatography. β -HCH, DDT and DDE were detected in all samples. The total OCP concentration ranged from 185 to 1750 ng/g of lipids, including β -HCH concentrations of 152 to 1270 ng/g, DDT concentrations of 2.9 to 46.8 ng/g, and DDE concentrations of 33 to 610 ng/g. Data obtained testify the decay of initial compounds, i.e., of "prolonged" circulation of pesticides in the marine environment and contamination of seafood and human body. This work was supported by the Russian Science Foundation (project No. 14-50-00034).

S9: POC Topic Session**Meso-/submeso-scale processes and their role in marine ecosystems****S9-P1****Dependence of Pacific saury fisheries upon the distribution of oceanographic parameters in the South-Kuril area**Polina K. **Kozub** and Tatyana V. BelonenkoSaint-Petersburg State University, Saint Petersburg, Russia
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The Pacific saury, *Cololabis Saira*, forms dense aggregations which are of great interest for its industrial fishing near Kuril and Japanese waters. Studying the conditions governing the formation of saury aggregations is important for forecasting fish stock, attain sustainable catch and improve economic growth. This study aims to evaluate the extent to which saury fisheries are dependent upon the distribution of oceanographic parameters in the South Kuril region. In preliminary analysis, CMEMS products and information of saury fishing areas derived from the TINRO-Centre (Vladivostok, Russia) were used (maps of fishing saury localization). We analyzed different types of satellite data products such as sea surface temperature (SST), sea surface temperature anomalies (SSTA), sea surface salinity (SSS), sea surface salinity anomalies (SSSA), sea surface chlorophyll-a concentration (SSChl), sea surface chlorophyll-a concentration anomalies (SSChlA), and sea level height anomalies (SSHA) for September, 2001. We compared maps of these data with fishing saury areas to confirm that saury aggregations were connected strongly with SST fronts. All fishing areas were located in areas of negative sea level anomalies and cyclonic vorticity. Although those areas were regarded as regions of convergence on the first week of September, they were further placed in the regions of divergence. That confirms that divergence areas are characterized by high concentrations of nutrients, and therefore they are more favorable for Pacific saury. The remaining satellite parameters did not affect the distribution of saury.

S9-P2**Submesoscale structure in the mesoscale eddies in the western subarctic North Pacific**Yuki **Okada**¹, Hiromichi Ueno¹, Takahiro Tanaka² and Sachihiko Itoh³

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Mesoscale eddies in the western subarctic North Pacific have a significant impact on the heat, freshwater, macro- and micro-nutrient and biota exchanges between shelf and offshore regions and thus play an important role in the marine ecosystem of the offshore region. In this area, we conducted cross-section observation, including underway CTD observation with horizontal resolution less than 10 km, of two mesoscale eddies on board T/S Oshoro-maru in June-July 2016. In and around both eddies, submesoscale (10-20 km) features were observed especially in the temperature structure. This structure was related to the chlorophyll fluorescence around 50 m depth especially in one of the eddies (Eddy B) compared with the other eddy (Eddy A). Through analysis of satellite altimetry data, we found that Eddy B formed at 45.5°N, 166°E in February 2016 and stayed there until we observed. Eddy A formed in May 2011 in the area south of Alaska Peninsula, propagated southwestward along the Aleutian Islands, split into three eddies in 2016 before observation.

S9-P3**Characteristics of Aleutian eddy and its impact on Chlorophyll distribution**Hiromu Ishiyama¹, Hiromichi Ueno² and Masaru Inatsu¹¹ Hokkaido University, Sapporo, Japan² Hokkaido University, Hakodate, Japan

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Aleutian eddies are anticyclonic eddies formed in the area just south of the Aleutian Islands between 170°–175°E (AL area). They propagate southwestward to the deep-sea region of the western subarctic North Pacific. In this study, we investigated the propagation and temperature/salinity structure of the Aleutian eddy and its impact on chlorophyll distribution in detail, using satellite altimeter data, Argo profiling float data and satellite chlorophyll concentration data. Averaged radius and lifespan of Aleutian eddy were 65 km and 200 days, and averaged Aleutian eddy core contained intermediate temperature-maximum water warmer than 4°C, suggesting that they transport heat in the AL area to the deep-sea region of the western subarctic North Pacific. In the AL area, chlorophyll concentration was high in and around the Aleutian eddy, and even the chlorophyll concentration averaged in the AL area when at least one Aleutian eddy was located in the area was 16% higher than that without Aleutian eddies in the area. On the other hand, in the deep-sea region of the western subarctic North Pacific, chlorophyll concentration was relatively low in and around the Aleutian eddy.

S9-P4**Features of distribution and efficiency of saury fishery in relation to oceanological conditions in South Kuril Region on satellite data in August–November, 2002–2014**Yury V. Novikov and Eugene V. Samko

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The analysis of hydrological conditions and saury fishery in Southern Kuril Region for August–November, 2002–2014 within an exclusive economic zone (EEZ) Russia is carried out on the satellite, facsimile and saury fishery data.

The primary goal of the presented work is revealing of features of distribution and efficiency of saury fishery depending on variability of oceanological conditions in South Kuril Region in August–November, 2002–2014, in years with high and low catch values and efficiency of a fishery.

As investigated hydrological characteristics of a season were taken distance of the centre of a South Kuril anticyclone from Shikotan island and type of oceanological conditions of the area, defined by position of Northern subarctic front.

By results of the analysis three basic groups of years are allocated:

1. years with distant position of a South Kuril eddy and cold type of oceanological conditions (2002, 2003 and 2009). The stable saury fishery begins in the third decade of August, the fishery is conducted within EEZ in August–October, and completely outside of EEZ in November. Efficiency of the saury fishery was low, CPUE within 14–34 ton, with a maximum in November.
2. years with close position of eddy and warm type of conditions (2004, 2005, 2007, 2008 and 2014). The stable saury fishery begins in the first half of August, the fishery is conducted within EEZ in August–November. Efficiency of the saury fishery was high, CPUE within 31–43 ton, with a maximum in September.
3. years with close position of eddy, normal and cold type of oceanological conditions (2006, 2011, 2012 and 2013). The stable saury fishery begins in the second half of August, the fishery is conducted within EEZ in August–October, on border of EEZ and outside of EEZ in November. Efficiency the saury fishery was on an average level, CPUE within 20–36 ton, with a maximum in October.

The typical features of position and efficiency of the saury fishery for each group of years are described

S9-P5

Physical-biogeochemical characteristics off the northern Jiangsu coast (Yellow Sea, China) and their potential relations with the occurrence and expansion of *Ulva prolifera* in summer

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By using in-situ observations off the northern Jiangsu coast during the summer of 2006, combined with associated satellite-derived data and long-term data along a cross-section of 34°N across the Subei Shoal, the physical characteristics and regional biogeochemical processes off the northern Jiangsu coast are investigated, and the long-term evolutionary patterns of major environmental parameters in this area are examined. Furthermore, the potential relations between the physical-biogeochemical characteristics off the northern Jiangsu coast and the occurrence and expansion of *Ulva prolifera* are discussed. The results show that the offshore transport and expansion of coastal low-salinity water, as well as an inshore upwelling and invasion of offshore high-salinity bottom water, exist off the northern Jiangsu coast. The position of the upwelling is consistent with the 20- to 30-m isobath and the boundary of the Yellow Sea Cold Water Mass (YSCWM). The area within the depth range of 20–30 m off the Subei Shoal is therefore surrounded by the upwelling. Vertical transport by the upwelling results in a nutrient supplementation in the slope area within the depth range of 20–30 m off the Subei Shoal, where a rapid decline in the contents of suspended particulate matter (SPM) contributes to good light conditions. Thus, a high-value area of phytoplankton chlorophyll-a (Chl-a) is formed within the 20- to 30-m isobath off the Subei Shoal. Eutrophication off the northern Jiangsu coast provides rich nutrients for the frequent occurrence of *Ulva prolifera* in this area over recent years. The upwelling system off the Subei Shoal in summer plays a role in promoting the development of *Ulva prolifera*. The propagation and expansion of *Ulva prolifera* in the upwelling area and the bloom of *Ulva prolifera* within the shoal area can form a synergistic effect spatially, leading to the large-scale development of *Ulva prolifera*. The findings of this study indicate that eutrophication off the northern Jiangsu coast is the material premise for the bloom of *Ulva prolifera*, whereas the upwelling system off the Subei Shoal can drive the further propagation and expansion of *Ulva prolifera*.

S9-P6**Near-inertial internal waves observed in the vicinity of an anticyclonic eddy in the southwestern East Sea (Japan Sea)**Suyun **Noh** and SungHyun Nam

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Interaction processes between near-inertial internal gravity waves and anticyclonic mesoscale eddies are known to influence on turbulent mixing that affects biogeochemical processes thus marine ecosystem, yet our understanding on these interaction processes is still poor particularly in southwestern East Sea (Japan Sea). We analyzed time series data collected using a subsurface mooring (37.33N, 131.45E) in the southwestern East Sea (Japan Sea) from late March 2011 to June 2012. Using the ECMWF wind stress data, simple and modified slab models were applied and compared in order to examine the effect of background flow field on the evolution of near-inertial wave energy. Results show that high near-inertial wave energy persisted for about 10 days with maximum near-inertial currents exceeding 22 cm/s in October 2011. Clockwise-rotating near-inertial oscillations propagate down to 250 m with a speed of about 18 m/day, demonstrated from wavenumber-frequency spectral analysis. Comparisons between observed and simulated near-inertial waves reveal that the near-inertial oscillations were generated from the surface by local wind and then enhanced by lowered effective Coriolis frequency associated with the anticyclonic eddy in the vicinity of the mooring. Furthermore, the modified slab model incorporating geostrophic flows allows more near-inertial energy at the mooring location when the anticyclonic eddy is considered. Our results suggest that the anticyclonic eddy plays a significant role in modulating near-inertial wave energy in the upper ocean.

S9-P7**Mesoscale eddies in the East Sea (Japan Sea): Statistical categorization and characterization**KyungJae **Lee** and SungHyun Nam

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Mesoscale eddies conduct crucial roles which transport and redistribute heat, energy, chemical and biological properties in the ocean. Although their importance, the comprehensive studies about the eddy fields in the East Sea (Japan Sea) have not been performed yet. A new hybrid mesoscale eddy detection method is applied to the 1/4° gridded satellite altimeter data in the East Sea (Japan Sea) and validated with available hydrographic data collected within and outside the eddies from 1993 to 2015. The 782 eddies in total 22 years are identified and categorized into tens of groups, e.g., Ulleung Warm Eddy (UWE), Wonsan Cold Eddy (WCE), Hokkaido Warm Eddy (HWE), etc, based on the location of its formation. The eddies are statistically characterized with duration, propagation, intensity, amplitude, ellipticity, and so on. Typical ranges of durations are 88days, but there are some exceptional cases over 1 year. Mean eddy size and amplitude are about 80km and 5cm respectively. Their propagation tendencies do not show westward unlike world ocean cases, instead they seems to be advected by the main currents. The horizontal sizes determined from satellite altimetry coincided with hydrographic data in just few kilometers. Statistical categorization and characterization of eddy properties helps to understand the physical mechanism of each eddy, and interaction with other ocean phenomenons in the East Sea (Japan Sea).

S9-P8**Mesoscale and submesoscale coherence from physics to phytoplankton**

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Physical processes in the ocean are fundamental drivers of biological productions at various trophic levels. The large-scale marine biogeography has thus been attributed primarily to physical structure of current systems, such as subtropical and subpolar gyres. However, most of previous studies focused only on scales comparable or greater than mesoscale ($O(10\text{--}50\text{ km})$ in mid latitudes) and/or on a qualitative basis. In the present study, we conducted continuous shipboard observations of horizontal velocity, temperature, salinity, nutrient concentrations and chlorophyll *a* concentration along trans-basin transects in the Pacific, in order to examine the linkage from physics to plankton community. The data collected with a horizontal interval of 1–10 km were examined mainly through spectral analysis. Compiling all the data in the North and South Pacific, power spectral curves of surface salinity with respect to wavenumber k roughly follows curves of $k^{-3}\text{--}k^{-2}$, while those of nutrient and chlorophyll *a* concentrations show shallower spectra (more power at high wavenumber ranges). Regional and seasonal differences in the coherence of the data sets will also be shown in the presentation.

S9-P9**Seasonal variation of barrier layer in the Southern Ocean**

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The seasonal variability of barrier layer (BL) and its formation mechanism in the Southern Ocean are investigated using the most recent Argo profile data. The result shows the BL is a persistent feature in the Southern Ocean with extremely strong seasonal cycle. The thickest BL appears in winter with the maximum exceeding 250 m while it dramatically decreases to less than 50 m in summer. The spatial distribution of BL is zonally oriented in the Pacific and Indian Ocean sectors, in agreement with that of the mixed layer depth (MLD) and isothermal layer depth (ILD). Two most prominent BL areas are identified to the south of Australia and in the southeastern Pacific Ocean. The BL formation in both regions can be generally attributed to a shallow mixed layer controlled by surface fresh water and a deeper isothermal layer modulated by seasonal vertical convection, with regional difference on the source of low salinity water. In the former region the cold and fresh Antarctic Surface Water (ASW) is transported northward across the subantarctic front (SAF) by Ekman effect overlying the warm Subantarctic Mode Water (SAMW). The resulting inversed temperature structure facilitates thick BL development. In the latter the BL emerges in the ventilation area where the shallow Surface Salinity Minimum Water (SSMW) coming from north leans against the deep vertical isotherms. In summer positive surface heat flux in the Southern Ocean dominates over other dynamics in the heat budget of the mixed layer. The MLD and ILD coincide and thus the BL is annihilated.

S9-P10

Outer shelf of the Laptev Sea: Specific features of sedimentology processes

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Lithological investigations performed in the outer shelf of the East Siberian Seas revealed specific features in the structure and distribution of bottom sediments in the studied area. Predominant type of sediments found in the uppermost layers of sediments was mud (that is silt and clay) with particle size <0.01 mm. This is typical for the outer shelves and reflects lowering energy of the depositional environment and sediment maturity towards the shelf break. However, in some areas within the ESAS outer shelf, we found poorly sorted sediments comprised of multiple grain sizes – from <0.01 mm (mud) to >1 mm (coarse sand). Some authors described existence of such areas in the outer shelf of the Laptev Sea earlier without attributing such variability in sediment grain size to any processes. We hypothesize three possible mechanisms to explain intrusion of high energy processes into the low energy environment: 1) effect of geo-fluid and/or gas (methane) escape through open/deep taliks forming within subsea permafrost due to long-lasting warming by seawater and underlying fault zones (southern end of the Gakkel Ridge); 2) release of underground water through intra-permafrost hydraulic system; and 3) bottom erosion caused by ice-scouring.

S11: FIS/POC Session

Environmental variability in Arctic and Subarctic ecosystems and impacts on fishery management strategies

S11-P1

Environmental impacts on the Bering Sea pollock spatial distribution, migrations and evaluating fishery management

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Pollock spatial distribution and recruitment in the Bering Sea are subjected on annual variability environmental factors. These may include direct impacts of variability environmental trends on distribution, seasonal migrations, recruitment and indirect through changes zooplankton community.

The recruitment of pollock and strength of year classes have annual variability basically depending on young-of-the year fish survival during winter.

The great annual differences of pollock seasonal migrations and distribution are related with variability temperature conditions and zooplankton abundance (basically euphasiids and copepods) in the Bering Sea.

Understanding of environmental driven changes in pollock population can be used to improve predictions of assessed population and will positive affect on recreational fishing and commercial harvest. Environmentally-dependent strategy of fishery management need better predictions and strong environmental indicators.

The selecting of main environmental factors for using as indicators based on analyses physical oceanography data, zooplankton species composition and abundance. In spite of high general productivity of the Bering Sea, deficit of high energy food is regular essential element of pollock population functioning. The resilience strategy of it behavior in periods with low trophic level are early northwestern feeding migrations and early back southeastern migration as adopt to changing environmental conditions.

The most effective environmental indicators for predictions of spatial distributions and projecting to applied pollock fishery strategy in the Bering Sea are climate shift, water temperature, species compositions and abundance of zooplankton.

S11-P2

Distribution patterns of cephalopods on the Emperor Seamounts as revealed from bottom trawl catches

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Cephalopod species occurrence and distribution patterns were analyzed based on data collected during bottom fishing on the southern summits of Emperor Seamounts in the summer of 2011, 2012 and 2013. Most data came from the summit banks of Koko, Kanmu and Colahan seamounts. A total of 21 cephalopod species from 12 families were observed in bottom trawl catches. Most of the species were warm-water and of tropical origin, and only few represented south boreal fauna. Species assemblages on the seamount summits were compared using Shannon diversity index, and occurrence of different cephalopods was related to specific and rather variable oceanographic conditions on different seamounts.

S11-P3

The specifics of gonad maturation and the terms of spawning in saffron cod (*Eleginus gracilis* (Til.)) on the coasts of KamchatkaOlga Novikova

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Spawning of saffron cod populations on the west and east coasts of Kamchatka takes place in winter-spring period, but the character of gonad maturation and the terms of spawning are different and region-specific.

In 1980–2015 on the west coast of Kamchatka (the Okhotsk Sea) the gonads of saffron cod in December were mostly at the maturity stage III (50%) or IV (29%). The peak of spawning was in the last half of February. A high number of saffron cod individuals with their gonads melting can be seen there only in February and sporadically (up to 4%) in March. The spawning period on the east coast (the Bering Sea) is much more extensive. The fish with gonads melting can be observed from December to April. In December about 20% of the stock demonstrate the gonad maturity stage V, and 62% — the stage IV. The massive, approximately two-week long spawning takes place in mid January. The spawning in case of «warm» year begins earlier than in case of «cold» on both coasts. When the year is «cold» the number of males and females on the west coast in February and the number of males and females on the east coast in January with the gonad maturity stage V is higher and with the stages VI, VI–II is lower than in a «warm» year.

S13: BIO Topic Session**Joint PICES-ICES Session on Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services**

S13-P1

DOM and its optical characteristics on the East Siberian Arctic shelf: The spatial distribution and its inter-annual variability (2003-2016)Svetlana P. Pugach^{1,2}, Irina I. Pipko^{1,2}, Alexey S. Ruban² and Igor P. Semiletov^{1,2,3}

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The Siberian rivers have among the highest dissolved organic carbon (DOC) concentrations of the world's main rivers. The Great Siberian Rivers integrate meteorological and hydrological changes in their watersheds and play a significant role in the physical and biogeochemical regime of the Arctic Ocean. Given the magnitude of Siberian Arctic dissolved organic matter (DOM) export and the uncertain to which it is degraded to greenhouse gases, intensified studies to better quantify and understand this large carbon pool and processes acting on it are urgently needed. The East Siberian Arctic shelf is characterized by the highest rate of coastal erosion and significant volume of the riverine discharge which derived terrigenous DOM in the Arctic Ocean.

The colored fraction of DOM, CDOM, directly affects the quantity and spectral quality of available light, thereby impacting on both primary production and UV exposure in aquatic ecosystems. Combined analysis of CDOM and DOC data obtained at near-annual basis in (2003-2016) demonstrate a high degree of correlation between these parameters. For all the measured samples taken during the cruises, there is an overall linear relationship between DOC concentration, CDOM, and salinity. Here we report the spatial-time variability of river-borne DOM in the ESAS using CDOM as a proxy parameter. Higher absorption coefficients (a_λ), spectral slope parameter over range 275-295 nm ($S_{275-295}$) and CDOM concentrations reflect the dominant contribution of terrigenous DOM. It is shown that the attenuation light coefficient in the shallow ESAS is mostly determined by riverine CDOM.

BIO Contributed Paper Session

BIO-P1

Identification of myogenic regulatory genes in the muscle transcriptome of beltfish (*Trichiurus lepturus*): A major commercial marine fish species with robust swimming ability

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The beltfish (*Trichiurus lepturus*) is considered as one of the most economically important marine fish in East Asia. It is a top predator with a robust swimming ability that is a good model to study muscle physiology in fish. In the present study, we used Illumina sequencing technology (NextSeq500) to sequence, assemble and annotate the muscle transcriptome of juvenile beltfish. A total of 57,509,280 clean reads (deposited in NCBI SRA database with accession number of SRX1674471) were obtained from RNA sequencing and 26,811 unigenes (with N50 of 1033 bp) were obtained after de novo assembling with Trinity software. BLASTX against NR, GO, KEGG and egg NOG databases show 100%, 49%, 31% and 96% annotation rate, respectively. By mining beltfish muscle transcriptome, several key genes which play essential role on regulating myogenesis, including pax3, pax7, myf5, myoD, mrf4/myf6, myogenin and myostatin were identified with a low expression level. The muscle transcriptome of beltfish can provide some insight into the understanding of genome-wide transcriptome profile of teleost muscle tissue and give useful information to study myogenesis in juvenile/adult fish. The present study was supported by the National Natural Science Foundation of China (No. 41406136, No. 31272663 and U1406403), Key Laboratory of Marine Ecology and environmental Science and Engineering, SOA (MESE-2015-02) and Nantong Municipal Science and Technology Project (MS12015118).

BIO-P2

Diatom biogeography: Abundance and species diversity of a major phytoplankton group in Korean coastal waters during winter

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Diatom composition and abundance during winter were determined for 114 sites along Korean coastal waters. We recorded 190 taxa (87.5% of total phytoplankton species) and a mean abundance of 2.89×10^5 cells L⁻¹ (95.1% of total abundance). The Yellow, South, and East Seas contained 100 (mean: 2.31×10^5 cells L⁻¹), 110 (5.56×10^5 cells L⁻¹), and 143 (0.33×10^5 cells L⁻¹) diatom species, respectively. The best represented of 28 common species were the *Skeletonema dohrnii-marinoi* complex in all three seas; *Paralia sulcata* in the Yellow Sea; *Thalassiosira nordenskioldii*, *Chaetoceros lacinosus*, and *Eucampia zodiacus* in the South Sea; and *Licmophora grandis*, *Chaetoceros socialis*, and *Odontella aurita* in the East Sea. Cluster analyses revealed seven groups: Yellow Sea communities formed one, but South and East Sea communities clustered into two and four groups, respectively. Our results are the first to clarify diatom winter biogeography throughout Korean coastal waters.

BIO-P3

Seasonal and year-to-year variations in the surface copepodid population and egg production rate of *Eucalanus californicus* (Copepoda: Calanoida) in Sagami Bay, JapanYusuke **Ikawa**¹, Masumi Inui¹, Tomohiko Kikuchi¹, Tatsuki Toda² and Shinji Shimode¹¹ Graduate School of Environment and Information Sciences, Yokohama National University, Kanagawa, Japan

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Eucalanus californicus is one of the major secondary producers and performs seasonal ontogenetic vertical migration in the mid latitude area of the North Pacific Ocean. The species appears in the surface layer during spring phytoplankton bloom for feeding and reproduction, and diapauses in the deep depth (> 500 m) from summer to winter. Focusing on the relationship between the length of the surface occurrence period and the surface environments, we conducted monthly zooplankton samplings for five years from 2012 to 2016 in Sagami Bay, Japan. Egg production rate (EPR) experiments were also conducted from 2014 to 2016. In 2013 and 2015 among the five years, lower surface abundances of *E. californicus*, smaller oil sacs in CIV and CV and longer surface occurrences until July were observed, indicating that the species continued to feed, grow and reproduce during longer periods in the surface before starting dormancy in the deep depth. In addition, the average of EPR in 2015 was 3.5 egg female⁻¹ day⁻¹, which was comparatively low against those in the other years, since chlorophyll *a* concentrations were continuously lower than those of the other years. This result implies that the newly recruited population in 2015 might be limited. Our result suggest that year-to-year variations in the surface environmental conditions can regulate the population dynamics and recruitments of the species. (219 words)

BIO-P4

Coastal currents and effects of freshwater discharge on zooplankton aggregations in the Sea of OkhotskNatalia **Shlyk**¹, Konstantin Rogachev¹ and Eddy Carmack²¹ V.I. Il'ichev Pacific Oceanological Institute, Vladivostok, Russia

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Here we focus on zooplankton of the coastal Sea of Okhotsk during a significant freshening event that occurred in 2013. The Shantar Archipelago is located in the northwestern part of the Sea of Okhotsk and contains the wide and shallow Academy Bay, which are important whale feeding grounds. Cold water and the presence of a seasonal ice cover, appear to promote the presence of Arctic species of zooplankton. Satellite data used to determine ice drift and circulation features. Trajectories of individual ice floes obtained from satellites Aqua and Terra. We found that during freshening event the large anticyclonic eddy blocked the inflow of saline water from the northern part of the Sea of Okhotsk. We use and compare CTD and mooring data collected in different years to examine the relationship between hydrography and the aggregation of the dominant zooplankton species (copepods *Calanus glacialis* and pteropods *Limacina helicina*). Variation in tidal and subtidal advection of Okhotsk Sea shelf water with high salinity and containing large zooplankton aggregations was the most important process influencing variation in plankton concentrations. Cross-isobaths compression of copepods coupled with the behavioral maintenance of their vertical position by swimming against sinking is proposed as the main mechanism that results in zooplankton accumulation on the bottom slope. We show that the reduction of salinity accompanied by a significant decrease in abundance of copepods and pteropods. We surmise that freshening and strengthening of the coastal circulation is the major cause of the reduction of zooplankton abundance.

BIO-P5**Transcriptome profiling of *Galaxea fascicularis* and its endosymbiont *Symbiodinium* reveals chronic eutrophication tolerance pathways and metabolic mutualism between partners**

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In the South China Sea, coastal eutrophication in the Beibu Gulf has seriously threatened reef habitats by subjecting corals to chronic physiological stress. To determine how coral holobionts may tolerate such conditions, we examined the transcriptomes of healthy colonies of the galaxy coral *Galaxea fascicularis* and its endosymbiont *Symbiodinium* from two reef sites experiencing pristine or eutrophic regimes. We identified 236 and 205 genes that were differentially expressed in eutrophic hosts and symbionts, respectively. Both gene sets included pathways related to stress responses and metabolic interactions. An analysis of genes originating from each partner revealed striking metabolic integration with respect to vitamins, cofactors, amino acids, fatty acids, and secondary metabolite biosynthesis. The expression levels of these genes supported the existence of a continuum of mutualism in this coral-algal symbiosis. Additionally, large sets of transcription factors, cell signal transduction molecules, biomineralization components, and galaxin-related proteins were expanded in *G. fascicularis* relative to other coral species.

BIO-P6**Zooplankton production parameters in the north-western Bering Sea in the present period**

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On the basis of plankton surveys, conducted in the north-western Bering Sea in 2010–2015, the production characteristics of zooplankton were calculated and analyzed. Zooplankton was divided into two trophic groups: predatory (mainly chaetognaths and hyperiids) and non-predatory (copepods and euphausiids) zooplankton. Considerable variations of zooplankton production parameters were observed in for autumn period. This is due to the inter-annual dynamics of regional features of the size, taxonomic and trophic structure of zooplankton. The sharp decline in the copepod biomass after 2011 and the significant reduction in the biomass of euphausiids in 2013 were characteristic of the considered period in this region. All these features of the dynamics of copepods and euphausiids had an influence on the value of zooplankton production. The highest non-predatory zooplankton production was in 2010–2011 (up to 5081 mg/m³); the lowest, in 2012–2014 (up to 2716 mg/m³). Production of predatory zooplankton was the most significant in 2013 in the waters of the eastern part of the Gulf of Anadyr, which is associated with the presence of *Themisto libellula*. In general, non-predatory zooplankton in the north-western part of the Bering Sea produced from 14.8 to 53.1 million tons during the autumn; predatory zooplankton, from 5.0 to 14.2 million tons.

BIO-P7

Pathologic survey of Protozoan Parasites in different marine bivalve hosts in the South Coast of Korea using PCR and histologyHye-Mi Lee¹, Hyun-Sil Kang¹, Young-Ghan Cho¹, Hee-Jung Lee² and Kwang-Sik **Choi**^{1*}

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Degradation in coastal environmental quality is often imprinted on sessile or less mobile benthic animals, including oysters, mussels, and clams. In this study, we surveyed protozoan parasite infection in intertidal bivalves using histology and PCR. Molecular markers were designed to detect *Perkinsus olseni*, *P. honshuensis*, *Marteilia granula* and *Haplosporidium nelsoni*, in oyster, *Crassostrea gigas*, clam *Ruditapes philippinarum*, *Coecella chinensis* and mussel *Mytilus edulis galloprovincialis*. *Perkinsus* infection was also assayed using Ray's fluid thioglycollate medium assay (RFTM). RFTM indicated that 78% of *R. philippinarum* were infected by *Perkinsus* sp., with the mean intensity as 4.0×10^6 cells/g gill. *P. olseni* infection was also confirmed in the Chinese wedge clam *C. chinensis*, although the prevalence and intensity was low (2% and 1.0×10^5 cells/g gill). RFTM and histology showed no *P. olseni* infection among oysters and mussels, while the PCR yielded detectable signals from the two species. PCR and histology indicated that Manila clams were also infected by *M. granula*, a paramixian parasite responsible for mortality of clams. PCR and histology failed to show infection by *Haplosporidium* spp. PCR was found to be sensitive and fast to diagnose parasite infection in marine bivalves, while histology provided essential microscopic images of the parasites.

FIS Contributed Paper Session

FIS-P1

A preliminary study on the nautical area scattering coefficient and distribution of mesopelagic fishes in the central-southern part of the South China Sea

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In order to explore the abundance and spatial-temporal distribution of mesopelagic fishes in the central-southern part of the South China Sea, two acoustical surveys were conducted using a Simrad EK60 echosounder (38 kHz) in the Nansha, Zhongsha and Xisha areas in spring 2013 and in spring 2014, and the abundance and distribution were estimated by the echo-integration method. The NASC composition of fishes were insignificantly different between fish living in 10–200 m at night and 200–1000 m during the day in the Nansha area in spring 2013, but the differences were significant in the Zhongsha and Xisha areas in spring 2014. The NASC composition of fishes living in 200–1000 m during the day for the different latitude scope in the Nansha area presented significant differences, and the differences were also significant in the Zhongsha and Xisha areas. The NASC of mesopelagic fishes in the central-southern part of the South China Sea was 2387 ± 601 m² nmi⁻². According to existing mesopelagic fishes target strength parameters and the median value, we estimated the abundance of mesopelagic fishes in the central-southern part of the South China Sea to be 82 ± 21 million tons. The research results indicated that the NASC of mesopelagic fishes in the central-southern part of the South China Sea was higher by 29.2% than the global average.

FIS-P2

Denitrification effect, substrate enzymatic activities and microbial information in an integrated vertical-flow marine constructed wetlands

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Indoor and the outdoor integrated vertical-flow constructed wetlands were constructed in order to investigate substrate enzymatic activities and microbial information in a marine aquaculture wastewater treatment system. The denitrification efficiency and the activities of urease, dehydrogenase and nitrate reductase in the surface fine sand substrate (0–5cm) of the outdoor system were analyzed. The results show that the system has a good denitrification efficiency under the condition of adding periodic continuous marine aquaculture wastewater. The urease, dehydrogenase and nitrate reductase in the surface fine sand substrate (0–5cm) of the outdoor system have a higher activity, and the surface of the downstream is higher than that of the upstream. The urease, dehydrogenase, and nitrate reductase are related to the denitrification process of the system. The constructed wetlands have a rich microbial community and differences in every substrate. At the phylum level, the *Proteobacteria*, *Bacteroidetes* are the dominant bacteria. And the *Chloroflexi*, *Acidobacteria*, *Actinobacteria*, *Planctomycetes*, *Latescibacteria*, *Parcubacteria*, *Cyanobacteria*, *Gemmatimonadetes*, *Nitrospirae*, *Acetothermia*, *Deferribacteres*, *Chlamydiae*, *Saccharibacteria*, *Chlorobi*, *Firmicutes*, *Hydrogenedentes*, *Spirochaetae*, *Lentisphaerae* are the main microbial community, and they are distributed in every substrate. The *Verrucomicrobia* are distributed mainly on the surface substrate and the planting roots of the outdoor constructed wetlands, the *Synergistetes* and *thermotogae* are distributed mainly on the planting roots of the indoor constructed wetlands.

FIS-P3

Histological observation of hermaphroditism of chum salmon *Oncorhynchus keta* (Walbaum, 1792)Zhukova Kristina¹ and Sergey S. **Ponomarev**²¹ Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Moscow, Russia

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Hermaphroditism is the simultaneous presence both male and female reproductive tissue in the same gonad (ovotestis). The occurrence of teratological intersexuality has been reported in many species of the Salmonidae family. The chum salmon is a gonochoristic species; there is no protandry and protogyny: sex differentiation proceeds in the male or female without an intermediate female or male phase. Hermaphroditism in this family species has been reported by many authors, but histological studies were not conducted.

An intersexual chum salmon specimen was collected in the North Pacific near the Kuril Islands in 2016. The fork length of this specimen was 49.4 cm, age was 3 years, weight was 1474 g, and gonad weight was 6 g.

The hermaphroditic gonad type was delimited by the classification of Sadovy and Shapiro (1987). Histological analysis revealed that testicular and ovarian structures were separated from each other by connective tissue. Normally developing germ cells were present in both male and female tissues. In the ovarian part the older generation of germ cells was represented by oocytes in the cortical alveoli stage and perinuclear oocytes were also present. The testes of the bisexual specimen contained primary spermatocytes. Gonad maturity of both males and females parts occurred at the same development phase.

FIS-P4

Development of habitat suitability index models of demersal fishes off the eastern coast of JapanHiromichi **Igarashi**, Yoichi Ishikawa, Yusuke Tanaka, Takehisa Yamakita, Misako Matsuba, Yumiko Yara and Katsunori Fujikura

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An accurate estimate of a potential habitat of fish species enables us not only to understand the response of species to environmental changes but also to utilize it for an efficient use of fish resources. Habitat suitability index (HSI) models are widely used as tools in ecological impact assessments, ecological restoration studies, and practical exploration of potential fishing zones. It describes the relationships between fish abundance and ocean environmental variables and then estimates the level of habitat suitability as an HSI score representing “poor” to “good” habitat qualities. In this study, we developed HSI models for several species of demersal fishes off the eastern coast of Japan by applying several machine learning algorithms to a Japanese commercial fishery dataset compiled by Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, that includes trawling catch data of more than 30 species of demersal fishes. We used an ocean reanalysis dataset FORA-WNP30 produced by JAMSTEC and MRI-JMA. The horizontal resolution is 0.1*0.1 degree of latitude and longitude with 54 vertical levels, which can provide realistic fields of 3-dimensional ocean circulation and environmental structures. We investigated the HSI response of several species to ocean environmental changes occurring off the eastern coast of Japan. The results indicated that the habitat distributions of *Pseudopleuronectes yokohamae* and *Microstomus achne* could be influenced by the Oyashio intrusion that occurred in winter 2012. In addition, the time series of the CPUE of four demersal species during 1998-2014 were reproduced by the HSI model.

FIS-P5

Estimation of trawl selectivity for four cephalopod species in the Yellow Sea

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In recent years, cephalopods showed an increasing trend globally and gradually became the dominant species in the China Seas. Actually, cephalopods are not the main target species in the Chinese coastal fisheries, and they are usually bycatch of trawl fisheries. The status of the cephalopods is not well understood due to limited information. Here, based on trawler research surveys in the Yellow Sea, we construct selectivity curves of trawlers for four cephalopods species (*Loligo japonica*, *Sepia esculenta*, *Octopus ocellatus*, *Octopus variabilis*) to estimate the relative density of cephalopod stocks in the Yellow Sea. Assuming the cephalopods with each mantle length class have the same stock density in the sampling sites, we obtained preliminary selectivity curves for each species based on the trawler survey data. Accordingly, the selectivity function can be determined based on the estimated trawl selectivity curve. Eventually the trawl selectivity for each cephalopod species was determined by adjusting the selectivity parameters and the number of each mantle length class using an objective function by minimizing the sum of the error squares. The selectivity evaluation of trawlers is the key issue for the assessment and management of fishery resources, particularly for bycatch species. Our results provide new insights for the assessment of cephalopod stocks by determining gear selectivity.

FIS-P6

Partitioning of food resources among three co-occurring scorpionfish in the coastal waters of the northern Yellow SeaZhongxin Wu^{1,2}, Xiumei Zhang¹, Charlotte R. Dromard³, James R. Tweedley² and Neil R. Loneragan²¹ Ocean University of China, Qingdao, Shandong Province, PR China. Email: wuzhongxin2007@126.com² Centre for Fish and Fisheries Research, School of Veterinary and Life Sciences, Murdoch University, South Street, Murdoch, Western Australia 6150, Australia³ UMR BOREA, CNRS 7208 – MNHN – UPMC – UCBN – IRD 207, Laboratoire d'Excellence « CORAIL », DYNECAR, Université des Antilles, 97157 Pointe-à-Pitre, Guadeloupe

The partitioning of food resources amongst three abundant co-occurring reef-associated scorpionfish, *Hexagrammos agrammus*, *Hexagrammos otakii* and *Sebastes schlegelii*, was examined at nearshore (< 100 m from shore) and offshore sites (~ 2 km from shore) in the coastal waters of Lidao, northern China, using stomach content and stable isotope analyses ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$). These three species consumed similar prey items, mainly a variety of crustaceans, fish, polychaetes and macroalgae, but the proportions of the items differed. *Hexagrammos agrammus* fed primarily on polychaetes, macroalgae and crustaceans, *H. otakii* on crustaceans and *S. schlegelii* on fish and crustaceans. Multivariate analyses showed that the dietary composition of the three scorpionfish in nearshore waters differed significantly. In offshore waters the diets of *H. otakii* and *S. schlegelii* were not significantly different with both species feeding predominantly on shrimps and crabs. $\delta^{13}\text{C}$ values varied significantly among the three scorpionfish at nearshore sites, suggesting niche segregation, probably as a way to reduce competition for food. The $\delta^{15}\text{N}$ values also varied among the three species, with *H. otakii* and *S. schlegelii* exhibiting greater values than *H. agrammus*, indicating that they were higher-level carnivores. No significant differences in isotopic signatures among *H. otakii* and *S. schlegelii* were detected in offshore waters. Bayesian mixing models further confirmed that all fish were carnivorous and that the main food sources (fish, shrimp and crabs) were assimilated in different proportions. However some discrepancies of prey items percentage contribution were detected between the results of stomach content observation and stable isotope model estimation, highlighting the importance of application of both complementary analysis methodology in comprehensively understanding food resource partitioning relationship. The evidenced partitioning of food resources among the co-occurring three scorpionfish would reduce the potential competition for resources and account for their co-existing in large numbers.

FIS-P7

Evaluation of the increasing trend of Japanese sardine *Sardinops melanostictus* recruitment in the waters north and west off Kyushu island, Japan

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Spawning stock biomass of the Tsushima Warm Current Stock of Japanese sardine *Sardinops melanostictus* had stayed at a high (10^6 – 10^7 metric ton) level during the early 1980s and early 1990s, thereafter it had decreased to a low ($<10^4$ metric ton) level in the late 1990s. After the mid 2000s, an increasing trend has been seen in the commercial catch in waters north and west off Kyushu island (NWK). To evaluate that the increase is a true signal of stock increase, we examined spatial and temporal variations in catch per unit effort of the young of the year sardine (CPUE_{YOY}, kg tow⁻¹) obtained from midwater trawl surveys in summer from 1997 to 2016. The total of 344 trawling sites were divided into three sub-areas of North, Middle and South based on a generalized linear model using software R with the package “glm.tree” (Ichinokawa and Brodziak 2010). As an index of recruitment success, relative CPUE was calculated by dividing yearly mean CPUE_{YOY} by the number of eggs collected in the egg survey conducted in the NWK in a given year. Remarkable increase in CPUE_{YOY} was found only in the North area after 2007. Relative CPUE in the North area drastically increased from 0.0 to 0.2–20.9 after 2005, suggesting an increase in recruitment probability of Japanese sardine in the NWK. The increase in commercial catch in the NWK is attributed to the increase in recruitment of the stock inhabiting these waters.

Ichinokawa M and Brodziak J (2010) Using adaptive area stratification to standardize catch rates with application to North Pacific swordfish (*Xiphias gladius*). *Fish Res* 106, 249–260.

FIS-P8

The nekton community of the Pacific waters off the Kuril Islands and Northwestern Pacific: Trophic links and the amount of forage base consumption

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The study of fish and squids feeding and the consumption of forage resources by nekton species allows us to examine trophic links in the nekton community and to assess the role of the most massive species in its trophic structure. This research is based on data obtained during TINRO trawl surveys in the upper pelagic layer (0-50 m) of the Pacific waters off the Kuril Islands and Northwestern Pacific in summer 2004-2016.

In the early summer (June-July 2004-2013), the forage base consisted mainly of copepods (60 %) and chaetognaths (26 %), while amphipods and euphausiids' share amounted to only 7 %. The largest share of the nekton community biomass belonged to myctophids (32 %), and salmon (23 %). Analysis of the data on forage base consumption by nekton species showed that salmon consumed 32 % of the total amount and mesopelagic fish (basically myctophids) consumed 24 %. Generally nekton species diet consisted of copepods (38 %) and euphausiids (29 %). The following main energy transfer pathways were: euphausiids → pink salmon; copepods → myctophids. The highest grazing pressure fell on pteropods (33 %) and amphipods (17 %). However, the total consumption of forage resources did not exceed 2 % of the total biomass.

Due to mass migrations of subtropical fish, such as chub mackerel *S. japonicus* and Japanese sardine *S. melanostictus*, in June-July and July-August 2014-2016, the composition of the dominant species in the nekton community changed and these subtropical species became the main consumers of forage resources, accounting for up to 80 % of the total consumption. Total nekton biomass tripled and the amount of consumption also increased by three to five times. Therefore the most significant energy transfer pathways were: copepods → chub mackerel; euphausiids → chub mackerel; copepods → Japanese sardine. Despite this, the total grazing pressure on forage resources did not exceed 18 % of the stock.

FIS-P9

Mesopelagic species in the upper epipelagial layer of the deep-sea part of Okhotsk Sea in summer and autumn periods

Pavel O. **Emelin** Presented by Aleksei Khoruzhiy (for Pavel O. Emelin)

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This study is based on data collected by identical methods during 15 regular trawl surveys conducted in the summer and autumn period from 1998 to 2003, as well as in 2011 and 2012. All abundance estimates used in this study are determined for the deep-sea part of Okhotsk Sea (total area south of 54°N; 772.86 thousand km²). The selected data consisted of 752 trawl stations, 322 of which (123 at night) were conducted in summer, and 430 (200 at night) in autumn. The long-time annual average numbers of mesopelagic species, collected during one survey in summer and autumn, was almost identical - 5.75 and 6.25, respectively. In summer, the number of mesopelagic species varied from 5 (1999, 2000, 2003, 2011) to 7 (2002 and 2012). Their total biomass value ranged from 49.79 (2001) to 1673.43 thousand tons (2012), with an average of 697.42 thousand tons. For the autumn period, the number of mesopelagic species varied from 5 (1999, 2002, 2003) to 9 (2012). Their total biomass ranged from 106.99 (2011) to 1023.81 thousand tons (2000), with the average value of 409.23 thousand tons. In summer, not only the higher total biomass of mesopelagic fish and squid, but also their contribution to the composition of the nektonic community was observed. Their contribution varied widely from 4.93 (2001) to 89.32% (2002), the long-time annual average was 43.71% of the biomass of all fish and squid. In autumn, the contribution of mesopelagic species was lower, and varied from 7.17 (2003) to 72.41% (2000), with a long-time annual average value of 32.25% of the biomass of all fish and squid. In summer, northern smoothtongue (*Leuroglossus schmidti*) was dominant most often in the biomass structure of the entire nektonic community. Meanwhile, another mesopelagic species - the boreopacific squid (*Boreoteuthis borealis*) was a subdominant. In autumn, when juvenile pink salmon (*Oncorhynchus gorbuscha*) was dominant most often, the northern smoothtongue was a subdominant.

FIS-P10

Development of stereo camera methodologies to improve pelagic fish biomass estimates and inform ecosystem management in marine waters

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Integrated research and long-term monitoring of marine fish are required to support the management of sustainable ecosystems. Time series of fish biomass are used in species-specific stock assessments, or ecosystem models that are then applied in setting total allowable catches or to assess the state of ecosystems. One challenge in acquiring a time series of fish biomass is that catchability or availability of fish to survey gear can change with habitat, weather, or vessel traffic conditions. Additionally, trawl samples are costly in terms of time and effort required to deploy the net and process the resultant catch. Underwater stereo-cameras have shown promise in providing a non-lethal, efficient, and cost-effective method to observe and measure fish in areas that cannot be sampled otherwise, but these methods have yet to be demonstrated for mid-water pelagic or semi-pelagic fishes. We designed, built, and utilized a stereo-camera for fish identification and length measurements in the water column. Results demonstrated that a stereo-camera can be a viable tool for acoustic target verification of fish species and measurements of fish length, tilt, and yaw. Challenges of stereo-cameras include small sample sizes and difficulty identifying small fish. Benefits of stereo-cameras are that it is an efficient, non-lethal tool that acquires depth-specific species composition. In addition, fish tilt measurements have implications for acoustic target strength values, which can affect biomass estimates. Stereo-camera technology is proving to be a useful tool for studying fish in the water column.

FIS-P11

Migrations of rat-tail and greenland halibut in the Okhotsk SeaVladimir **Tuponogov** and Nadezhda AseevaPacific Fisheries Research Center (TINRO), Vladivostok, Russia
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Seasonal migrations of two deep-water fish species, as rat-tail and greenland halibut are considered for the Okhotsk Sea and adjacent Pacific waters on the data of 193 trawl surveys (both bottom and pelagic) conducted from 1963 to 2016, taking into account dynamics of trawl, net, and longline commercial catches, location of the spawning grounds and distribution of different size groups of these species. Large-scale migrations of both species are determined for the first time, ranged in hundreds of miles. The following schemes of the migrations are presented: i) the rat-tails migrate from the Pacific waters to the Okhotsk Sea side of northern Kuril Islands in winter-spring and backward to the Pacific side in summer, to their spawning grounds; ii) the greenland halibuts migrate from the continental slope of Kamchatka southward to the slope of Kuril Islands in winter-spring and backward in summer-autumn, to their spawning grounds at Kamchatka. The schemes are principally different between these species because of their different life cycles, so far as rat-tail is a proper deep-water species and greenland halibut is a secondary deep-water species. The presented schemes are strongly generalized and real ones can vary in dependence on large-scale changes of environments.

FIS-P12

Environmental influence on Pacific Halibut *Hippoglossus stenolepis* spatial distribution and migration in the Eastern Okhotsk SeaRoman **Novikov**Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO), Petropavlovsk-Kamchatsky, Russia
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The work is based on the data collected in 1985-2015 during bottom trawl surveys on fishing vessels.

Analysis of distribution of Pacific Halibut in the Eastern Okhotsk Sea has revealed two plots of a longterm and relatively stable increased density of the fish, where they are stirring no matter what season. The plots near the west coast of Kamchatka are situated: one on the shelf (from 51°30'N to 53° 30'N) and the other in the upper part of continental slope and (from 55°30'N to 57°30'N). The density of the fish there answers local hydrological terms, because the plots are in the area of powerful rotations. In general the distribution of the species during the year mainly depends on the water temperature dynamics in the demersal horizon, and in summer the dynamics predetermines distribution of mass forage organisms.

MEQ Contributed Paper Session

MEQ-P1

Assessment of contamination in the coastal zone around Vladivostok and benthos status in 2016

Alexander V. **Moshchenko**, Tatyana A. Belan, Boris M. Borisov, Tatyana S. Lishavskaya and Alexander V. Sevastianov

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Results of environmental survey in coastal zone of Peter the Great Bay in 2016 are presented. Data obtained included contents of selected metals, hydrocarbons, pesticides, phenols in sediments and species composition and quantitative parameters of benthos.

The aim of this report is to study the ecological conditions in the coastal zone around Vladivostok in 2016, and reveal ecological status of benthic communities.

The most dramatically ecological situation observed at the Holden Horn and Diomid Inlets, due to the highest level of anthropogenic impact. Benthos characterized by lowest values of taxonomic diversity, as well as biomass, but high density of opportunistic species. Ecological status of benthos varies from bad to poor. Ecological situation in Amursky Bay is at moderate level. Worsening of ecological state of benthos in these areas was caused both by high level of chemical contamination and oxygen deficiency (and by complex of factors connected) that is permanent at the north of Golden Horn Inlet and seasonal in the east part of Amursky Bay.

Relatively good state and wide species diversity of animals were found in East Bosphorus Strait and Ussurisky Bay (good and high), where the level of contamination was less notably, and events of oxygen starvation were observed infrequently and were expressed in less degree.

MEQ-P2

Oxygen regime in the rivers flowing into the Japan/East Sea as an indicator of anthropogenic impact

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Chemical parameters of the waters in 8 rivers of the Japan/East Sea basin were monitored in all seasons of 2016. They differed significantly by their oxygen regime. The data on dissolved oxygen content (DO) in the river water were used for hierarchical cluster analysis by Ward method with the Euclidean distance as a measure of similarity. Two types of the oxygen regime were identified: several rivers represented the natural seasonal changes of the oxygen content and several others – its changes under a strong anthropogenic impact. The minimum DO were recorded in winter period in the samples from the largest Suyfen/Razdolnaya River with a prominent part of the drainage basin located in China (1.9 ml L⁻¹, 19.7 %) and from the Knevichanka River with the whole basin located in southern Primorye, Russia (0.9 ml L⁻¹, 8.7%). Spring aeration caused by phytoplankton and macrophytes bloom was observed everywhere, but in the rivers of the latter group it was accompanied by growth of biochemical oxygen demand, with BOD₅ index exceeding the maximal permissible concentration (MPC = 2.1 ml L⁻¹) in 3-5 times in spring and summer. This huge oxygen demand determined the lowered DO in these two rivers in other seasons. Other rivers in the southern Primorye (Ryazanovka, Barabashevka, Kievka, Partizanskaya, Sokolovka, Artemovka) could be considered as “clean” ones, following to Russian standards of water quality. Seasonal variability of oxygen content in their waters is driven by changes of water temperature and photosynthesis.

MEQ-P3**Soft bottom macrozoobenthos of Peter the Great Bay and chemical contamination of marine environment**

Alexander V. **Moshchenko**, Tatyana A. Belan, Boris M. Borisov, Tatyana S. Lishavskaya and Alexander V. Sevastianov

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Results of benthos investigations in Peter the Great Bay for 1992–2016 are presented. Data included average number of taxonomic groups and species per station, Shannon-Wiener index, density, biomass, Clark's statistics (G, S, H', A, B and W). Contamination level was characterized by *TPF* index.

The aim of this report is to study the effects of contamination on composition and abundance of macrozoobenthos.

At the area studied 488 species of macrozoobenthos were found. Polychaetes dominated in species number (178), bivalves and amphipods included 73 and 72 species, correspondingly. Bivalves prevailed in biomass and polychaetes did so in population density (46.2 and 62.1 %).

Changes of all benthos parameters were not monotonous along gradient of contamination. Values of G, S, H' remained at similar level (B diminished clearly) within range of "zero – moderate contamination" and then they dropped sharply under transition from moderate level to heavy one. Population density increased at initial stage of contamination and underwent sharp drop within the same range as other parameters. The most expressed decrease of W statistics occurred for the range of "heavy – extreme" contamination. Changes of all parameters along *TPF* gradient were statistically significant. Thus, contamination is one of the most important factors affected benthic populations in the region studied.

MEQ-P4**Levels of artificial radionuclides in squid from northwestern Pacific after Fukushima accident**

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In order to enhance the understanding of potential impact from Fukushima accident on marine biota in northern Pacific, 13 composite samples of squid (*Ommastrephes bartrami*) obtained at northwestern Pacific in December 2011 were analyzed for a wide range of radionuclides (Cs-134, Cs-137, Ag-110m, U-238, Ra-226 and K-40). The radiological dose and relevant risk for the species and for human via consumption of these squid were assessed with the commonly used method. Last but not least, the whole-body to tissue and muscle to gut concentration ratios of several radionuclides were calculated and reported, providing a simple method to estimate the whole-body concentration in the environmental monitoring programs.

MEQ-P5

Spatio-temporal variation of radiocesium in sea sediment East of Japan after the Fukushima Dai-ichi Nuclear Power Plant accident

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A large amount of radionuclide (mainly I-131, Cs-134, Cs-137) was released into the environment from the Fukushima Daiichi Nuclear Power Plant (FDNPP) of Tokyo Electric Power Company Holdings, Inc. (TEPCO) following the Great East Japan Earthquake that occurred in March 2011. Most of the radionuclide released to the ocean was transported and diffused by the ocean currents to the open ocean area; but a part of the released radiocesium which has strong particle adsorption property continues to remain on the sea-bottom of the east coast of Japan. Therefore, as part of elucidating the influence of these radioactive materials on marine benthic ecosystems, the Fisheries Research and Education Agency (FRA) has addressed an issue to comprehend the spatio-temporal distributions of the radiocesium concentration in sea sediment since 2012. Radiocesium was mainly distributed in surface sediment in the coastal area off Ibaraki, Fukushima and Miyagi prefectures during the early survey. However, while those near shore concentrations have been decreasing recently, the concentration in the offshore area and/or in the deeper sediment layers tended to increase slightly. This result is consistent with our numerical study, which demonstrated the transportation of sediment to the southern offshore area. The total amount of radiocesium in the whole survey area tended to temporally monotonically decrease. These results indicate that the potential effect of the sea sediment on marine ecosystem has been steadily decreasing.

MEQ-P6

Persistent Organic Pollutants in black-tailed gull eggs from South Korea

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Eggs have been used successfully as a non-destructive monitoring tool for persistent organic pollutants (POPs) and heavy metals. Seabird eggs have long been used as biomonitors for long-term monitoring of environmental contaminants in the Europe and North America. In South Korea, national monitoring program on environmental contaminants has been run primarily for coastal sediment and bivalves, while biomonitoring program for high-tropic marine species such as marine mammals and seabirds has not been established yet. This study was performed to find out the best approach and strategy for seabird monitoring, and to identify the levels and profiles of contaminants in seabird eggs inhabiting along the Korean coasts. Black-tailed gull eggs were collected from breeding places located in the southern (Hong-do), eastern (Dok-do), and western (Seoman-do) coasts and egg content was used for chemical analysis. Among the target analytes, PCBs and DDTs showed highest levels at all sites, indicating their great bioaccumulation and biomagnification potential. The overall level of contaminants was highest in eggs from the eastern coast, which might be related to foraging range and food quality of seabird. However, PBDEs showed high levels in western coast. The relatively persistent isomers or congeners of each compound such as p,p'-DDE, β -HCH, BDE-47, α -HBCD were dominantly accumulated in seabird eggs.

MEQ-P8**An in-situ monitoring system for gamma radionuclides in seawater**

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A removable in-situ monitoring system for gamma radionuclides in seawater was developed, and was tested with standard solution of radionuclides onboard. The results show that the lower limits of detection is about 0.36 Bq/L, which is lower than the limit value 0.7 Bq/L of Chinese Sea Water Quality Standard, for ^{137}Cs in seawater in one hour with the detection efficiency of 0.018%. This system could be used for the monitoring of gamma radionuclides in seawater in emergency status.

Key words: Gamma radionuclides, Seawater, Monitoring system, In-situ

MEQ-P9**Contamination the Japanese Scallop *Mizuhopecten yessoensis* (Jay, 1856) by the filamentous fungi (Peter the Great Bay, Sea of Japan)**

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Mycological investigation of the Japanese scallop *Mizuhopecten yessoensis* (Jay) (Bivalvia) from different areas of the Peter the Great Bay (Sea of Japan) was conducted. In total, 72 species of filamentous fungi from 30 genera of ascomycetes, anamorphic fungi, and zygomycetes were isolated from internal organs of Japanese scallop.

The complex of filamentous fungi associated with the Japanese scallop from the Amur Bay includes 35 species of 16 genera, complex of filamentous fungi from Japanese scallop from coastal waters of the Rikorda Island comprises 39 species of 19 genera and complex of filamentous fungi from Japanese scallop from Vostok Bay comprises 15 species of 8 genera.

A low degree of the similarity in species composition of complexes of the filamentous fungi in bivalves from marine habitats with different indicators of environmental quality and degree of anthropogenic load was revealed. Species richness of the conditionally pathogenic and toxigenic filamentous fungi, primarily the fungi of the genera *Aspergillus*, *Penicillium*, *Cladosporium*, and *Chaetomium*, in internal organs of the bivalve mollusks increases in contaminated coastal waters.

Strains of filamentous fungi are stored in the Bioresource Centre of Microorganisms “Marine Biobank” NSCMB FEB RAS.

POC Contributed Paper Session

POC-P1

Okhotsk troposphere cyclone as the general factor for ice cover formation in Tatar Strait and in the Okhotsk sea

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During the winter the air circulation along Eastern Asia coast depends on a middle troposphere dish mode. The Okhotsk troposphere cyclone (OTC) and its cold core are positioned in the Southern part of the trough-dish above the North-West part of the Okhotsk Sea. This study examines the relationship between ice cover conditions in the Okhotsk Sea and Tatar Strait and shifts in the OTC climatic location. Using satellite data of GCOM-W1/AMSR2 and MODIS Terra we show that extreme ice cover years in the Okhotsk Sea and Tatar Strait are related to OTC position. The location and intensity of the OTC control the trajectory and strength of near-surface cyclones above the Okhotsk Sea and Tatar Strait. During a southward shift of the OTC, the Tsushima current intensifies leading to the early ice melting in Tatar Strait. Anomalous warm condition for the ice cover in March occurred in 2015. In contrast, during a northward shift of the OTC, the Tsushima current weakens favoring an increase in ice cover. This observed mechanism and patterns of extreme ice cover formation in the Okhotsk Sea and Tatar Strait can be used to forecast ice cover in commercial areas of the Okhotsk Sea and Tatar Strait.

POC-P2

Mean sea-level rises and coastal vulnerability along the Korea coasts

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Sea-level changes along the Korea coasts have been estimated based on the selected 18 tide-gauge records of the Korea Hydrographic and Oceanographic Agency (KHOA) over the last several decades. The sea level has risen 3.35 mm/yr in the east, 3.02 mm/yr in the south, and 1.06 mm/yr in the west, with an average rate of about 2.68 mm/yr. The purpose of this study is to develop a coastal vulnerability assessment system (CVAS) related to long-term sea level rises (SLR) with the basic framework of IPCC. Three coastal vulnerability indices, the CEI (Coastal Exposure Index: SLR), the CSI (Coastal Sensitivity Index: human, physical and geographical sensitivity) and the CAI (Coastal Adaptation Index: socio-economic and governmental adaptation), are developed to evaluate the CII (Coastal Impact Index) and the CVI (Coastal Vulnerability Index). Assessment of coastal vulnerability was applied to the coastal zone in South Korea. An indicators database (D/B) was constructed using numerical modeling along with national statistics information. The Indicator D/B was generated with spatial data in coastal areas by GIS analysis, and then classified into five categories using probability distributions. The results of assessment show three types of risk areas: (1) high exposure areas (Jeju, Pohang), (2) high sensitivity areas (Incheon, Changwon and Busan), and (3) low adaptation areas (Haenam, Jindo). These results provide decision makers with critical information for preserving and improving the safety and well-being of the coastal zone.

POC-P3**Interannual variation of solar heating in the Chukchi Sea, Arctic Ocean**

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Arctic sea ice cover in summer has declined rapidly over the past few decades. The albedo of sea ice is much higher than that of open water; reduction of sea ice cover is associated with increase of solar heating in the Arctic Ocean. In this study, we focus on solar heating in the Chukchi Sea located in the Pacific side of the Arctic Ocean where remarkable sea ice reduction has occurred. The Chukchi Sea is a pathway of Pacific Water from the Bering Strait to the Arctic Basin. The heat transport of the Pacific Water through the Bering Strait, which has increased recently, plays an important role in a decrease in sea-ice formation during winter as well as sea-ice melt in summer in the Canada Basin. Although the Pacific Water heat transport through the Bering Strait is becoming clearer, we expect that solar heating significantly modifies the Pacific Water in the Chukchi Sea. Therefore, we estimate solar heating in the Chukchi Sea through analysis of satellite-derived sea ice concentration data as well as reanalysis data of shortwave radiation, and discuss the role of the solar heating in the Chukchi Sea in the heat transport into the Arctic Basin. We also use in-situ shortwave radiation data obtained by R/V Mirai to validate the reanalysis data of shortwave radiation in the Chukchi Sea.

POC-P4**Sea ice detection for the Bohai Sea using MODIS IST data**

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The Bohai Sea is a seasonal ice covered semi-enclosed basin located in the northeast coast of China. Sea ice in the Bohai Sea is a serious threat to marine navigation, off-shore constructions and the fishery industry. Monitoring of the Bohai sea ice is of great importance for preventing sea ice-related disasters and for better managing and planning of offshore activities. Sea ice parameters retrieved from satellite remote sensing technology include sea ice extent, ice edge location, concentration, and thickness classifications. MODIS' spatial resolution and wide spatial coverage allows a better representation of the distribution and thickness of ice compared to other sensors, and is therefore more useful for sea ice detection and forecasting. In this study, MODIS Level 1B data is used to supply the sea ice extent and thickness. Based on the spectral characteristics of sea ice and threshold segmentation method, sea ice extent is retrieved. Level ice thickness was calculated using MODIS ice surface temperature and an ice surface heat balance equation. The retrieved ice thickness agreed reasonable well with in situ observations from two off-shore oil platforms. The MODIS results under cold conditions (air temperature < -10 °C) also agreed with the estimated ice growth from Lebedev and Zubov models. Our method is feasible for the Bohai Sea operational ice thickness analyses during cold freezing seasons. These results provide an important source of information for monitoring sea ice in the Bohai Sea and providing initial data for sea ice forecasting. It is also a good reference for verifying sea ice forecasting.

POC-P5**Development of a medium range ocean prediction model for the seas around Korea**Heeseok **Jung**¹, Chan Joo Jang^{1,2} and Sukyung Kang³¹ Korea Institute of Ocean Science and Technology, Ansan, R Korea. E-mail: cjjang@kiost.ac.kr² University of Science and Technology, Daejeon, R Korea³ National Institute of Fisheries Science, Busan, R Korea

Due to a decline of total catch production in Korean waters during the recent decade, the prediction of ocean conditions for the management and recovery of fishery resources has emerged as an important goal. Since fishery resources are influenced by the marine environment, changes in marine environment especially due to a climate change should be considered to predict the fishery resources. However, a medium range (2 ~ 6 months) prediction of marine environmental change has been rarely performed. Here we report on a newly developed medium range ocean prediction model for the Northwest Pacific that includes the seas around Korea. A three-month re-forecast simulation was conducted to validate the model against the NCEP CFSv2 data, which is also used as an atmospheric forcing and open boundary condition. We analyzed the last month (March of 2016) of the simulation output and verified that the model successfully re-forecasted the temperature anomaly distribution of sea water from the surface to 500 m depth. As observed, the model showed a positive anomaly compared to the normal year averaged for 1982-2010, especially in the regions with warm currents such as Kuroshio and Tsushima, East Korea Warm Current, and Yellow Sea. Our results suggest that the developed medium range ocean prediction model can be used to predict the marine environment at least three month in advance. Our future plan is to couple the ocean prediction model with a biological model and to apply the model to a prediction of fishery resources on a medium range.

POC-P6**Argos drifters reveal amplification of tidal currents in the Oyashio**Konstantin **Rogachev** and Natalia ShlykPacific Oceanological Institute, Baltiyskaya St., Vladivostok, Russia. E-mail: rogachev@poi.dvo.ru

The south-flowing waters of the Kamchatka and Oyashio currents and west-flowing waters of the Alaskan Stream are key components of the western subarctic Pacific gyre. The dissipation of tidal energy in shallow and coastal regions of these currents and the resulting mixing is an important process that affects upper layer temperature and salinity. An example of the impact of tidal currents on water temperatures is the persistent tidally driven mixing above Kruzenshtern Bank in the Oyashio current. Drifter observations used to understand the characteristics of tidal currents over the bank reveal the existence of a mean anticyclonic circulation. We suggest that the amplified diurnal tidal currents over the Bank are caused by the resonance with diurnal shelf waves. For the steep slopes of the bank, the frequency of shelf waves is found to be close to the diurnal tidal frequencies. The velocity dominated by diurnal signals. The K_1 and O_1 tidal ellipses are clockwise. The enhanced tidal currents suggest that cold spots in summer are due to diapycnal mixing with subsurface cold intermediate water. We found that the 18.6-year lunar nodal cycle is a significant feature of salinity at the temperature minimum in the Oyashio over the period 1990-2015. Significant salinity variations are found to be driven by the 18.6-year nodal modulation. These variations correlate with tidal mixing and may have important consequences for biological productivity.

POC-P7

Carbonate characteristics of the western Chukchi Sea Shelf

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Variability of the Arctic climate has affected many aspects of the Arctic environment, especially in the Pacific sector of the Arctic. The primary implication is that today's Arctic cryosphere (glaciers, frozen ground, and sea ice) and biosphere (terrestrial, lacustrine, and marine) are not at steady state; they have changed and will continue to change in response to evolving Arctic climate. Like everywhere in the Arctic, understanding of environmental change in the Chukchi Sea is hindered by sparse data. Here we focus on the carbonate system data collected in the western (Russian) part of the Chukchi Sea over > 15 years (2000-2016).

Our data exhibit a strong mesoscale and interannual variability of carbonate system parameters in the surface seawater. The aragonite saturation state (Ω_{Ar}) was highly variable but has also been decreasing overall in the upper waters from 2000 to 2011. Despite strong sea ice loss, waters heating and storm increasing, the surface waters in this area have been consistently undersaturated by CO_2 with respect to the atmosphere. The lowest pCO_2 values were found in the areas of highest primary production. Notable localized exceptions, where CO_2 outgassing occurs, include the well-mixed waters near Bering Strait. Combining our carbonate system data set with the available literature data we suggest that the entire Chukchi Sea during the ice-free season absorbs $\sim 12\text{-}15 \times 10^{12}$ g C, and that a significant part of this carbon is transferred to the deep layers and insulated from contact with the atmosphere for a long time.

POC-P8

SST variations in the Northwest Pacific related to West Pacific Teleconnection Pattern

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The spatial and temporal structures of the relationship between sea surface temperature (SST) variations and the West Pacific Teleconnection Pattern (WP) are examined. Statistically significant correlation of interannual changes is noted in two large areas: high positive correlation coefficients ($r > 0.5$) in the zone located to the south from Kuroshio current and close negative correlation ($r \sim -0.6$) in the central North Pacific. Changes in the correlation sign occur over the Subarctic frontal zone. The closest relationship was found between the January WP and February SST anomalies (with 1 month lag), consistent with the SST response to WP forcing. During the period 1950-2016, one regime shift in the variability of WP was observed: lower values of the index prevailed until 1986 and increased afterwards. In the southern region, SST variability is characterized by the same regime shift with higher values occurring in 1987/1988. However, in the northern region, three climatic regimes were found: before 1974, between 1975-2008 and after 2009. Composite analysis of the events with positive and negative WP phase showed differences in the cyclones trajectories and the position of the upper atmospheric ridges over the Northeast Pacific or along the west North American coast, similar to those found by Rodionov et al. (2007). The important determining factor is intensive air-sea interaction under advection of cold and dry air in the rear of cyclones.

POC-P9**The transition of the sea surface temperature long-term trend in the Yellow and East China Seas in the late 1990s: Effects of the North Pacific regime shift**Yong Sun Kim¹, Chan Joo **Jang**^{1,2} and Sang-Wook Yeh³¹ Korea Institute of Ocean Science and Technology, Ansan, Gyeonggi-do 15627, Republic of KoreaE-mail: cjjang@kiost.ac.kr² University of Science and Technology, Daejeon 34113, Republic of Korea³ Hanyang University, Ansan, Gyeonggi-do, 15588, Republic of Korea

The Yellow and East China Seas (YECS) are widely believed to have experienced a robust warming since the 1980s. However, after the warming reached its peak in the late 1990s, the sea surface temperature (SST) reveals a basin-scale cooling trend in the YECS. To understand the mechanism of the decadal transition in the YECS SST, this study investigates its relationship with the large-scale climate variability around the YECS using a basin mode of YECS SST estimated from the optimum interpolation SST (OISST) for 33 years (1982–2014). The principal component (PC) of a basin mode in the YECS varies coherently with the Pacific Decadal Oscillation (PDO) before the late 1990s; however, the correlation between the PC and the PDO dramatically decreases to insignificant levels after the late 1990s, indicating a potential regime shift in the dynamical linkage between the YECS and the North Pacific. Instead of the PDO, after the late 1990s, the winter SST in the YECS is more closely associated with the variation of the Siberian High along with its intensification, suggesting that the intensified Siberian High in recent decades has played an increasing role in forming the recent surface cooling trend of the YECS through the increase in the latent and sensible heat fluxes.

POC-P11**Oceanographic conditions in the northwestern Japan Sea based on satellite information and data from the regular ‘TSUGARU’ transect in winter 2000-2015**Alexander A. **Nikitin**, B.S. Djakov and A.V. Kapshiter

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Oceanographic conditions in the Northwestern Japan Sea are estimated by using satellite altimetry and infrared imagery, and data from the regular ‘TSUGARU’ hydrological transect in winter 2000-2015. By combining the water mass information along the transect with the thermal and dynamic structures from satellite imagery, we characterize cold, warm and intermediate periods in the data. Specifically, we identify the cold (2013), warm (2004, 2007-2008, 2010-2011, and 2014-2015), and intermediate (2000-2003, 2005-2006, 2009, and 2012) years. Important attributes that characterize these periods are the condition of the Primorye (Liman) Current, the location and branching of the Subarctic Front, the development of the warm water belt along 42°N, and condition of the Tsushima Current.

General Poster Session

GP-P1

The great 2011 Tohoku tsunami on the Mexican coast: Spectral analysis and energy parameterization

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The great tsunami generated by the Tohoku (East Japan) earthquake of 11 March 2011 (M_w 9.0) caused catastrophic damage and loss of life in Japan and was recorded throughout the Pacific Ocean. This tsunami was recorded along the entire Mexican Pacific coast by tide gauges and offshore DART (Deep-ocean Assessment and Reporting of Tsunamis) stations. Statistical and spectral analyses of these records enabled us to estimate the principal parameters of the waves along the coast and to compare statistical features of the tsunami with other tsunamis recorded on this coast. Based on these analyses, we identified coastal “hot spots”, corresponding to sites having maximum tsunami risk, where wave heights exceeded 1.5-2 m and tsunami-induced currents were strong enough to close port operations. Based on joint spectral analyses of the tsunamis and background noise, we reconstructed the spectra of tsunami waves in the deep ocean and found that they were in close agreement with the “true” tsunami spectra evaluated from DART records. The energy of the Tohoku tsunami derived from the total open-ocean tsunami energy and frequency content of the individual events was compared with the corresponding results from the Chilean tsunami of 2010.

GP-P2

Establishment of marine ecosystem forecasting systems in China

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Based on the Regional Ocean Modeling System (ROMS), a new generation of operational marine forecasting systems for the China coastal seas and the Northwestern Pacific Ocean is established. With the consideration of biological characteristics in China seas, the growth and mortality formulas of marine organism has been modified according to the observations and other modeled results. After a series of experiment, a biological model including 12 components is selected to establish the 3-D physical-biogeochemical model. As for the Northwestern Pacific Ocean, the horizontal resolution of the coupled model is $1/12^\circ \times 1/12^\circ$, the vertical levels are 22 sigma levels. While for the Bohai sea, the Yellow sea and the East China sea, the model has a higher resolution with $1/15^\circ \times 1/15^\circ \times 30$ sigma levels. Both of the models are forced by the air-sea fluxes (wind stress, long wave radiation, short wave radiation, sensible heat and latent heat, freshwater fluxes) for WRF and GFS, and predict the biological variables including nitrate, ammonium, Chlorophyll-a and dissolved oxygen concentrations for the next five days with a daily resolution.

GP-P3**Investigation results of pollution of Uglovoy Bay in winter of 2017 (Peter the Great Bay, Japan/East Sea)**Oleg V. Losev¹, Valery I. Petukhov¹ and Evgeniya A. Petrova^{1,2}¹ Far Eastern Federal University, Vladivostok, Russia

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Small half-closed bights and bays in the basin of Peter the Great Bay are traditionally considered as acute anthropogenic impact areas. Industrial and domestic sewage water comes along with a river runoff. One of these water areas is Uglovoy Bay was previously known as the basin with deposits of silt therapeutic muds and oysters grounds. Environmental pollution monitoring of trace metals (Fe, Cu, Mn, Ni, As, Hg, Pb, Cd, Co) and petroleum hydrocarbons is being conducted since 2010 in winter. Pollutants content analysis in marine environment is being performed with atomic absorption spectroscopy and atomic emission spectrometry with inductively coupled plasma. Samples seawater, sea ice and bottom sediments were the research subject. The data sampling of the winter of 2017 show a significant decrease of contamination as compared to the data of previous years. It might be relate to an influence of Typhoon Lionrock that made landfall in September, 2016. Exceeding MAC (maximum allowable concentration) of Mn, Fe, Pb, Cu and Hg were noted only for surface layer of seawater in northern part of the Bay. Ice cores investigation allowed to reveal higher concentration Cu for all sampling station and Fe, Mn, Pb and Ni at one, where significantly influence of a river runoff. Assessment of bottom sediment pollution was performed with enrichment factor (EF). The EF values point out a minor enrichment (1-3) of bottom sediments with heavy metals.

GP-P4***Echinocardium cordatum* from the Sea of Japan is not the same species as from North Sea**Salim Dautov and Svetlana Kashenko

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For a range of sea urchins the biological characteristics of reproduction were studied, as those have been the subject of marine aquaculture. However, the inter-species distinguishing remains unclear for some species. We compare larval development of the *Echinocardium cordatum* from the Sea of Japan (SJ) (Kashenko, 1994) and from the North Sea (NS) (MacBride 1918, Nunes Jangoux 2007) where they exist under the same temperature and salinity. The duration of the whole period of larval development differed: 15 to 30 days from fertilization to subsidence for NS *E. cordatum* and 39 to 50 days for SJ *E. cordatum*. Duration of each larval stage also differed: for example, gastrulation and prism formation in SJ urchins' larvae took 28 hours vs 42 hours in NS urchins; the fourth pair of arms in the NS urchins appears on the 5-9th day vs 15-17th day in SJ. In NS urchins, the size of the larva does not exceed 1 mm, while in the SJ sea urchins the size of the pluteus reaches 4 mm. Such differences in larval development are sufficient to consider the status of populations of *Echinocardium cordatum* from the SJ and the NS as belonging to different species.

GP-P5

Research of the cetacean sighting survey in the northern part of the Sea of Okhotsk in 2015-2016

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Dedicated sighting survey following the common manners of the IWC was firstly conducted in the Okhotsk Sea in 1989 by Japanese. Since then, many sighting surveys have been conducted in the Okhotsk Sea under Russian-Japanese cooperation. However, the northern and eastern Okhotsk Sea have not been surveyed since the early 1990's because of the Soviet and Russian Federation regulations. Then the information on distribution and abundance of cetaceans in this area has never been revised. Therefore, in 2015-2016, the first successful survey in this restricted area was conducted by the Russian research vessel to fill in the information gap.

The following species were sighted – common minke whale (30 schools – 32 individuals), like minke whale (2-2), fin whale (43-93), humpback whale (4-5), killer whale (16-46), north pacific right whale (4-5), sperm whale (3-4), Dall's type Dall's porpoise (49-186), Truei type Dall's porpoise (16-50), Harbor porpoise (15-32), Unidentified type Dall's porpoise (193-626), white whale (32-255), Unidentified large cetacean (13-17), Unidentified small cetacean (1-3).

GP-P6

Intraspecific differentiation of *Alaria esculenta* (Phaeophyceae, Laminariales) from southeastern Kamchatka based on molecular-phylogenetic and cytochemical study

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In southeastern Kamchatka, two species from the genus *Alaria* Greville (1830) were recorded, such as *A. angusta* and *A. marginata*. They are characterized by high morphological variability and overlapping morphological characteristics, which are used in traditional taxonomy of this genus. Molecular analysis based on plastid-encoded RuBisCo spacer, mitochondrial cytochrome c oxidase subunit 1 and nuclear-encoded rDNA genes showed that both species from Kamchatka have high affinity with *Alaria esculenta*; moreover, they have 99.2% of sequence identity between themselves. Studies of their microscopic gametophytic stages showed that they differ remarkably in the shape of anterozoids and, most importantly, in the composition of polysaccharides in the egg cells and antheridia. For example, the anterozoids of *A. angusta* are spherical, whereas in *A. marginata* they are fusiform. In the first species, the anterozoids are more mobile. Staining with FITC-conjugated fluorescein lectins showed that in these species the surface of egg cells was labeled with different lectins: RCA and WGA in *A. angusta*, and DBA and PNA in *A. marginata*. In *A. marginata*, the surfaces of mature antheridia were labelled with PNA, RCA and WGA, whereas antheridia of *A. angusta* were not labelled with any lectins at all. Thus, we suggest possibility of the reproductive isolation in these species. It is obvious that the revision and intra-species taxonomy of *Alaria* species cannot be solved only on the basis of molecular data. The definition of clear species boundaries within the genus *Alaria* requires a comprehensive study based on molecular-genetic and cytological data.

GP-P7**The effect of noise on aquatic life: A literature review**Michael Adedotun **Oke**Michael Adedotun Oke Foundation, Federal Capital Territory, Nigeria
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Noise pollution has its effects on the aquatic life, which has been a recognized problem for decades, and the needs to address this will call for research that will promote information gathering and see the negative impact it has in the aquatic life. With this paper it will give us the necessary information that will allow us to know what other people have said. Studies showed that anthropogenic noise can cause auditory masking, leading to cochlear damage, changes in individual and social behavior, altered metabolisms, hampered population recruitment, and can subsequently affect the health and service functions of aquatic ecosystems. However, since different sampling methodologies and unstandardized measurements were used and the effects of noise on marine organisms are dependent on the characteristics of the species and noise investigated, it is difficult to compare the reported results. Moreover, the scarcity of studies carried out with other species and with larval or juvenile individuals severely constrains the present understanding of noise pollution. In addition, further studies are needed to reveal in detail the causes for the detected impacts.

Keywords: noise; marine organisms; aquatic life; auditory masking; behavior alteration; metabolism; recruitment; population composition

GP-P8**Distribution and Diffusion of an Invasive Solitary Ascidian, *Ciona intestinalis*, in South Korea**Donghwan **Kim**¹, Michael D. Ubagan¹, Sungjun Bae¹, Taekjun Lee², Philjae Kim¹, Dong gun Kim³, Tae Joong Yoon² and Sook Shin^{1,2}

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The introduction of non-indigenous ascidians into many harbors in several countries resulted in several distinct problems, because of their increased introduction rates. An invasive solitary ascidian, *Ciona intestinalis* (Linnaeus, 1767), belonging to family Cionidae of order Phlebobranchia distributes abundantly in many ports and marinas all over the world, and tolerates a wide range of environmental conditions such as temperature, salinity, and pollution. This species has caused significant fouling problems for the cultured mussel industry, especially in terms of increased production and processing costs, and has been causing severe damage to the ecosystem by overgrowth. The distribution and diffusion of *C. intestinalis* were investigated by the literature search, the environmental DNA method using real-time quantitative PCR (qPCR) with species-specific primer, and the field survey using artificial substrates at 36 harbors in Korea. Since this species was only observed around Busan, Korea Strait in 1967, it has been reported to spread quickly into all coastal areas in South Korea and was found in all coastal regions except for western part of South Korea. *C. intestinalis* specimens were observed at 29 harbors from field survey, and detected at 34 harbors from qPCR experiment from 2014 to 2016. The qPCR analysis was more efficient than the results of the field survey in confirming the diffusion aspects of distribution of *C. intestinalis* in South Korea.

GP-P9

Effects of the Salinity on the egg development and the larval settlement in various temperatures of *Ciona intestinalis* (Ascidiacea: Phlebobranchia: Cionidae)

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A vase tunicate, *Ciona intestinalis* (Linnaeus, 1767), is a marine benthic invertebrate that lives in shallow coastal and deep water down to 500m, and substantial populations of this species are frequently observed in shallow coastal waters. This solitary ascidian is native to northern European waters but now occurs worldwide, and has been reported as an invasive species of marine ecosystem in South Korea. Adults of *C. intestinalis* were collected from the Guryungpo harbor of Kyungsangnamdo province in South Korea on November 2016, and their artificial inseminated eggs were used for the experiment. The effect of the salinity on the egg development of *C. intestinalis* was examined at various temperatures. The egg development and the larval settlement were investigated at 9 different temperatures (10, 12, 14, 16, 18, 20, 22, 24 and 26°C) and at 2 constant salinities (30 and 34psu) in the laboratory. The results of hatching, development and settlement rate and settlement time showed that the optimal temperature range for egg development and larval settlement were estimated to be from 16 to 22°C at 30psu and 12 to 22°C at 34psu, respectively. The lower developmental threshold temperatures were estimated to 7.69°C (30psu) and 4.25°C (34psu). These results showed that the range of tolerance to temperature of *C. intestinalis* can be varied depending on the salinity changes. The interaction of the temperature and the salinity is considered to have an important effect on the distribution and the diffusion of *C. intestinalis* in South Korea.

GP-P10

Contribution of black carbon induced climate change on mountain snow-melt over Eastern Africa region

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This study aims to assess effect of land-based black carbon (BC) aerosols on Climate Change using radiative forcing (RF). Also, modeling of future rainfall and temperature change over Eastern Africa region is performed. Spatial-Temporal Characteristics of the direct radiative forcing of BC is determined. Future global warming is estimated over the area of study using MAGICC SCENGEN (Model for Assessment of Green House gas Induced Climate Change: A Regional SCENario GENERator). Radiative forcing caused by black carbon over the Eastern Africa region is determined and past and future precipitation and temperature scenarios generated. Results of this study provide information on feedbacks of black carbon induced climate change mountain snow-melt over the region of study, radiative interactions and future climate scenarios.

GP-P11**Morphology, phylogeny and life history of *Chattonella marina* from the East China Sea**Xinfeng Dai¹, Hongxia Wang¹, Pengbin Wang¹, Xia Ping¹ and Douding **Lu**¹

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The strain of *Chattonella* sp. isolated from the East China Sea was *Chattonella marina*. Cell shape and size changed with different life stage. Most mature cells are obovoid, with an average length $65.5 \pm 8.3 \mu\text{m}$ and average width $38.7 \pm 3.3 \mu\text{m}$. Chloroplast are oblate and ellipsoid, radially arranging. Nucleus is sphere and located in the center of the cell. There are many small particles surround the cell surface. These particles are sphere, with a diameter about $0.60 \pm 0.13 \mu\text{m}$ ($n=25$) and some small bars embedded radially from the center. The phylogenetic tree based on ITS sequences by ML analysis showed that strains of *C. marina*, *C. antiqua* and *C. ovata* were clustered in one clade, which included the strain of strain that isolated from the East China Sea. *C. marina* was found have a complicated life history. Cell fusion, small particles produced by matured cell, budding reproduction are could be found in different cell age.

GP-P12**Contribution of atmospheric circulation in the change of the thermal regime of the north-eastern coast of Russia in the period 1950-2013**Julia V. **Stochkute**, L.N. Vasilevskaya and D.N. VasilevskyFar Eastern Federal University (FEFU), 8, Sukhanova St., Vladivostok, 690950, Russia
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The effect of atmospheric circulation on the change in the thermal regime of the coastal regions of northeastern Russia was studied. The correlation analysis was carried out between monthly air temperature at 17 meteorological stations and climatic indices in the period 1950-2013.

WP Index. Asynchronous changes in air temperature with the WP index were detected throughout the year. The positive (negative) phase of the WP index defines a negative (positive) temperature background in all seasons. The closest relationship was found on the coast of the Sea of Okhotsk ($r = 0.5 - 0.6$). *PNA index.* The influence of this oscillation is manifested in a regime of air temperature on the coast of the Chukchi and Bering seas directly in August-September ($r = 0.5 - 0.6$), and in the opposite direction in March-April, June and October ($r = 0.4 - 0.5$).

Index of Blinova E.N. Generally the negative relationship between air temperature and global circulation index of Blinova E.N. (α) is found. The most significant effect of zonal transfer on the thermal regime is manifested on the Arctic coast and the northeastern coast of the Sea of Okhotsk in the cold season - from October to January, and on the coast of the Bering Sea - from October to December ($r \geq 0.3$).

GP-P14

The Responses of phytoplankton and bacterial communities along the salinity gradients in the Seomjin River estuaryMinji **Lee**^{1,2}, Seungho Baek¹ and Changho Moon²¹ Korea Institute of Ocean Science & Technology, Geoje, R Korea. E-mail: mjlee@kiost.ac² Pukyong National University, Busan, R Korea

To assess changes in abiotic and biotic factors between flood and ebb tides we investigated the seasonal phytoplankton and bacterial dynamics and environmental conditions along a salinity gradient at 14 stations in the Seomjin River estuary (SRE), Korea. We performed bioassays to identify the effect of additional nutrients (+N, +P, and +NP) on phytoplankton growth and performed high-resolution 16S rRNA tag pyrosequencing to obtain snapshots of the bacterial diversity and community structure along the salinity gradients. Nitrate+nitrite and silicate loading increased as a result of freshwater input, and that phosphates loading may primarily have involved leaching from bottom sediments of the shallow inner bay. Bioassays confirmed that relative phytoplankton growth in the saltwater zone near Gwangyang Bay was higher for +N and +NP treatments than for +P treatments, whereas it was significantly higher in the freshwater zone for +P treatments than for +N treatments. Based on the algal bioassays and the field surveys, we suggested that nitrate+nitrite and phosphates could be limiting factors in the saltwater and freshwater zones, respectively. The significant differences in abiotic factors between flood and ebb tides play important roles in controlling the biotic factors, including the occurrence of aquatic organisms including microalgae. In particular, bacterial diversity was significant at station 9, where freshwater and saltwater species had coexisted. Our results demonstrated dynamic changes of abiotic factors such as salinity and nutrient had influenced with the response of phytoplankton as well as bacterial communities, which is depended on the tidal levels and salinity conditions.

GP-P15

Study on the outbreak and extinction mechanisms of marine harmful microalga *Cochlodinium polykrikoides* in Southern Sea of Korea in 2016Yunji **Kim**^{1,2}, Seung Ho Baek¹, Minji Lee¹ and Soonmo An²¹ Korea Institute of Ocean Science & Technology, South Sea Research Center, Geoje-si, Gyeongsangnam-do, R Korea
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In Korea, red tide events by dinoflagellate *Cochlodinium* occur every year and affect serious economic losses to fisheries. In particular, the chain form of *Cochlodinium* is known to cause fish death by gill-clogging when its abundance exceeds approximately 1000 cells ml⁻¹. The study aims to clarify the outbreak/extinction mechanisms of marine harmful microalga *Cochlodinium polykrikoides* blooms based on the physical, chemical and biological environments (i.e., vertical structure of sea water, nutritional characteristics and biological interaction etc.). At near coast of St. 22, there was no significant difference between temperature of upper and bottom layers, and high nutrient was kept in surface layer. These suggest that wind driven coastal upwelling have supplied nutrients to the euphotic zone. In August, low salinity water (below 30 psu) at offshore front station was constantly observed, which may have originated from Changjiang River discharge in China. Such events of upwelling and introduction of Changjiang Diluted Water can lead to nutrient-rich environmental condition, indicating that the diatom species respond to pulsed nutrient loading and dominate in Tongyeong coastal area. For these reasons, red tide of dinoflagellate *Cochlodinium* in 2016 did not occur in late July and early August normally. In late August of 2016, however, the *Cochlodinium* bloom occurred in Goheung area partly, which was delayed about a month. At that time, strong typhoon Malakas have approached in Korean coastal area, and water turbulence by strong wind storm are likely to affect the abundance of *Cochlodinium*. Therefore, the typhoon events may have eliminated *Cochlodinium* bloom in Korean coastal area, which play an important role in reducing the *Cochlodinium* cell in 2016.

GP-P16**Distribution of mesozooplankton during spring and autumn across the frontal zone of South Sea, Korea**Minju **Kim**, and Jung-Hoon KangSouth Sea Environment Research Center, KIOST, Geoje, R Korea
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We investigated and compared the spatial distribution of mesozooplankton and the related environmental characteristics across the frontal zone in the South Sea of Korea during spring and autumn 2016. Due to the characteristics of hydrological fronts being active in exchanges of energy and matter, it exhibits high productivity. We visited eight stations through the frontal zone formed by the Tsushima Warm Current and the Korean Southern Coastal Waters, and collected mesozooplankton by vertical tows using a standard net (200 μm mesh) with environmental parameters. A relatively warmer and saline water mass was observed towards the offshore waters compared to the coastal waters, and a strong temperature stratification occurred at the ecotone. The ecotone was accompanied by higher total surface chlorophyll-*a* (chl-*a*, $1.4 \mu\text{g L}^{-1}$) concentrations during spring, and chl-*a* was ~ 3.0 times higher at coastal area than the ecotone ($2.1 \mu\text{g L}^{-1}$) during autumn. Mesozooplankton was highly distributed near the coast and decreased towards the offshore waters. Cyclopoid-to-calanooid copepods ratio (cy:ca ratio) was highest at the ecotone (0.8) which coincided with that of chl-*a* in spring but was lowest at the ecotone (0.1) during autumn despite high chl-*a* concentration. This implicates that each of the surveyed periods differed in the development phase of ecotone. During spring, the ecotone was likely to be at an early phase with higher cyclopoids, while autumn exhibited a late phase with higher calanooid abundance. These results suggest the formation and duration of the frontal zone may be explained with cy:ca ratio in association with environmental parameters.

GP-P17**Geochemical characteristics of the sediment pore water in the Northeastern Equatorial Pacific**Taehee **Lee**, Kyeong-Hong Kim, Ju Won Son and Young Baek SonKorea Institute of Ocean Science & Technology (KIOST), Jeju, R Korea
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This study investigated dissolved oxygen (DO), nutrients, manganese (Mn) and Iron (Fe) characteristics at the sediment pore water in Northeastern Equatorial Pacific based on the geochemical analyses. The DO concentrations of sediment pore water at the upper sediment ranged 90-136 μM , drastically decreased with sediment depth increasing, showed that ranged 30-60 μM . The concentrations of ammonia, nitrate, phosphate and silicate ranged 0.02-16.34 μM , 44.73-229.32 μM , 2.04-2.98 μM and 73.44-405.24 μM , respectively. The vertical profiles of ammonia and nitrate at the sediment pore water showed a contradictory distribution in SD07 and SD16. The concentrations of Mn and Fe ranged 0.1-8.1 μM and 0.3-40.4 μM , respectively. Low concentrations of Mn and Fe are due to the oxic condition at the sediment upper layer. The Mn and Fe reduction zones generally occurs below nitrate reduction zone and at the depth of complete DO removal from the pore water. Manganese reduction in pelagic sediments may be involved in the formation of ferromanganese nodules, since under some circumstances manganese reduction in the sediments and the resulting upward diffusion of dissolved manganese across the sediment-water interface may be an important source of manganese nodules.

GP-P18**Unusually significant bacterial production of dissolved organic matter in a marginal sea (East/Japan Sea)**Tae-Hoon **Kim**Jeju National University, Jeju, R Korea
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Vertical and horizontal distributions of total hydrolysable enantiomeric amino acids (THAA), dissolved organic carbon (DOC), and nitrogen (DON) were measured in the entire East/Japan Sea (EJS) in 2009. The euphotic zone of this sea is extremely N-limited, and the N:P ratio in the deep layer (200–3500 m) is approximately 13. We observed high concentrations of D-amino acids (24 ± 5 nM), relative to the major oceans (12–13 nM), in the deep layer of the EJS. On the basis of higher D/L ratios (0.65 ± 0.20) of Alanine (Ala), the percentage ($16 \pm 3\%$) of D-enantiomers (%D), and DOC- and DON-normalized yields (14 ± 5 nmol mg C⁻¹ and 255 ± 100 nmol mg N⁻¹, respectively) of D-Ala in the deep layer, we suggest that the majority of the dissolved organic matter (DOM) in the deep EJS is produced by bacterial activities. Surprisingly, D/L ratios of Ala, %D, and DON-normalized yields of D-Ala in the deep layer agreed with those in the surface layer (> 200 m) within 5%. This result indicates that DOM in the deep sea originates from the surface layer where non-biodegradable DOM is effectively produced by bacteria (i.e., cyanobacteria) under an N-limited condition. Our results suggest that the stoichiometry of nutrients and the phytoplankton composition in the deep water formation area is critical for controlling the storage of carbon in the deep sea.

GP-P19**Surface current in “Hotspot” serves as a new and effective precursor for El Niño prediction**Jianing **Wang**¹, Youyu Lu², Fan Wang¹ and Rong-Hua Zhang¹¹ Institute of Oceanology, Chinese Academy of Sciences, Qingdao, PR China
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The El Niño and Southern Oscillation (ENSO) is the most prominent sources of inter-annual climate variability. Related to the seasonal phase-locking, ENSO's prediction across the low-persistence barrier in the boreal spring remains a challenge. Here we identify regions where surface current variability influences the short-lead time predictions of the July Niño 3.4 index by applying a regression analysis. A highly influential region, related to the distribution of wind-stress curl and sea surface temperature, is located near the dateline and the southern edge of the South Equatorial Current. During El Niño years, a westward current anomaly in the identified high-influence region favors the accumulation of warm water in the western Pacific. The opposite occurs during La Niña years. This process is seen to serve as the “goal shot” for ENSO development, which provides an effective precursor for the prediction of the July Niño 3.4 index with a lead time of 2-4 months. The prediction skill based on surface current precursor beats that based on the warm water volume and persistence in the subsequent months after July. In particular, prediction based on surface current precursor shows skill in all years, while predictions based on other precursors show reduced skill after 2002.

GP-P20**IOCAS scientific observing network in the Western Pacific Ocean**Fan **Wang**

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The Institute of Oceanology, Chinese Academy of Sciences (IOCAS) has been building the scientific observing network in the Western Pacific Ocean since 2013, supported by the Strategic Priority Research Program of the CAS entitled *Western Pacific Ocean System*. The network targets western Pacific circulations, climate, and deep blue. In this region, three-dimensional current system critically influences the western Pacific warm pool and the life cycle of El Niño/Southern Oscillation, which are the prominent sources of global and regional climate variability.

Three arrays, comprising 16 subsurface moorings and including more than 440 instruments, form this mooring observing network. For each mooring, one upward-looking and one downward-looking 75kHz ADCPs were equipped on the main float. The ADCP measured the velocity over upper 1000 m depth. For the layer that is deeper than 1000 m, current meters and conductivity-temperature-depths were equipped on the mooring cable to monitor the deep-sea hydrography and currents. After the mooring design in 2013 and the initial deployment in 2014, the 2-3-year time series of mooring data have been retrieved. Overstepping the sporadic observations in the past, we will get a comprehensive view of current system in the Western Pacific.

In 2016, we successfully upgraded two of moorings to achieve real-time transmission of ADCP data. The ADCP data were collected and transmitted to the surface buoy through the commutation cable and wireless acoustic modem every one hour. Then the data were sent to the users through the satellite. Real-time transmission of ADCP data will promote capabilities in the marine environment and climate prediction.

GP-P21**Low frequency shift of wind waves induced by long waves based on experimental observation data**Xinyang **Yue**, Xiaochen Zou and Shouhua Liu

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The influence of long regular waves on wind waves are examined in laboratory tank. The wave spectra of wind waves when there is and there is not long waves are compared. Besides the widely addressed suppression of wind waves by long waves, it is also found that, the presence of long regular wave induces low frequency shift of wind waves when long wave slope is small and also its frequency f_l is quite apart from wind wave crest frequencies f_p . The effect of long wave modulation on wind wave spectra is estimated according to Longuet-Higgins & Stewart (1960) (abbreviated as LS60 afterwards), which is found to be prominent at large ratio of f_p/f_l . It's also found that, when the limitation of wave breaking on wind wave steepness is taken account of, the LS60 theory can explain the low frequency shift satisfactorily. These work suggests that, at small long wave slope and large ratio of f_p/f_l , the LS60 modulation mechanism together with the enhanced wave breaking may dominate the influence of long waves on wind waves.

GP-P22

Marine environmental situation and Blue Bay remediation in XiamenKeliang **Chen**¹, Hongzhe Chen¹, Senyang Xie^{2,3} and Xiaohua Wang^{2,3}¹ Third Institute of Oceanography, SOA, Xiamen, PR China. E-mail: klchen@tio.org.cn² School of Physical, Environmental and Mathematical Sciences, University of New South Wales, Canberra, Australia³ The Sino-Australian Research Centre for Coastal Management, University of New South Wales, Canberra, Australia

This paper introduced the basic situation of Xiamen Bay as an important port in China. By summarizing research records and unpublished data, the climate, hydrology, geology and biodiversity in this bay, and some of the more concerned ecological disasters were described. Extensive reclamation works in the Xiamen Bay from the year 1955 are summarized. The main reclamation projects are the Gao-Ji Dike, the Xinglin Dike, the Maluan Dike, the Yundang Dike, and the Dongkeng Dike. Up to the year 2010, the total area of reclamation in the Xiamen Bay reached 140 km². These reclamation works, however, has greatly changed the coastline structure and exert negative impacts on the hydrodynamics and the marine ecosystem of the Xiamen Bay. With high population density and upstream input of Jiulong River, Xiamen waters are confronted with serious eutrophication problem. In order to restore and maintain the ecosystem and environment of Xiamen Bay, Xiamen's Blue Bay Remediation Action was established based on the system and mechanism guarantee. Many comprehensive remediation projects were carried out in Xiamen in recent years including clearing marine aquaculture areas, dredging sediment, reconstruction of mangrove ecosystem, eco-restoration of uninhabited islands, ecological transformation of coastline, reduction of marine debris, construction of National marine park and other activities. Finally, some suggestions have been proposed for the blue bay remediation in Xiamen. This paper showed some challenges and good experiences in the process of eco-restoration in Xiamen Bay.

GP-P23

Distribution of coccolithophores in the Yellow Sea and East China Sea in summer and winterJian **Zhang**, Jia-rui Li, Da-wei Ji, Wei-kang Zhai and Yuan-jun Wang

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A community-based survey of the monthly distribution of coccolithophores in the Yellow Sea was conducted in two seasons of 2009: summer (July 20–September 1) and winter (December 23–February 5). In the summer of 2009, 21 species of coccolithophores were identified in the survey area of the Yellow Sea, which were dominated by *Emiliana huxleyi*, *Gephyrocapsa oceanica*, *Umbellosphaera tenuis*, and *Florisphaera profunda*. The abundance of coccolithophores was between 0.23×10^3 and 17.62×10^3 cells/L, with an average of 2.84×10^3 cells/L. In winter 2009, 20 species of coccolithophores were identified in the survey area of the Yellow Sea, which were dominated by *E. huxleyi*, *G. oceanica*, *F. profunda*, and *U. tenuis*. The abundance of coccolithophores was between 0.12×10^3 and 35.35×10^3 cells/L, with an average of 3.84×10^3 cells/L. The distribution of coccolithophores in the Yellow Sea and East China Sea were systematically studied to determine the community distribution of coccolithophores in the Yellow Sea and East China Sea.

Key words: coccolithophores; community and distribution; Yellow Sea and East China Sea; summer and winter

GP-P24**A staining method to determine marine microplanktonic organism viability and investigate the efficacy of a ship's ballast water treatment system**Seung Ho Baek¹, Bonggil Hyun² and Kyoungsoo Shin²¹ South Sea Institute, Korea Institute of Ocean Science & Technology (KIOST), Geje, 656-830, R Korea² Ballast Water Research Center, Korea Institute of Ocean Science & Technology (KIOST), Geje, 656-830, R Korea
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We determined a method to determine marine planktonic organism viability using Evan's blue, Aniline blue, and 5-chloromethylfluorescein diacetate (CMFDA). The Evan's blue and Aniline blue methods produced bright blue light for dead phytoplankton and zooplankton and were the best dyes to detect dead cells. The staining efficiency of Evan's blue and Aniline blue were $\geq 90\%$ of the original field sample. However, it was difficult to test the efficiency of a ship's ballast water treatment system because detection of living cells. In contrast, the CMFDA method, which is based on measuring cell esterase activity using a fluorimetric stain, was the best dye to detect live cells of almost all phytoplankton species, and staining efficiency was 70%. The CMFDA method is similar to the fluorescein diacetate (FDA) staining method. Therefore, we estimated viability of phytoplankton species using a double-staining method by combining CMFDA and FDA to determine optimum staining efficiency. As a result, the frequency of dying cells based on the double-staining method was 95%, which was significantly higher than that of single CMFDA staining. Our results suggest that a CMFDA + FDA assay is more effective to determine survival of marine plankton and that this method was applicable to investigate the efficacy of a ship's ballast water treatment system.

GP-P25**Disturbance of seals by anthropogenic activity at the haul out of Piltun Bay (Sakhalin Isl.)**Peter A. Permyakov and Alexey M. Trukhin

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During the ice-free period the haul out of three species of phocid seals (ringed, spotted and bearded seals) exist in Piltun Bay mouth. Seals are regularly subjected to disturbance by anthropogenic activity [DAA], such as fishery, hunting, transportation and recreation. The study of DAA was done from June to October, 2016. Totally we registered 626 cases of DAA. Most usual means of transportation were automobiles (cars (23.2%) and lorries (20.6%)) and boats (rubber boats and skiffs [RBS] (24.6%) and lightweight ships [LWS] (6.5%)). Helicopters were less frequent (18.7%) and pedestrians were rarest (5.4%). Another 5.1% of cases were other DAA. The impact on seals was not equal through different types of transport. Proportion of anthropogenic activity that caused acute disturbance in seals was biggest for LWS ($p=0.33$) and RBS ($p=0.31$). Somewhat less disturbing were cars ($p=0.23$), pedestrians ($p=0.21$) and lorries ($p=0.17$). Helicopters were least stressful for seals ($p=0.08$). The events of DAA were most frequent during periods from late June to early July and from late August to late September. Spikes in DAA coincided with sharp increases in seal abundance on shore. We assume that both DAA and rise in number of seals were caused by spawning run of diadromous fishes at the mouth of a bay. Significant number of DAA (including events that were lethal to seals) happened due to conflict between fisheries and marine mammals. Nevertheless, the fishery-related DAA was unlikely to seriously affect seasonal abundance of seals, which is basically controlled by trophic factor.

GP-P26

Impacts of ocean warming on China's fisheries catches: An application of 'mean temperature of the catch' conceptCui **Liang**¹, Weiwei Xian^{1,2} and Daniel Pauly³

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Ocean warming can strongly impact marine fisheries; notably, it can cause the "mean temperature of the catch" (MTC) to increase, an indicator of the tropicalization of fisheries catches. In this contribution, we explore MTC changes in three large marine ecosystems (LMEs) along China's coasts, i.e., the Yellow Sea, East China Sea, and South China Sea LMEs, and their relationships to the shifts of the sea surface temperature (SST). The results showed that, while the MTCs began to increase in 1962 in the East China Sea and in 1968 in the Yellow Sea, there was no detectable increase in the South China Sea. There also was a strong relationship between MTC and SST in the Yellow and East China Seas from 1950 to 2010, especially when taking a 3-year time-lag into account. The lack of change of the MTC in the South China Sea is attributed to the relatively small increase in SST over the time period considered, and the fact that the MTC of tropical ecosystems such as the South China Sea is not predicted to increase in the first place, given that their fauna cannot be replaced by another, adapted to higher temperature. Overall, these results suggest that ocean warming is already having an impact on China's marine fisheries, and that policies to curtail greenhouse gas emissions are urgently needed to minimize the increase of these impacts on fisheries.

GP-P27

Pacific herring distribution and some features of biology in the northwestern Bering Sea in 2010-2015Sergey V. **Loboda**

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Distribution of pacific herring is determined on the data of bottom trawl surveys conducted in the northwestern Bering Sea in 2010-2015, its biological status is briefly described, and its stock is assessed. The 2010-2015 were distinguished by high abundance of herring in this area, its biomass changed in the range 571.1-950.9·10³ t. It distributed widely over Anadyr Bay and Koryak shelf, concentrating at Cape Navarin. The herring started its mass northwestward migration from the eastern Bering Sea in June, conditioned by oceanographic conditions. Generally, its distribution on feeding grounds corresponded to the scheme of water circulation in the northwestern Bering Sea. Age groups from 0+ to 12+ were found in the catches of bottom trawl, with absolute domination of the ages 5+-9+ years (in sum 75-93 % of the catches). So, there was concluded that mostly mature individuals migrate for feeding into the northwestern part of the sea, including the maturing for the first time ones. Intensity of the migration depends on the year-classes strength; the year-classes of 2005-2010 birth were the most abundant in the surveyed period and formed the bulk of the herring stock in this area.

W4: MEQ Workshop

Long-term changes in HAB occurrences in PICES nations; the Eastern vs. Western Pacific

W4-P1

Green tide monitoring in the China Sea using Remote Sensing Data

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Enteromorpha Prolifera, named green tide, over the Yellow Sea and East China Sea were first reported in summer 2008. Green tides destroy the marine ecosystem, threaten coastal tourism and block the ship navigation when they gather over the coastal area. Based on the spectral characteristics of green tides, NDVI (Normalized Difference Vegetation Index) and Floating Algae Index (FAI), the green tide over Yellow Sea and the East Sea was monitored with data MODIS (Moderate Resolution Imaging Spectro-radiometer) operationally and the detection reports, including the distribution range and coverage range, are given to the relevant authority and coastal city every day. When the green tides move to the coastal area and influence the ship navigation and it needs to be cleaned, the images of HJ-1A/1B satellite's CCD and GF-1's WFV are used to supply the more detailed information with their high spatial resolution. Based on the monitoring results with multi-source satellite remote sensing images of the past few years, we can get the drift trend and distribution area of green tide by dynamic monitoring of drift path and impacting marine area.

W4-P2

Outbreak and movement pattern of red tide patches occurred by *Cochlodinium polykrikoides* during last 4 years in the Korean coastal waters

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From 2012 to 2015, large-scale red tide occurred by *Cochlodinium polykrikoides* in the Korean coastal waters. These generated massive damage to fisheries and economic losses. During 4 years, the expansion and movement pattern of red tide were different which affected by current, tide, typhoon and rainfall. In 2012, there were two peaks of red tide in summer and fall. Especially in 2014, red tide occurred in July intensively, and maximum number of *C. polykrikoides* cell recorded within 4 years. The movement of red tide patch affected by the local current characteristics at each year. The red tide patch was moved only toward east coast or moved both east and west coast. Sometimes the red tide patch moved toward west but turning the direction and moved east.

The data showed that movement of the red tide patch made by *C. polykrikoides* closely related by physical condition like current, tide, eddy, tidal front, thermocline and meteorological conditions. For analyze the movement pattern of red tide patches, a wide range of environmental data such as physical modelling and satellite data will be needed.

W6: BIO Workshop**Advantages and limitations of traditional and biochemical methods of measuring zooplankton production****W6-P1****A comparison of protein synthetases activity to standing stock and productivity in a cultured copepod population, *Pseudodiaptomus inopinus***

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We compared aminoacyl-tRNA synthetases (AARS) activity to copepod abundance, biomass and productivity measured by direct method using the cultured population, *Pseudodiaptomus inopinus*. Their body length and mass were increased with development. Specific growth rate was higher for naupliar stages than copepodite stages. After the seven days when the artificial cohort predominated by late copepodite stages was created, *P. inopinus* exhibited subsequent development from early to middle naupliar stages and increased their abundance, biomass and production rate. Since the recruitment to copepodite stages was less after the fourteen days, they declined their abundance, biomass and production rate. Specific AARS activity was high in the early phase of the incubation but gradually declined. The specific AARS activity showed a significantly positive correlation to daily P:B ratio ($r^2 = 0.501$) but negative correlations to the protein content ($r^2 = -0.831$) and animal body mass ($r^2 = -0.588$). These results suggest that the specific AARS activity is synchronized with growth but prior to increase of standing stock and production rate.

W6-P2**A comparison of chitobiase-based estimates to developing biomass and production rates of a laboratory culture of *Pseudodiaptomus inopinus***

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The recent development of biochemical methods to measure secondary production rates offer potential resolution to the logistical difficulties associated with measuring community-level rates at both fine resolution and across broad spatial scales. The chitobiase method is an example of a biochemical method which can be applied to measure community-level rates of crustacean zooplankton production in the field at relatively high resolution. The method relies on measurements of activity and rate of production of the crustacean moulting enzyme chitobiase. Although the method has been applied in multiple marine systems, laboratory-validation with zooplankton cultures has been limited to two early studies. Here we present results of a new detailed comparison of daily chitobiase-based production rates to the development of a synchronous culture of *Pseudodiaptomus inopinus*. Overall, daily chitobiase-based production rates varied positively with biomass ($r^2 = 0.59$) and production rate ($r^2 = 0.54$).

NPFC

North Pacific Fisheries Commission – new Regional Fisheries Management Organization in the North Pacific Ocean

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The North Pacific Fisheries Commission (NPFC), which came into force on 19 July 2015, is an inter-governmental organization established by the Convention on the Conservation and Management of the High Seas Fisheries Resources in the North Pacific Ocean. The objective of the Convention is to ensure the long-term conservation and sustainable use of the fisheries resources in the Convention Area while protecting the marine ecosystems of the North Pacific Ocean in which these resources occur.

The current Members of the NPFC include Canada, China, Japan, Republic of Korea, the Russian Federation, Chinese Taipei, the United States of America, and Vanuatu. The Commission has two key areas of work: the scientific area where catch and stocks data are gathered to provide advice to the Members for sustainable management of the resources and ecosystems, and the compliance component where management measures are developed and implemented. NPFC and PICES have considerable potential for cooperation due to their geographical overlap, common membership and similarity in science interests in the North Pacific, and they are taking steps to enhance collaboration in the areas of common interests.

NOWPAP

Strengthening regional cooperation for the protection of the marine and coastal environment in the Northwest Pacific through the Northwest Pacific Action Plan to achieve Sustainable Development Goals (SDGs)

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The Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) is the regional intergovernmental mechanism established in 1994 by the governments of Japan, Peoples Republic of China, Republic of Korea and the Russian Federation. Having the overarching goal of supporting “the wise use, development and management of the coastal and marine environment so as to obtain the utmost long-term benefits for the human populations of the region, while protecting human health, ecological integrity and the regions sustainability for future generations”, NOWPAP activities contribute to quality of life of societies and support long-term environmental sustainability of the environment within the region and beyond. Since it was established NOWPAP has been addressing major five elements of the Action Plan: to assess regional environmental conditions, to collate and record environmental data and information, to develop and adopt a harmonious approach towards coastal and marine environmental planning on an integrated basis, to develop and adopt effective measures for mutual support in emergencies as well as prevent coastal and marine pollution.

NOWPAP members renew their commitment to strengthen efforts addressing regional challenges of marine environmental protection and sustainable development of the Northwest Pacific. The implementation of the NOWPAP Medium-term Strategy 2018-2023 will contribute to the achievement of ocean-related SDGs in an integrated way, inter alia:

1. Preventing and reducing land- and sea-based sources of pollution (SDGs 12 and 14),
2. Supporting integrated coastal and river basin planning and management based on the ecosystem-based approach (SDGs 11, 13 to 15), and
3. Assessing status of the marine and coastal environment (SDGs 13 to 15, and 17).

NEAR-GOOS

North-East Asian Regional Global Ocean Observing System: 20 years of building partnership in oceanographic data exchange and services

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North-East Asian Regional Global Ocean Observing System (NEAR-GOOS) is one of the oldest global GOOS regional alliances. The project started in 1996 with a focus on marginal seas surrounded by China, Japan, Korea and Russia under the Sub-committee for Western Pacific of the Intergovernmental Oceanographic Commission (IOC/ WESTPAC). The major achievement of NEAR-GOOS is a network of real-time and delayed mode data bases accessible through the Internet free of charge. In spite of some restrictions on oceanographic data exchange in some member states, NEAR-GOOS regional archives now contain 59 different types of data files with total volume of more than 197 GB (as of Jun. 2017). A challenge of the second phase of project development (after 2003) was to make a shift from data management toward building a sustained regional integrated ocean observing and operational forecasting system. This required not only an improvement of the existing data exchange mechanisms through the inclusion of additional parameters, increased coverage in space and time, and generation of data products., but also enhancing its observing capacity by increasing the number of available observing platforms in the region. This, in turn, depends on the effectiveness and usefulness of NEAR-GOOS products and services. Most of the users of oceanographic information now are concerned in coastal areas which are monitored by national observing systems. One of the challenges for NEAR-GOOS remains to prove its usefulness as an international project. To its Currently NEAR-GOOS has 3 working groups which tasks are to enhance efficiency on NEAR-GOOS data management, products and ocean forecasting system. Since 2011 a pilot project of Cross Basin Climate Monitoring Section has been implementing by Japan and Russia. A new pilot project on ferry box monitoring in the region is under preparation. The story of success and challenges of the project development over 20 years has been discussed in this paper.

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