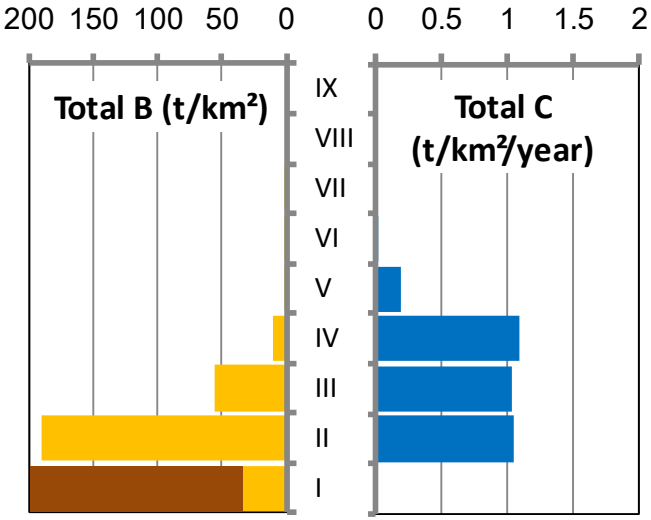
Response of commercial fisheries and a top predator to long-term ecosystem fluctuations in the western North Pacific



Masashi Kiyota and Shiroh Yonezaki
National Research Institute of Far Seas Fisheries
Fisheries Research and Education Agency, Japan

科研費 KAKENHI

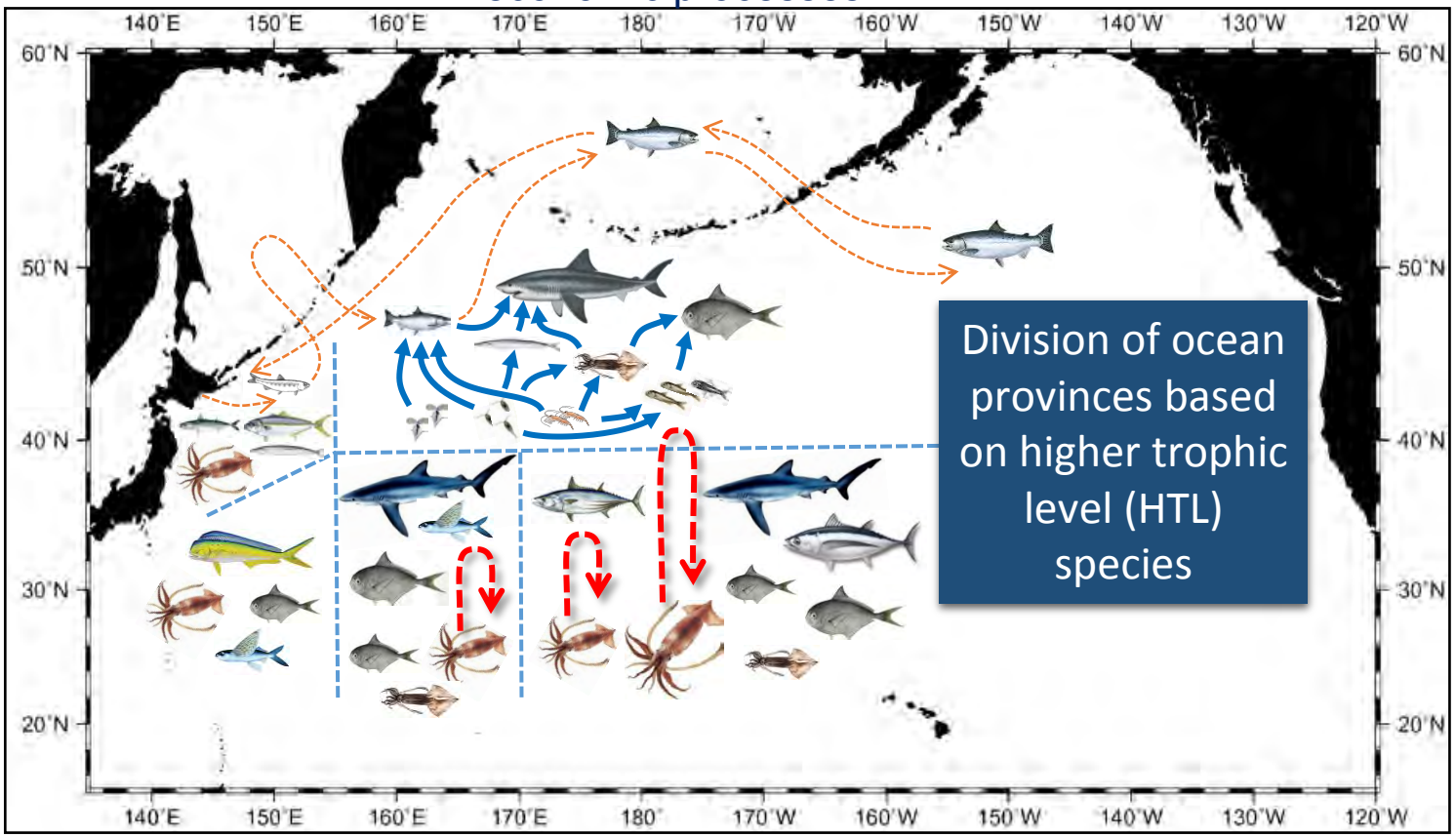
How to better understand the roles of top predators and commercial fisheries in marine food webs

- Introduce several attempts and projects:
  1. Classification and characterization of oceanic ecosystems by using scientific survey data/samples
     - a: Spatio-temporal variation of HTL communities
     - b: Confirmation of the trophic linkage by stable isotope analysis
     - c: Construction of Ecopath models for identified subareas (ongoing)
  2. Top predator as an indicator of ecosystem change
  3. Commercial fisheries as consumers in marine food webs
  4. Information feedback to commercial market and general public
- Presents general concepts overarching these topics

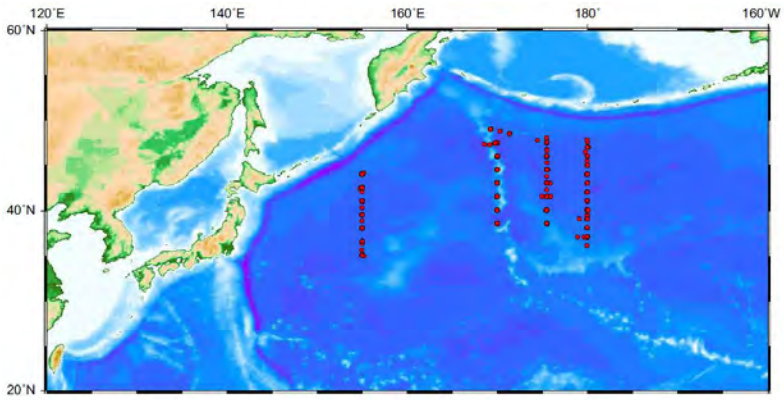
1. How to define the units of oceanic ecosystems

NEOPS
New Ocean Paradigm
on Its Biogeochemistry, Ecosysytem and Sustainable Use

The NEOPS (New Ocean Paradigm on its Biogeochemistry, Ecosystem, and Sustainable Use) project aims to propose new ocean provinces in the Pacific Ocean based on a better understanding of the structures and functions of physical, biogeochemical, ecological and socio-economic processes.

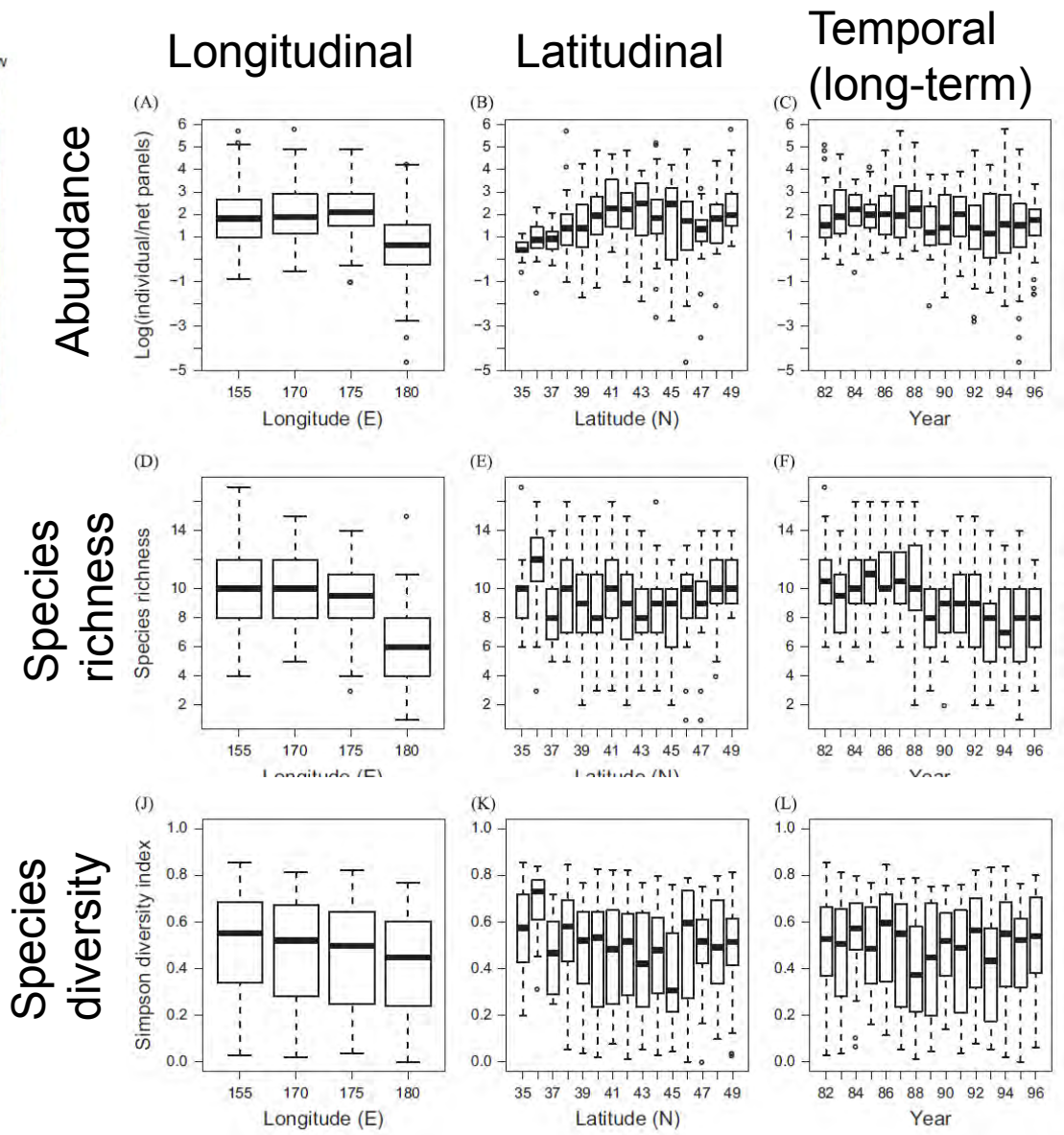


1a. Examination of spatio-temporal variability of HTL communities

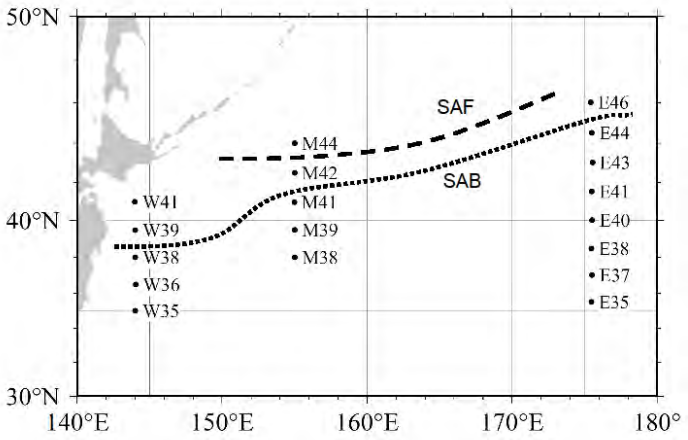


- HUFO driftnet survey data (1982-1996)
- ANOVA-based and multivariate analyses

- *Okuda et al. (2015) DSR II 113:81-90*

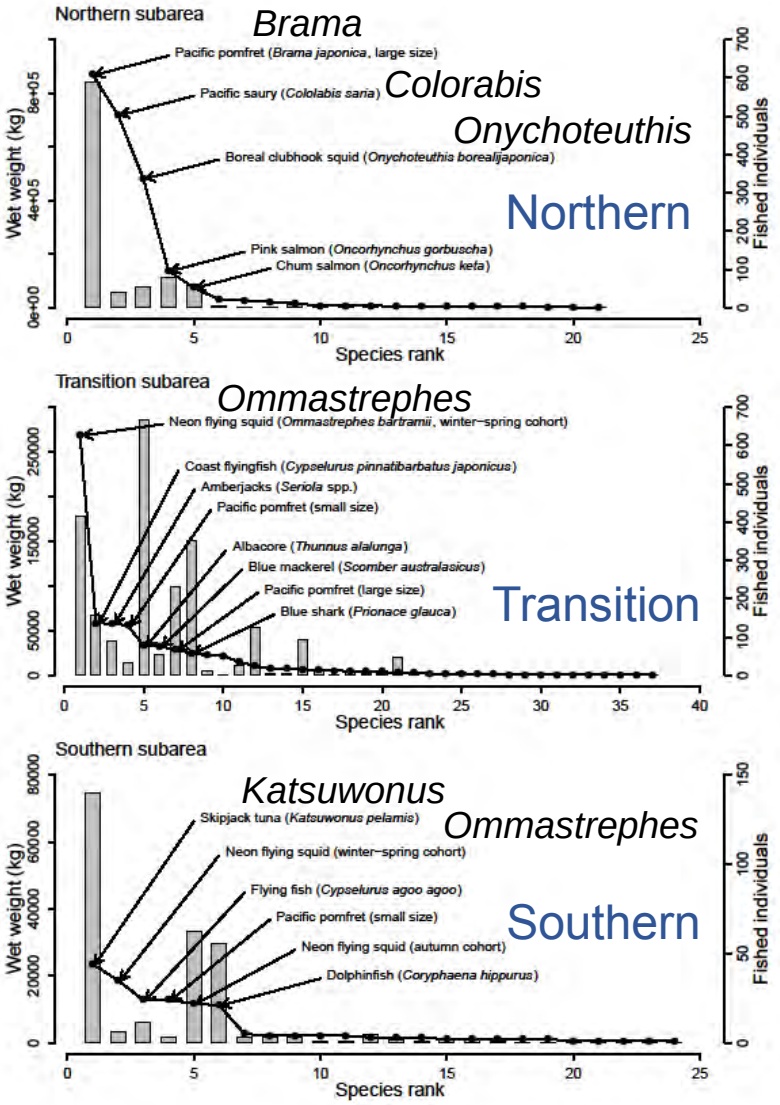


1a. Classification of the HTL communities

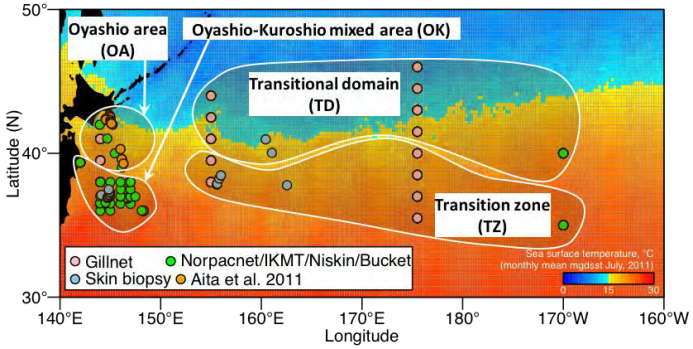


- FRA driftnet survey 2011
- A novel cluster analysis technique (Dissimilarity segmentation methods)

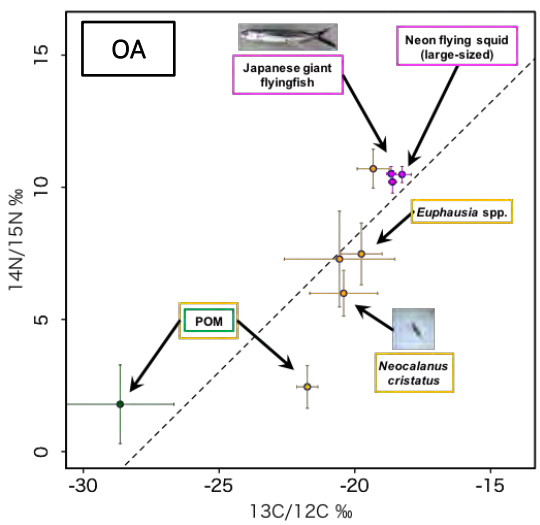
- *Okuda et al. (submitted)*

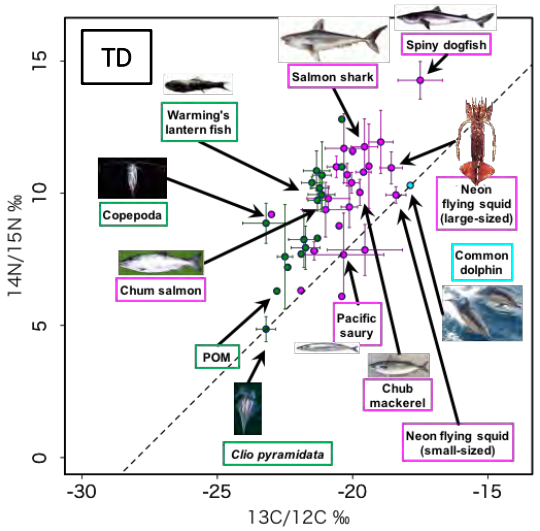


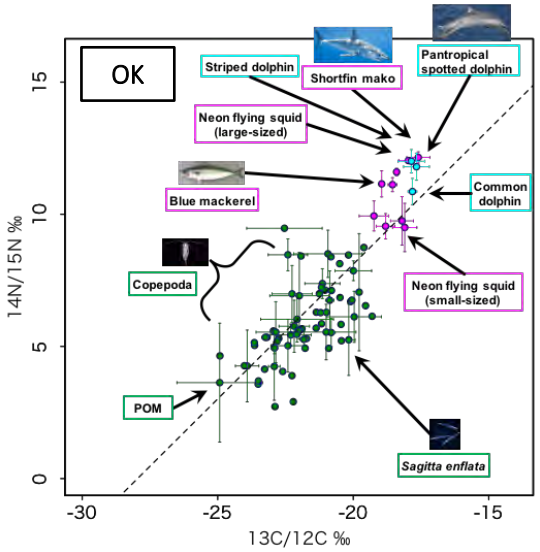
1b. Confirmation of area-specific trophic linkage by stable isotope analysis

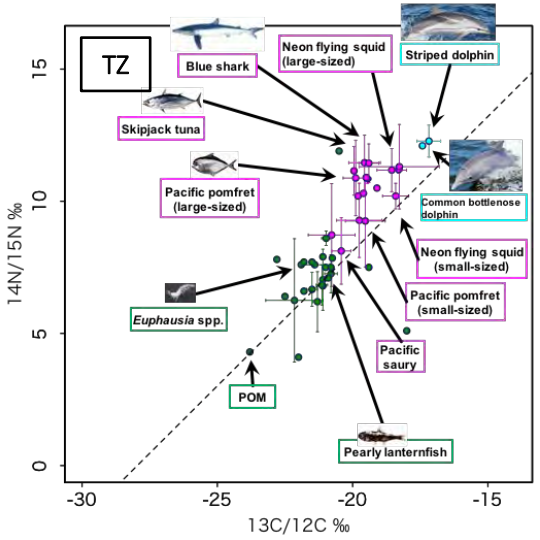


- POM, plankton and micronekton samples from oceanographic surveys
- Pelagic fish and squid samples from driftnet surveys
- Linear model analysis selected [δ^{15}N] ~ [δ^{13}C] + [Area]
- Ecopath modelling for each subarea is on-going.



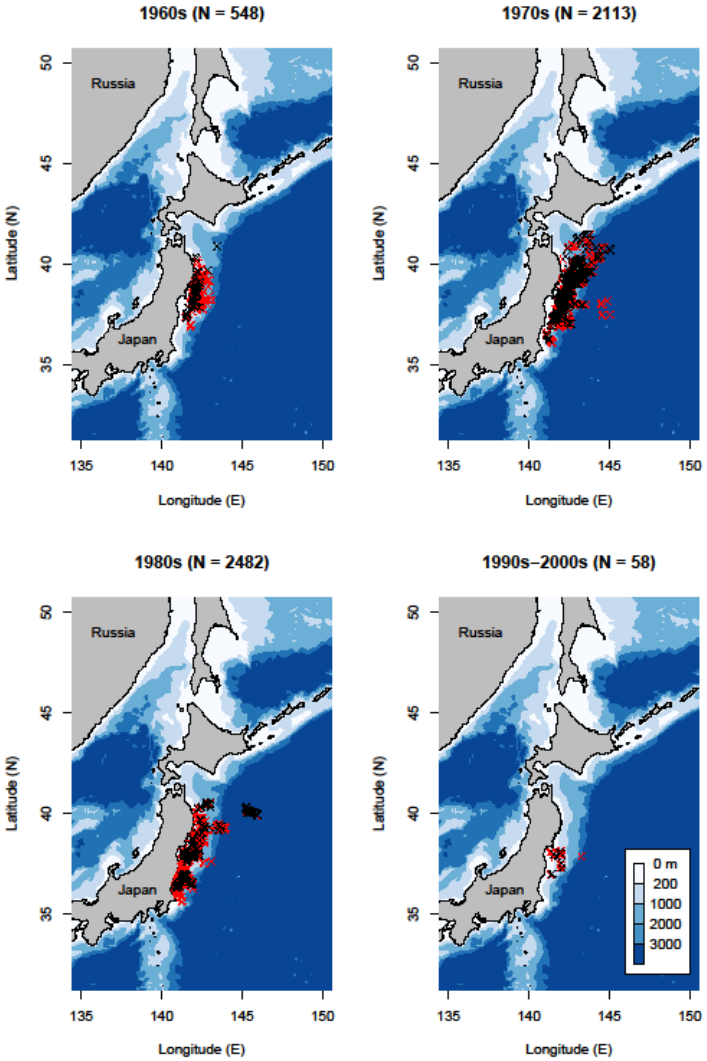






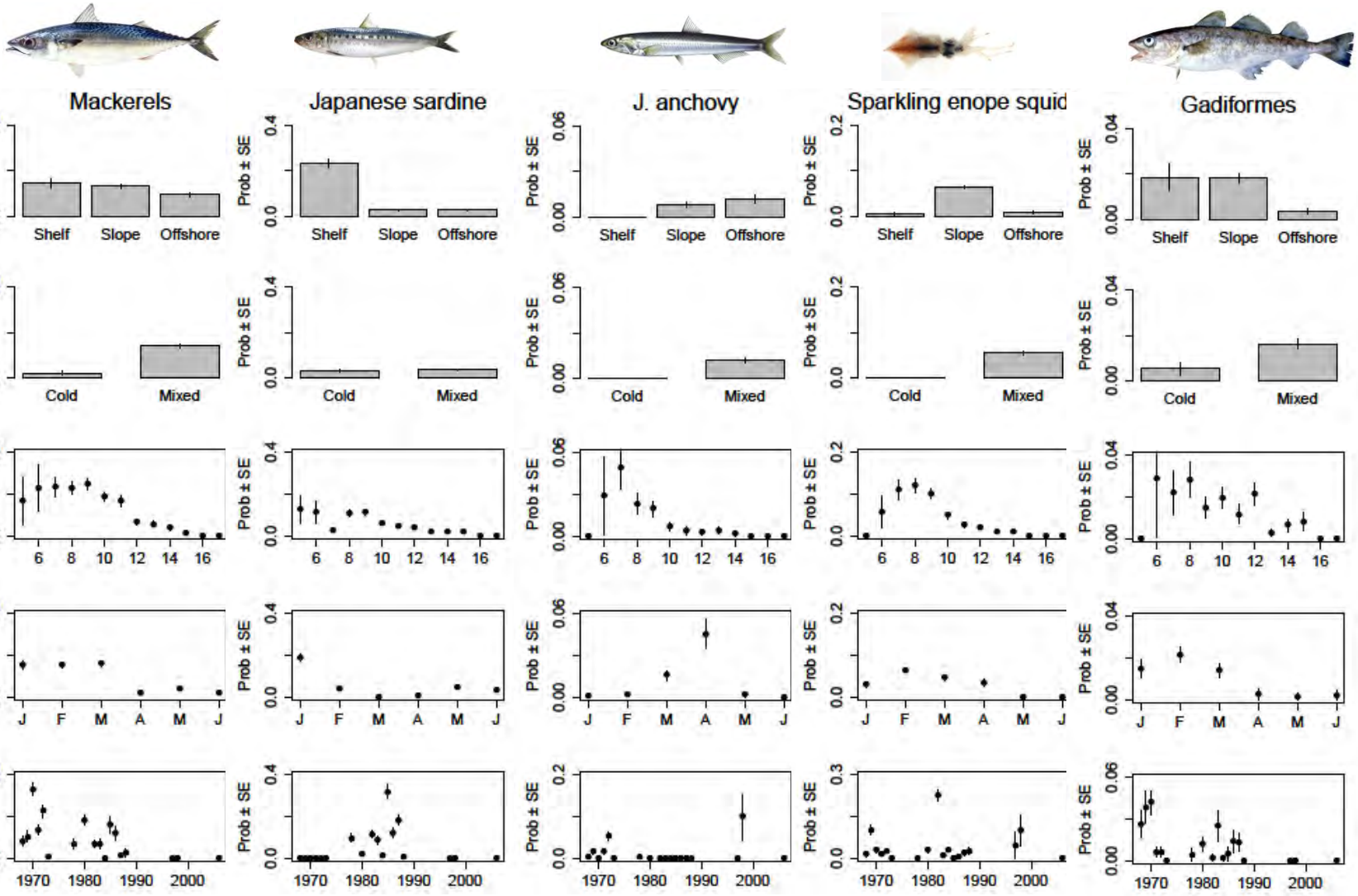
2. Top predator as an indicator of long-term ecosystem changes

- Long-term northern fur seal samples (1968-2008) under the former NPFSC
- Non-random pelagic sampling of fur seals
- Fur seal diet changes with migration (area, season, sex and age class)
- We analyzed the Individual-specific stomach content records to extract long-term trends of prey availability and diversity.
- Standardized prey occurrence probabilities were estimated by using binomial GLMs.

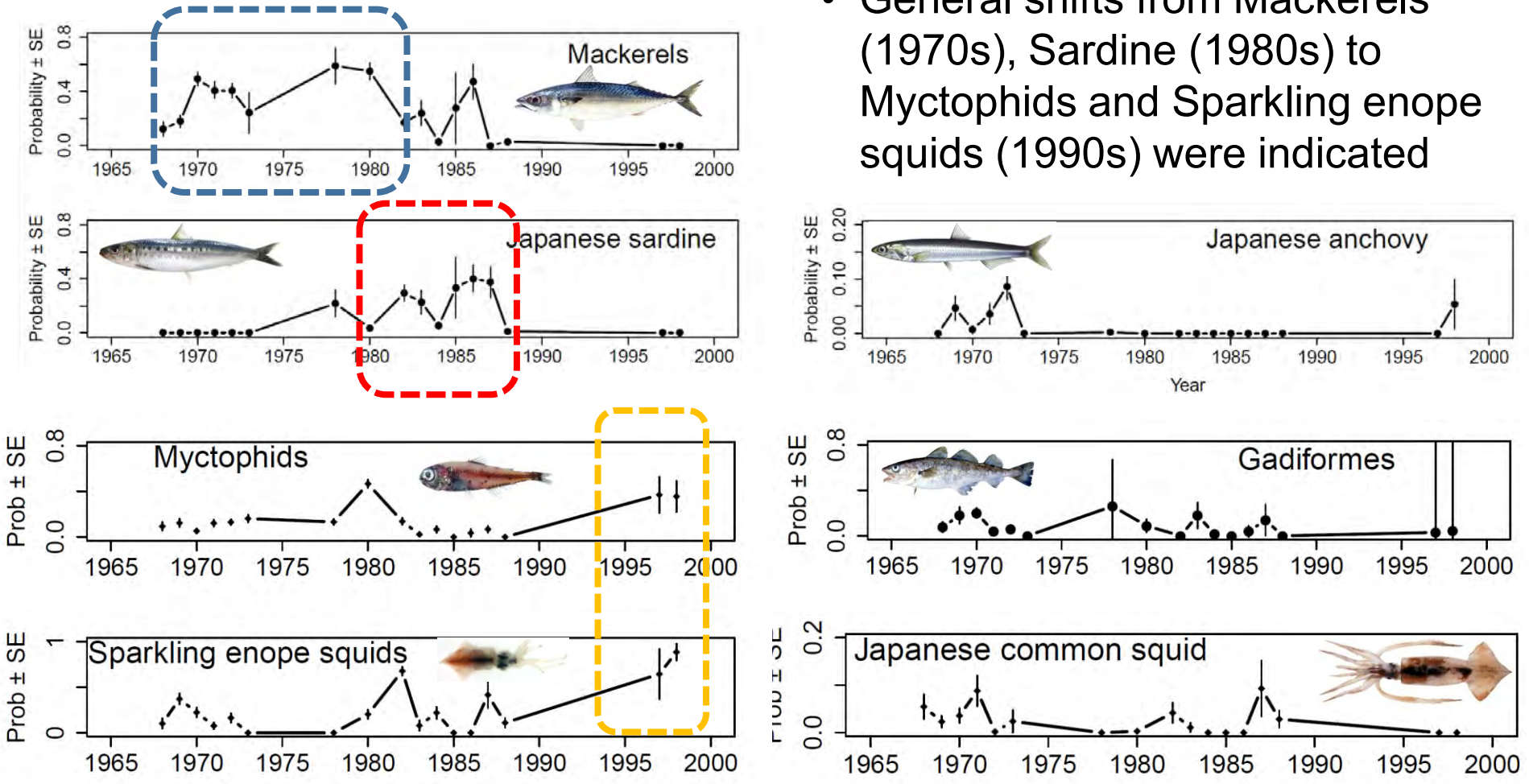


- *Kiyota and Yonezaki (submitted)*

2. Stomach contents reflect prey distribution and fur seal feeding/migration



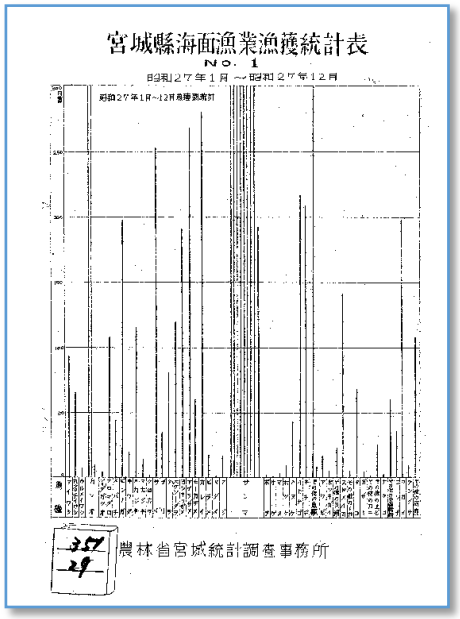
2. Long-term trends of prey availability



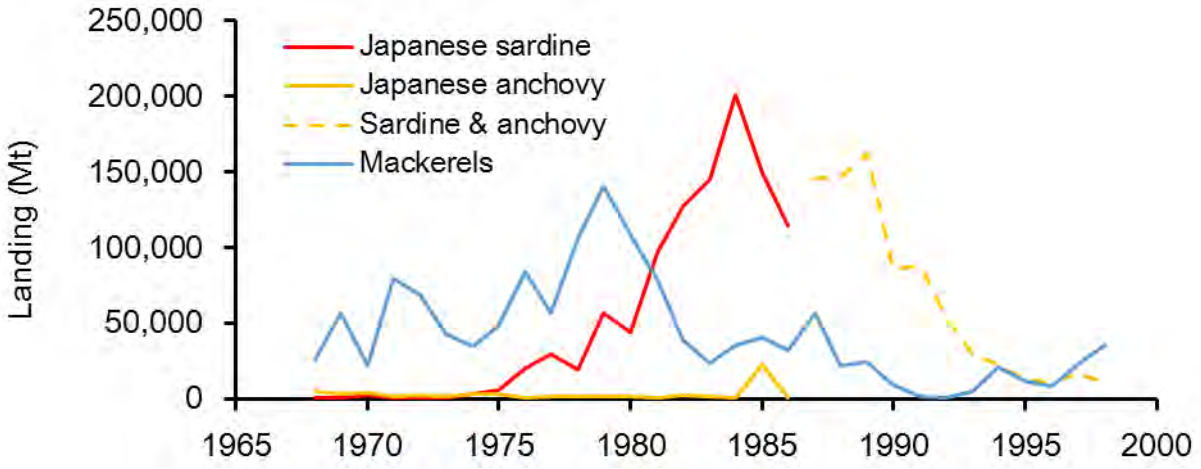
- General shifts from Mackerels (1970s), Sardine (1980s) to Myctophids and Sparkling enope squids (1990s) were indicated

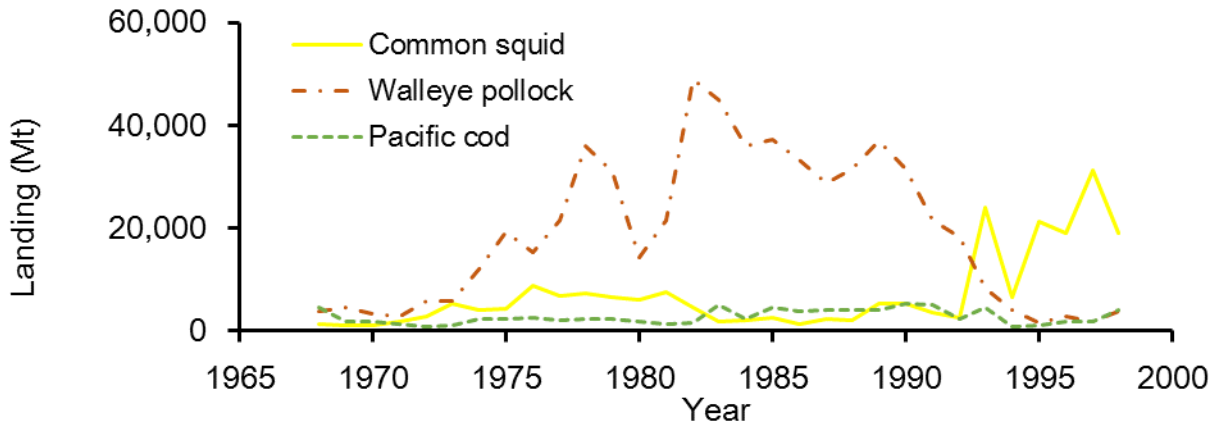
3. Utilization of fishery statistics data

- Japanese fishery statistics provide long-term data by area, species and fishing method since the 1950s.

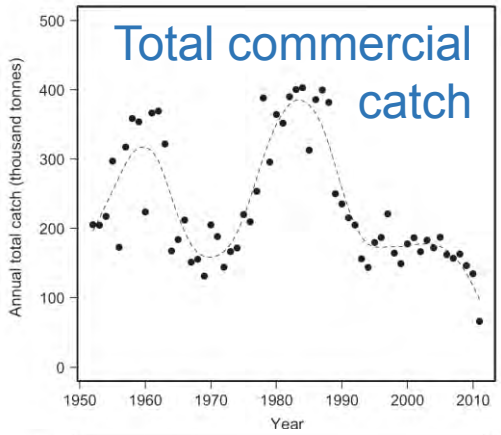


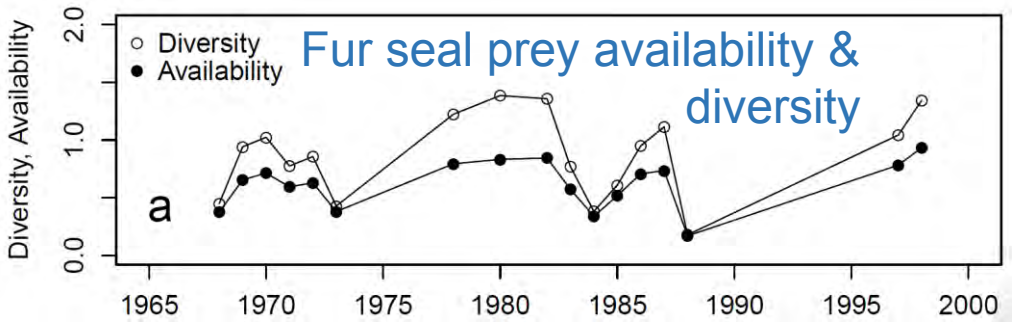
Miyagi Prefecture
Fisheries Statistics 1952

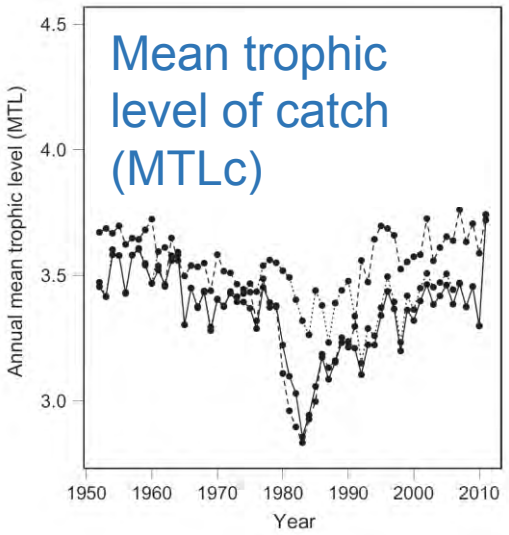


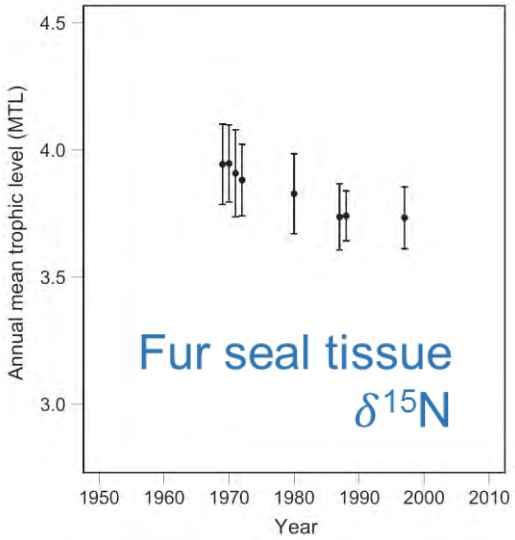


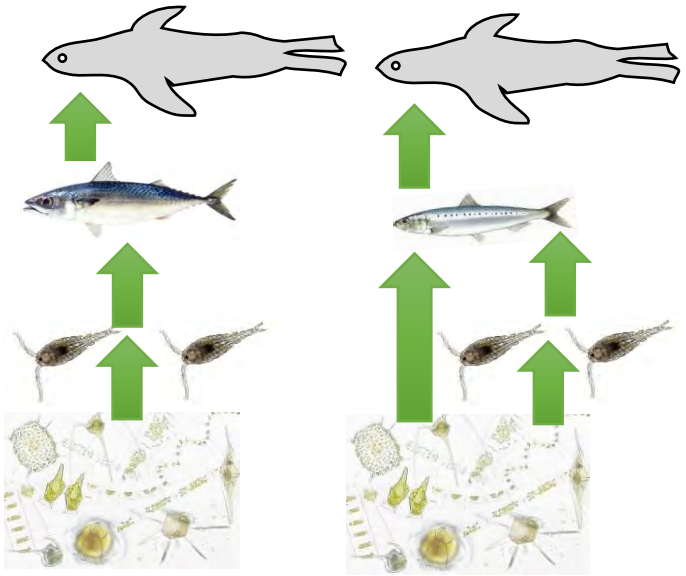
3. Fishing down?: Analysis of commercial fishing data and comparison with top predator indices









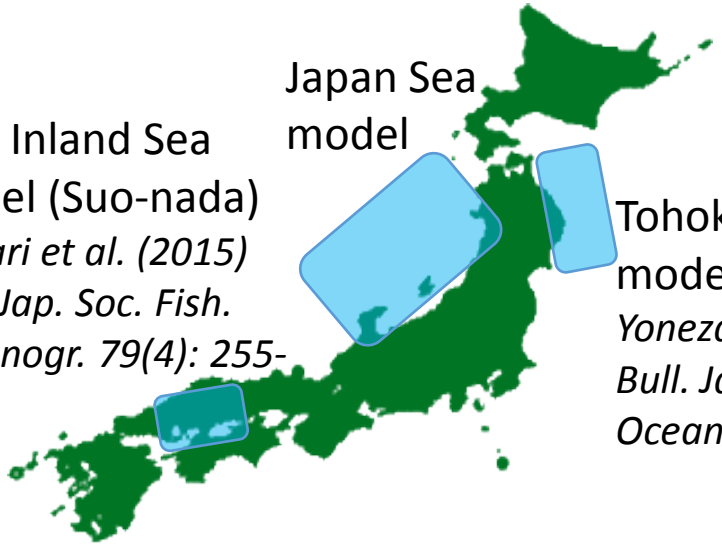


- Commercial fisheries are driven by many factors including technical development, management regulations and market demands.
- *Yonezaki et al. (2015) DSR II 113*

- Shortening of the food chain length and improvement of system efficiency might occur during the sardine dominant regime.

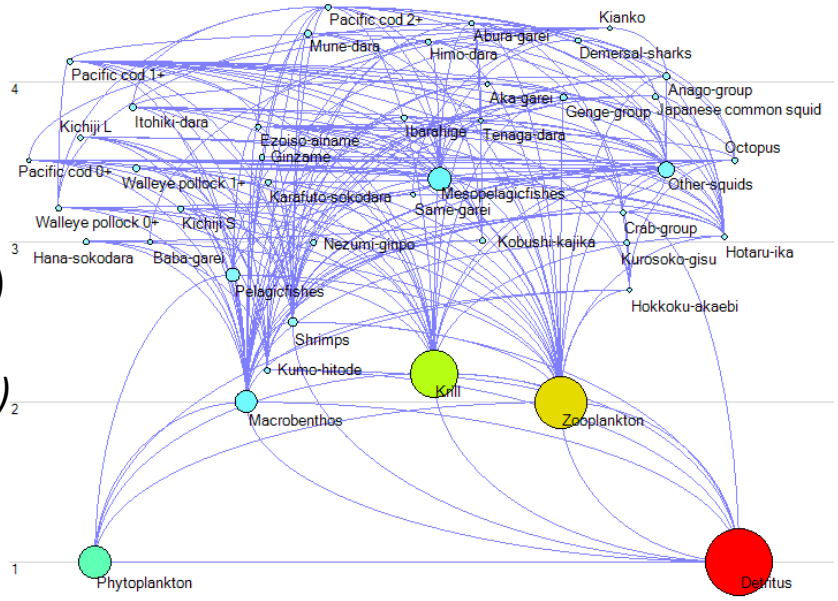
3. Quantitative assessment of fisheries impacts: Ecopath approach

- Our on-going approach:
  - To construct regional Ecopath models around Japan based on commercial fishery data and survey data
  - To compare the system properties and fishery impacts with published EwE models around the world

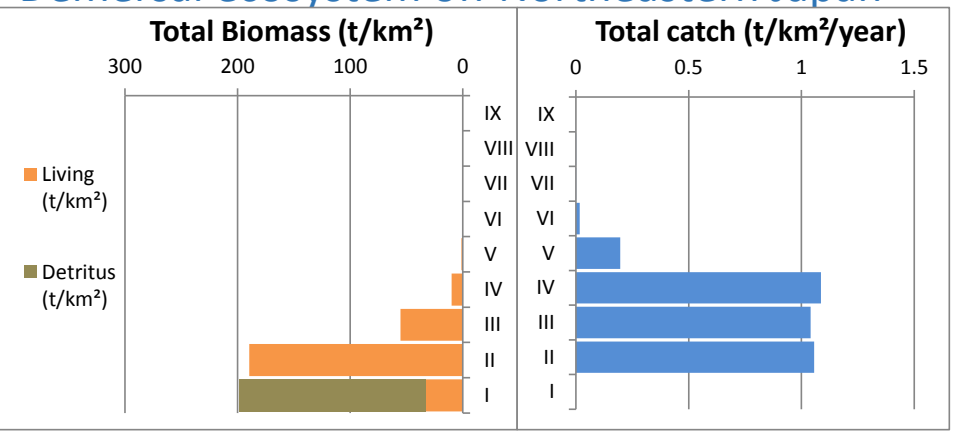


Seto Inland Sea model (Suo-nada)
Watari et al. (2015) Bull. Jap. Soc. Fish. Oceanogr. 79(4): 255-265

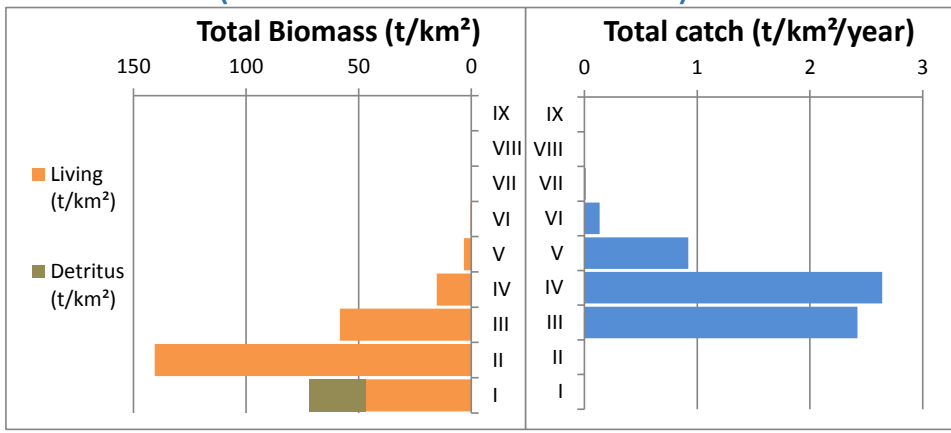
Tohoku (demersal) model
Yonezaki et al. (2016) Bull. Jap. Soc. Fish. Oceanogr. 80(1):1-9



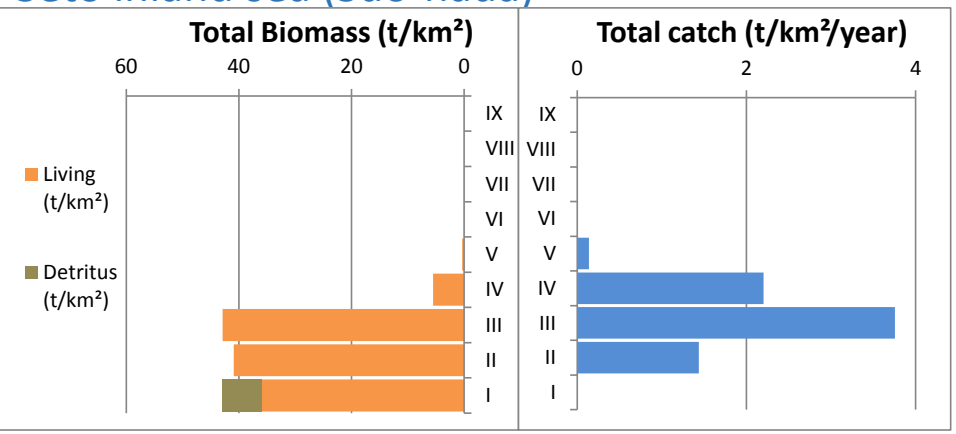
Demersal ecosystem off Northeastern Japan



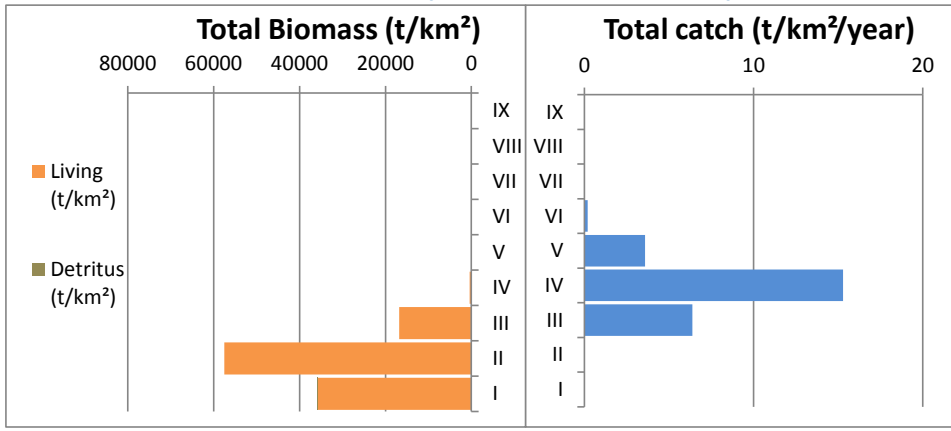
North Sea (Christensen et al. 2002)



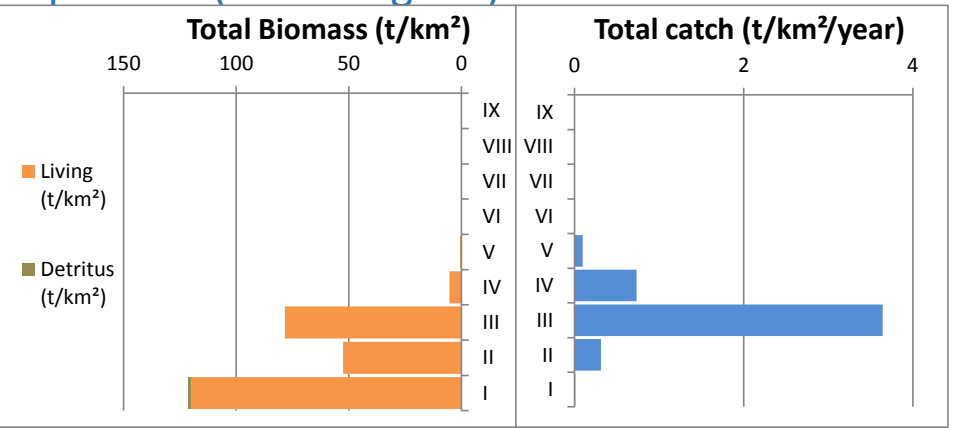
Seto inland sea (Suo-nada)



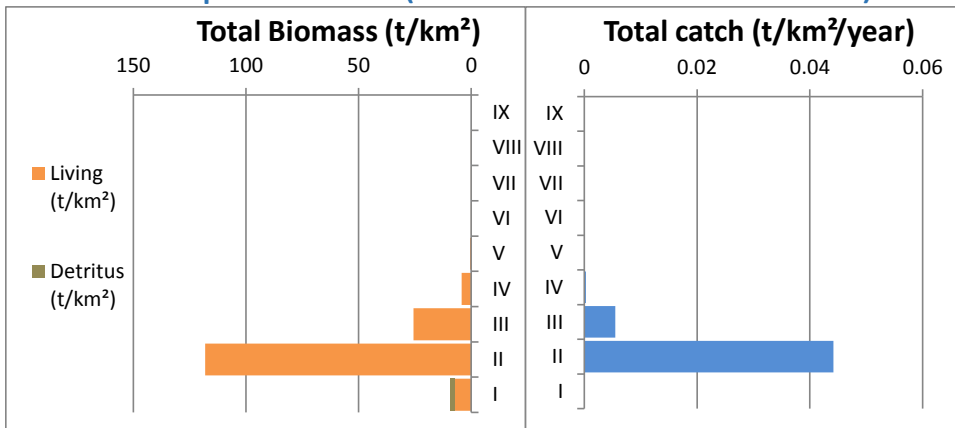
Central North Pacific (Cox et al. 2002)



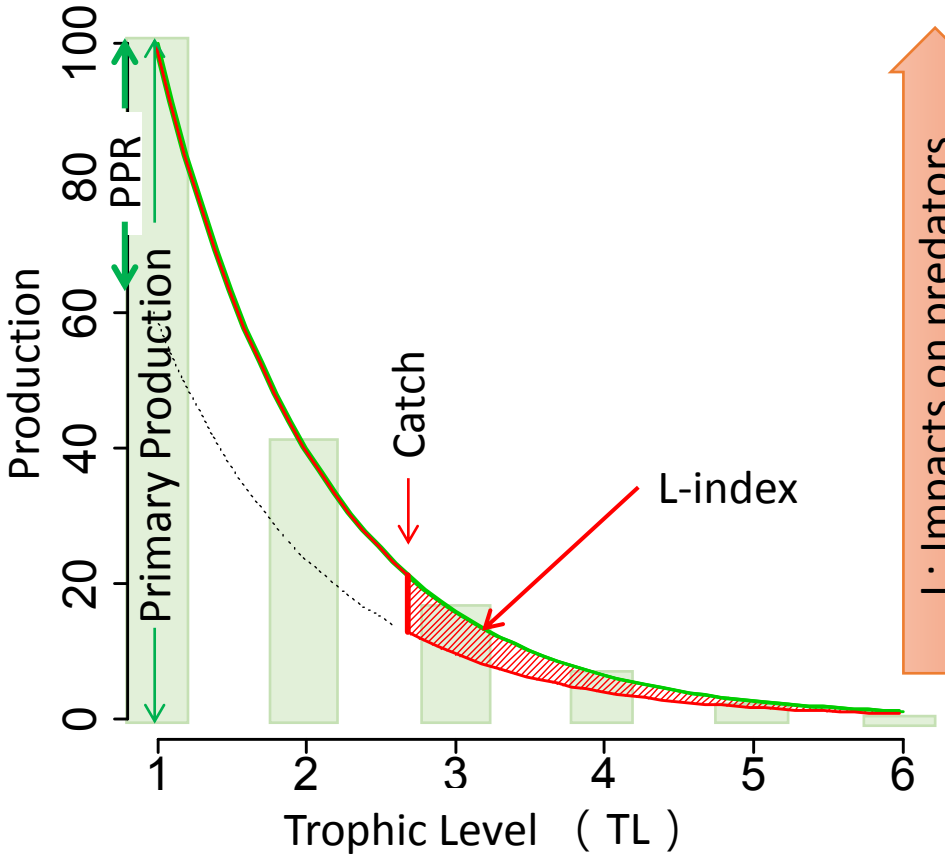
Japan Sea (warm regime)

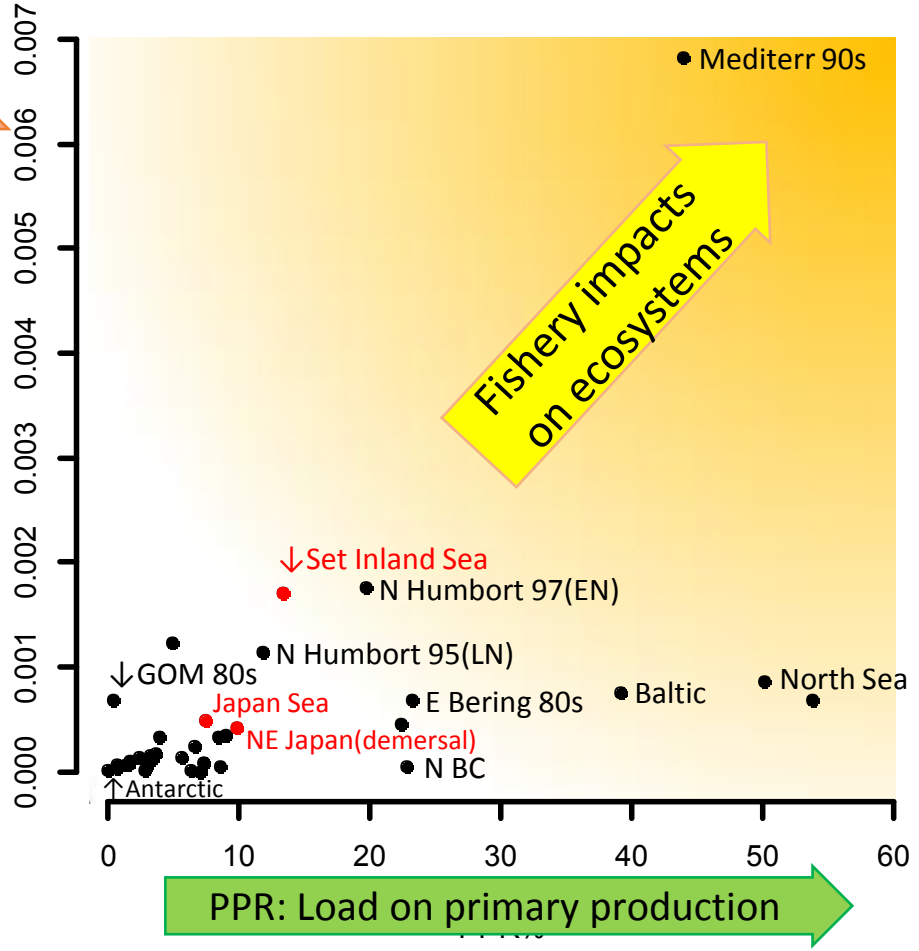


Antarctic peninsula (Efran and Pitcher 2005)



3. PPR and L-index: Quantification of fishery impacts

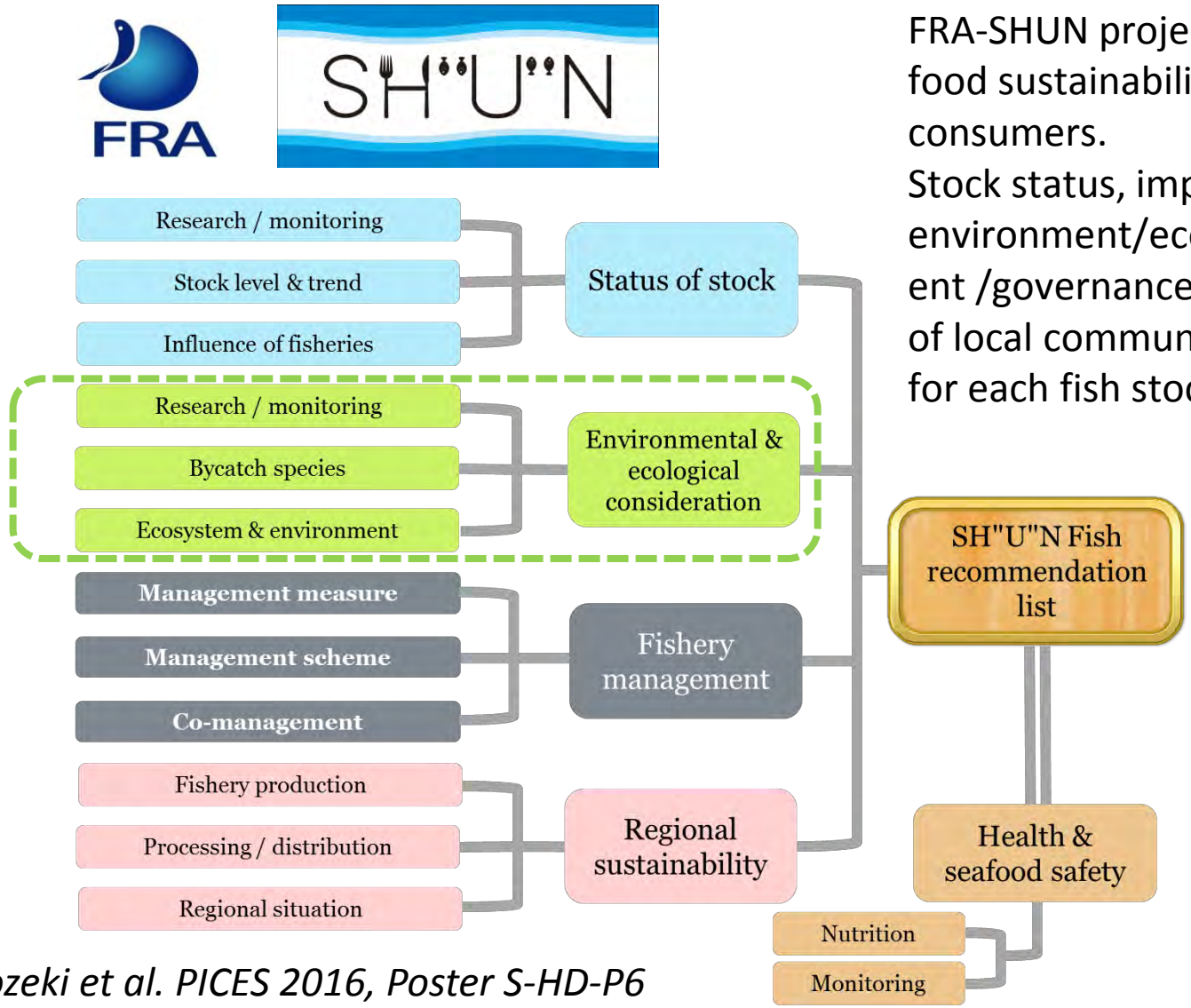




- L index : Loss of foods for upper level predators (Libralato et al. 2006)
- PPR : Primary production required to produce commercial catch (Pauly and Christensen 1995)

- PPR-L plot is a good indicator of impacts (ecological footprints) of commercial harvests on ecosystems.

4. Information feedback to commercial market and general public; the real “consumer” in the socio-ecological system

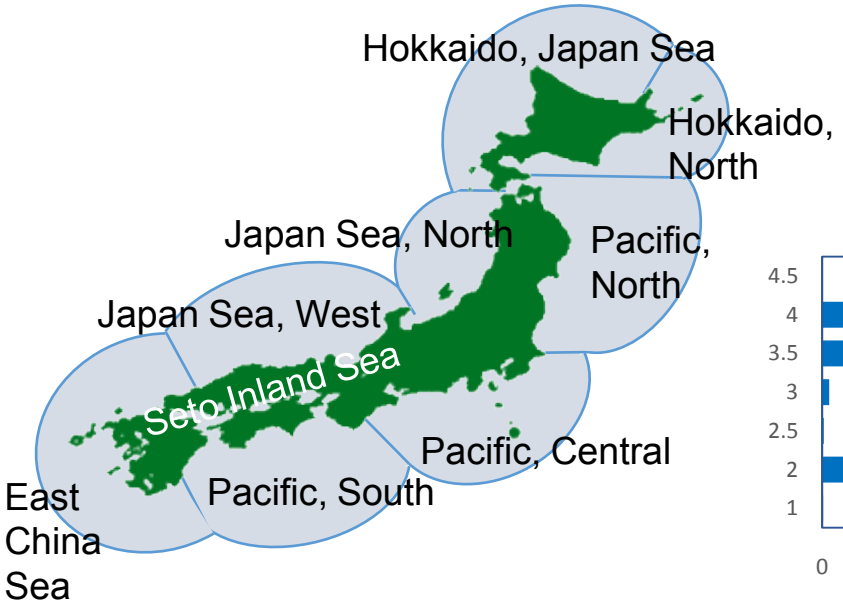


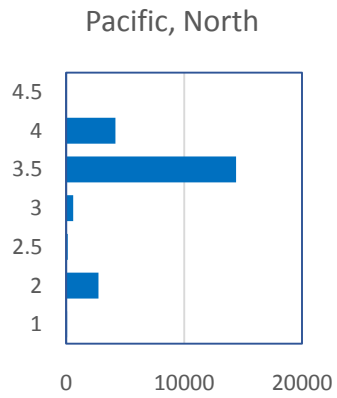
FRA-SHUN project provides sea food sustainability guide lists for consumers.
Stock status, impacts on marine environment/ecosystem, managem ent /governance and sustainability of local community are evaluated for each fish stock.

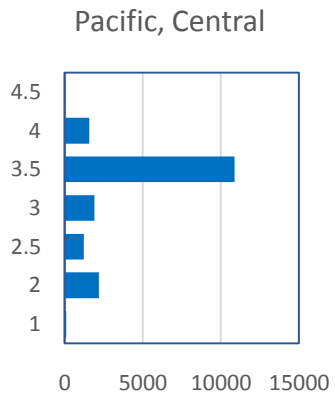
Ooozeki et al. PICES 2016, Poster S-HD-P6

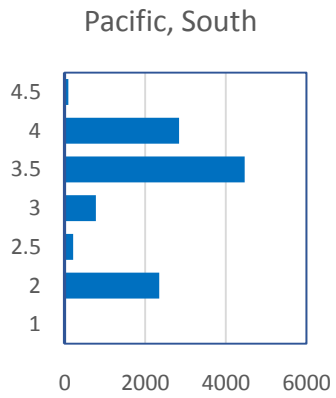
4. Use of fishery statistics as surrogate information

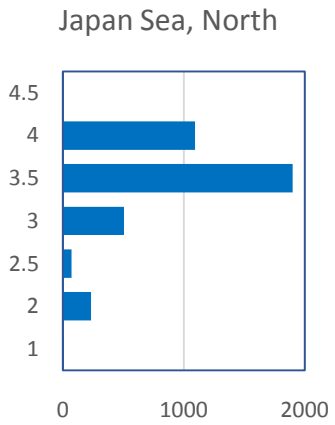
- Ecosystem assessment is applied to each Japanese statistical area.
- Use of catch-by-area-and-species data are under consideration until Ecopath models are constructed for each area.

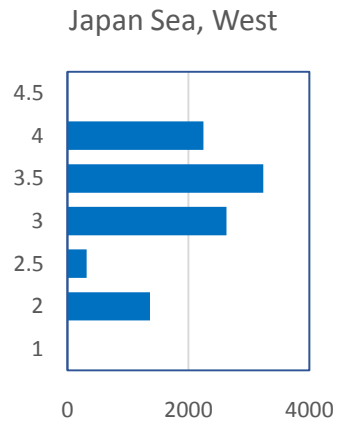


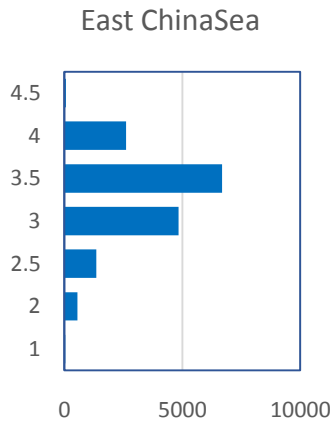


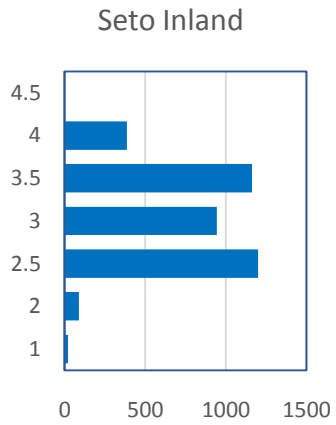












Closing remarks

- Long-term scientific survey data and fishery data provides valuable information on marine ecosystems.
- Food web analysis (e.g. TL partitioning) is a promising practical approach to quantify the position and function of top predators and commercial fisheries in regional ecosystems.
- Shrinkage of scientific survey and fishery statistics may cause problems in ecosystem monitoring and impact assessment.
- Fisheries are not opportunistic consumers, but are affected by multiple socio-economic factors including market demands
- Information feedback to commercial market and general public is another important task to ensure the sustainability of the socio-ecological system.