Report of Working Group 41
on *Marine Ecosystem Services*

The PICES Working Group on *Marine Ecosystem Services* (WG 41/WG-MES) conducted its third meeting over two days, September 28-29, 2020. The meeting was held virtually via WebEx. Dr. Dan Lew presided over the meeting as Co-Chair.   Dr. Shang Chen is the other Co-Chair but was unable to attend.   Ten Working Group members were in attendance (*WG 41 Endnote 1*).   In addition to the WG 41 members, Dr. Meng Su (China) and Julia Yazvenko (PICES) were in attendance.   Dr. Su has been an active participant and contributor in the working group's activities.   This was the best attended WG41 business meeting in terms of working group member participation.

Day 1, September 28, 2020
AGENDA ITEM 1
Welcome/introductions, adoption of agenda, terms of reference, goals

The meeting began with a welcome and detailed introduction about the meeting goals and format from Dr. Lew.   He explained that the meeting will take place over two days, with Day 1 dedicated primarily to progress updates on the working group projects and Day 2 focusing on identifying next steps for the projects and the working group generally. This was followed by introductions from those in attendance, a review of the proposed agenda, and a vote to adopt the meeting agenda (it was adopted without change; *WG 41 Endnote 2*). During introductions, Dr. Sugimoto indicated she will be stepping down from the Working Group due to obligations to other PICES expert groups.   However, she pointed out that Dr. Wakamatsu was just appointed and will be of great help to the group.   Dr. Lew then presented some background information on the origins and timeline of the Working Group, its purpose and terms of reference, and a brief description of the projects.   This background included a short discussion of where marine ecosystem services (MES) fit in the FUTURE social-ecological-environmental system framework (Bograd *et al.*, 2019)[1].

AGENDA ITEM 2
Review of project descriptions

The two Working Group projects intended to fulfill the TOR are the following:

1.   Review of MES studies in member countries

The first project is a review paper.   This project is intended to address Terms of Reference #1, #2, and #3 by assessing the scope of MES available in the North Pacific, reviewing the methods for assessing MES along the ecological, economic, and sociocultural dimensions, and a case study of the application of methods for assessing aquaculture-related MES in the North Pacific member countries.   The review paper will provide insights into the range of quantitative and qualitative methods used to measure and value MES in the North Pacific (review of MES types and methods) as well as illustrate how different countries apply them (case studies). Thus, the paper will address the following questions:
- What are ecosystem services and MES and why are they important?
- How are they defined and classified?
- What is the range of MES in the North Pacific?

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[1] Bograd, S. J., Kang, S., Di Lorenzo, E., Horii, T., Katugin, O. N., King, J. R., Lobanov, V. B., Makino, M., Na, G., Perry, R. I., Qiao, F., Rykaczewski, R. R., Saito, H., Therriault, T. W., Yoo, S. and Batchelder, H. (2019). Developing a Social-Ecological-Environmental System Framework to Address Climate Change Impacts in the North Pacific. Frontiers in Marine Science, 6, 333.

▪   What methods are currently available to assess MES, both in terms of measuring their levels and valuing them individually and collectively?

▪   What are the similarities and differences between North Pacific member countries in terms of the range of MES and methods used to measure and value them (as illustrated through the case study)?

Note that for Project 1, it was agreed at PICES-2019 that the review of assessment methods (ecological, economic, and sociocultural methods) would be general and not geographically-constrained to what is done in individual countries (though discussion of this would help provide context). The main focus will be on providing a review of the methods used to assess MES, with particular emphasis on best practices. This is not intended as a fully exhaustive literature search and review, but rather a review that highlights the main methods and applications.

2.   Country-specific surveys of agencies and decision makers

The second project is a survey project involving the development of country-specific surveys that will be administered to decision makers, analysts, and scientists involved in ocean and coastal management and research in each country.   The goal of the study is to collect information necessary to understand how they view and use MES information, as well as the prospects and challenges currently facing each country for advancing its usage in policy and management and its integration into more integrative management frameworks (like ecosystem-based management).

AGENDA ITEM 3
**Project updates**

Project 1: Review of MES Report

Dr. Lew provided a detailed update about work he has done on the first several sections of the MES report. He thanked a number of members for providing feedback on those sections. The current outline for the report is as follows:

1. Introduction
2. The growth of ES and MES: Bibliometric Analysis
3. What are MES?
4. Assessing MES (quantifying, measuring, valuing, and understanding)
   a. Ecological
   b. Economic
   c. Sociocultural
5. Case study: Aquaculture
6. Discussion
7. Conclusion

He indicated that first drafts of sections 1–3 were completed, but require some revision and review. He explained that section 2 (Bibliometric Analysis) is new and was added to provide additional context about the growth of scientific knowledge and attention to ecosystem services generally and MES particularly (Figure 1). He asked the group whether they thought a similar analysis of the non-English language literature would be helpful. Dr. Sugimoto indicated that the Japanese language literature on ecosystem services is likely very small since Japanese researchers are more likely to publish in the English-language literature.

Bibliometric Analysis: ES and MES literature

Comparison of the growth of the general ecosystem services (English-language) literature and the coastal and marine ecosystem service literature, 1999-2019. Total docs: ES = 25,623, MES = 3,493.
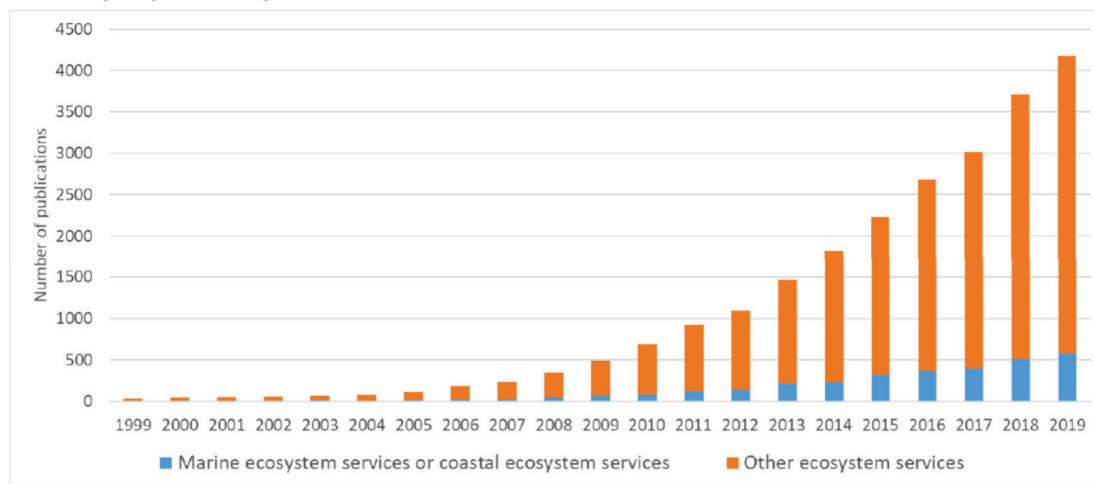

Figure 1. An illustration of the growth of scholarly research on ecosystem services and MES.

For section 3, he discussed the various definitions for ecosystem services that have been developed and used in the literature, the controversies with some of the early definitions, and efforts to move towards definitions that can be operationalized in efforts to quantitatively assess ecosystem services. In particular, he spent some time discussing the concept of final ecosystem goods and services (FEGS), which are the ecosystem services directly used by humans. It is a concept particularly useful for economic valuation of ecosystem services. FEGS were contrasted against intermediate ecosystem services (ones that contribute to production of FEGS but are not directly used by humans) and then put into a simple conceptual framework for ecosystem services (Figure 2).

Dr. Lew outlined his plans to write an introductory subsection to section 4 (assessing MES) that draws from numerous intergovernmental initiatives focused on ecosystem services like OpenNESS and IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) that have proposed frameworks that embrace a pluralistic or transdisciplinary approach to evaluation of ecosystem services. In particular, he suggested that section 4 of the report (Assessing MES) be motivated from this pluralistic or transdisciplinary perspective. Dr. Lew then described plans for the economics subsection (section 4b of the report).

And finally, Dr. Lew provided an overview of the aquaculture case study section, which is intended to illustrate the elements of the ecosystem service approach in different PICES nations. He indicated that a recent review article on aquaculture ecosystem services by Weitzman (2019)[2] will likely be helpful in the preparation of the case studies and provided a quick synopsis of the paper and its results.

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[2] Weitzman, J. (2019). Applying the ecosystem services concept to aquaculture: A review of approaches, definitions, and uses. Ecosystem services, 35, 194–206.
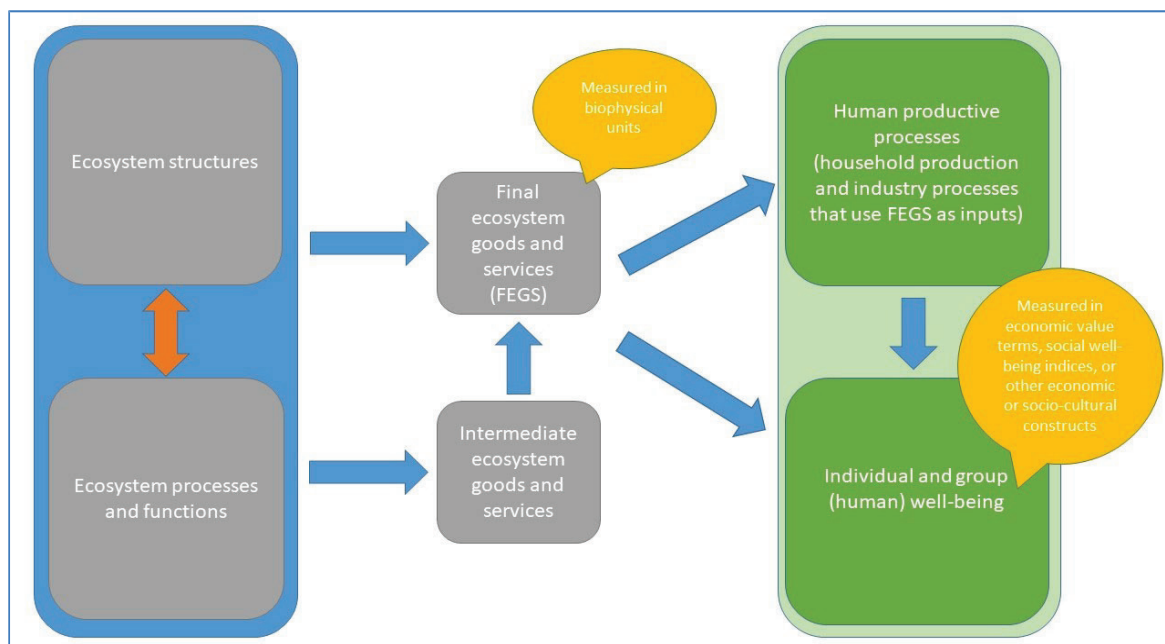
Figure 2. Conceptual diagram of relationship between the ecosystem, intermediate and final ecosystem services, and humans. On the left are the ecosystem structures and ecosystem processes and functions that represent the ecosystem. The bidirectional arrow between them represents the feedback mechanisms that occur between the ecosystem structures, processes, and functions. In the middle are ecosystem services, which represent a bridge between the ecosystem and humans. The ecosystem produces ecosystem goods and services (measured in biophysical units), some which are used directly by humans–the final ecosystem goods and services (FEGS)–and others that are intermediate in the sense that they contribute to the production of FEGS. On the right are the human dimensions, represented by individuals and groups in the lower box and productive processes in the upper box that take FEGS and combine them with human capital and labor to produce goods and services that are then used or enjoyed by humans. Thus, humans benefit from FEGS either directly or indirectly.

Dr. Sarah Dudas provided an update on the Ecological sub-group's efforts to understand the way ecosystem services are assessed from the perspective of ecology. She indicated that Dr. Caihong Fu provided some help, but that her schedule would likely prevent her further involvement. She had also reached out to Dr. Chen but had yet to hear back from him. However, Dr. Dudas mentioned that her colleague, Kieran, had helped conduct a selective review of the literature that was limited to studies that met the following criteria/considerations: (a) included an ecological assessment of MES, (b) diversity of applied assessment approaches, and (c) the assessment method and response metric were outlined. Studies meeting these criteria were reviewed to identify the following:

- Location, Ocean, Ecosystem, Habitat
- MES, Ecological Service Provided, Service Definition, Assessment Approach and Method, Aquaculture relevance
- Metadata: Article Type, Authors, Reference, DOI

Dr. Dudas indicated that it would be helpful to identify the key questions of interest and how to present information found in the review. She discussed that there are a lot of ways of presenting the information and as an example presented Table 1.

Table 1. An example of a draft summary table from the Ecological subsection, section 4a. The table describes the broad ecological service, the types of assessment applied to it, the metrics used in assessing it, and the MA ecosystem service category(ies) in which it falls.

Ecological Service	Assessment Category	Metrics	Ecosystem Service
Biodiversity	Biodiversity Maintenance	Index, Density, Diversity, Percentage	Provisioning, Supporting, Regulating
	Community Composition	Diversity, Density, Index	Supporting
	Functional Diversity	Fluctuations	Supporting
	Genetic Diversity	Diversity, Density	Regulating, Supporting
	Genetic Resources	Diversity, Genes	Provisioning
	Indicator Species	Index, Abundance, Biomass	Regulating, Supporting
	Non-Indigenous Species	Index, Abundance and Distribution	Supporting
	Resilience	Resilience	Regulating
	Spawning or Nursery Populations	Diversity and Density	Supporting
	Species Distributions	Distribution	Supporting
	Species Diversity	Density, Index, Diversity	Supporting
Climate	Carbon Sequestration	Concentration, Percentage, Tons and Rate, Models	Regulating
	Climate Regulation	Concentration, Flow Rate, Models	Provisioning, Regulating
	Temperature	Index	Supporting
Fish and Fisheries	Fish Biomass	Biomass, Trophic Level	Provisioning
	Fish Mortality	Survival	Provisioning
	Fishing Capacity	Hours per Year	Provisioning
	Foraging Area	Area	Provisioning
	Life Cycle Maintenance	Biomass, Area, Percentage	Supporting
	Population Composition	Population Average, Abundance and Biomass, Species Density	Provisioning, Supporting
	Seafood Quality	Index	Provisioning
Habitat	Biogenic Habitats	Abundance	Supporting
	Coastal Stability	Index, Quality, Abundance, Length, Mass, Model	Regulating, Supporting
	Habitat Provisions	Area, Density, Index	Supporting, Provisioning
	Migration Support	Contribution	Supporting
	Oxygen Demand	Capacity, Index	Regulating
	Sediment Quality	Index, Abundance and Composition	Supporting, Provisioning
	Water Quality	Concentration, Days, Liters, Flow Rate, Distribution, Index	Provisioning, Regulating, Supporting
Nutrients	Filtration	Concentration	Provisioning
	Nutrient Density, Regulation, and Cycling	Quality, Concentration, Index, Density, Mass	Supporting, Regulating
	Primary Production	Biomass, Index, Concentration	Regulating, Provisioning, Supporting
	Water Quality	Concentration, Dispersal, Joules, Index	Regulating, Provisioning, Supporting
Pollution	Ecotoxicology	Concentration	Regulating
Raw Material	Biotic Resources	Biomass, Concentration, Density	Provisioning
Renewable Energy	Energy Production	Area	Provisioning

Dr. Dudas also mentioned that for Project 2, she had prepared a video that would be used as an introduction to the survey.

Dr. Kirsten Leong made a presentation about the sociocultural subsection, section 4c. She indicated that Alohi Nakachi, a Ph.D. student working with her, had done a lot of the initial groundwork to review the literature on sociocultural valuation of ecosystem services. She also indicated that Dr. Sugimoto had provided useful input as well. Dr. Leong provided details about how they were thinking about ecosystem services in the context of larger social-ecological systems (SES) frameworks, and provided a number of examples of these frameworks and the role of ecosystem services and human well- being within them. She pointed to the IPBES's reframing of ecosystem services as nature's contributions to people (NCP), which include both positive and negative effects on humans. She advocated for more discussion of the role of human well-being and ecosystem services within a larger SES context, as well as the inclusion of relational values. She also shared a working list of aquaculture-related social values.

Dr. Gisele Magnusson provided a description of the environmental accounting subsection that will be incorporated into the report. There was some discussion about where to put the subsection, with the most likely section being the Discussion. In that section, applications of the ecosystem services approach like environmental accounting and coastal and marine spatial planning and management are likely to be central to the discussion.

Dr. Su presented the work she has done to develop the aquaculture case study for China. She explained that China is the world's largest aquaculture producer, accounting for 67% of the world's production. Its aquaculture production is greater (by volume) than its wild capture fisheries production. She noted that assessments of coastal and marine aquaculture, or mariculture, generally focus on understanding impacts of the density of operations and how it affects marine spatial planning. A literature review found 9 studies that used the keywords "mariculture ecosystem services" or "bay-mariculture". She analyzed these 9 studies to evaluate what types of mariculture operations are studied, the ecosystem services examined, and the types of assessment methods used. The mariculture-related ecosystem services examined in these studies are summarized in Figure 3. Dr. Su further examined the spatial distribution of the studies, the species involved in the mariculture operations, and the valuation methods used to generate monetary values for the individual ecosystem services. She then provided an assessment of the overall results, which included noting the focus on economic values of MES in specific regions and the inconsistent set of MES examined across studies.
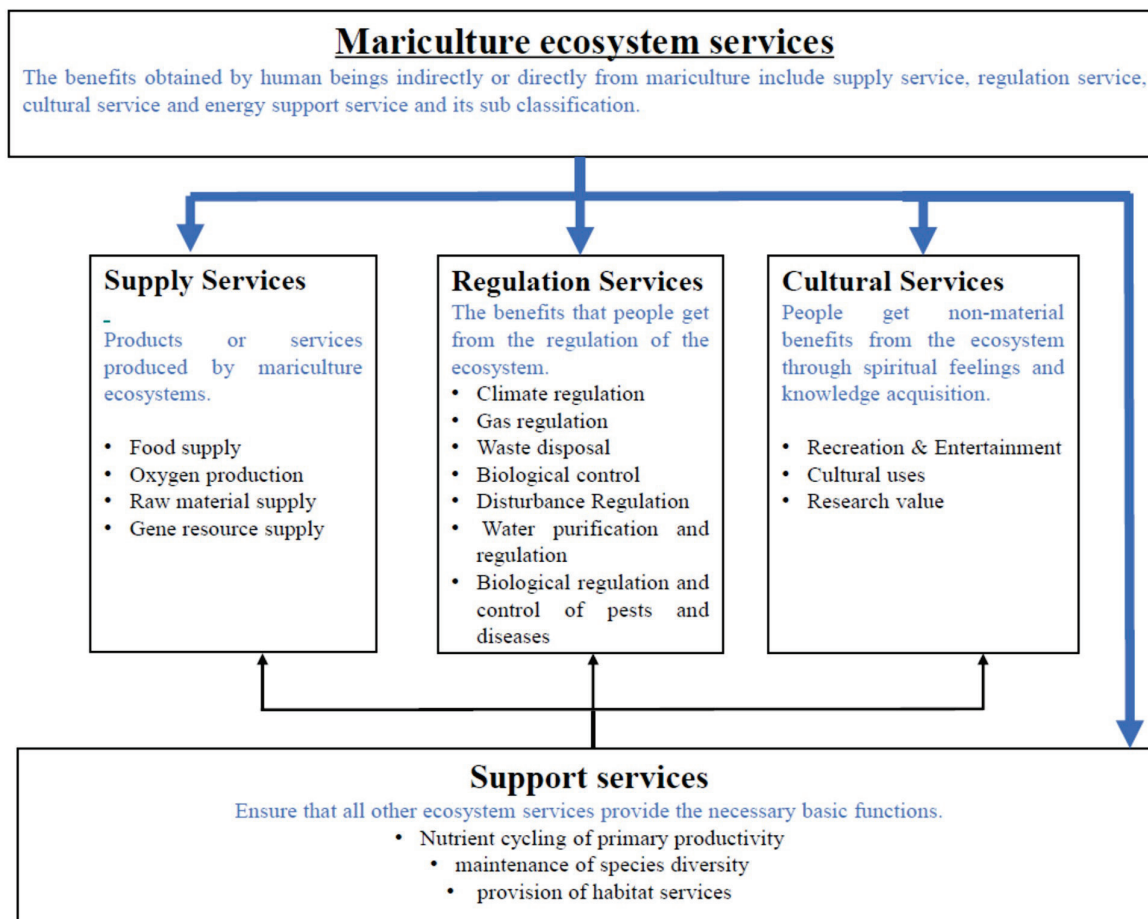
Figure 3. Types of ecosystem services related to mariculture in China.

Project 2: MES Survey

Dr. Lew provided a brief update on the Project 2 MES survey project in the U.S. Last year, a survey template had been developed with cooperation between U.S. and China and revised with input from the working group, but he indicated that due to some unexpected issues it is not clear whether the U.S. survey will be able to move forward and be fielded. Dr. Lew indicated that attempts will be made to continue with the survey if possible. Since Canada had been relying upon the U.S. to field their version as well, it is unclear whether the Canada survey will proceed. However, Dr. Magnusson has indicated that they may still be able to do it, particularly since most of the materials have been developed for the Canada version, though it still needs to be pretested.

Dr. Jingmei Li reported that China was able to revise their original survey to conform to the MES survey template.   She was able to field the MES survey this year.   She presented the preliminary results from the MES survey, which indicated that almost all respondents (95%) were familiar with the concept of marine ecosystem services, while about 57% were familiar with the concept of marine ecosystem service values.   MES values were divided into direct use, indirect use, and nonuse values in the survey.   Over half (52%) of respondents were familiar with use values, but only 39% were familiar with nonuse values. The use of MES value information differed across types of values, with the majority with experience using use values in their work and conversely the majority did not have experience with nonuse values.   The lack of usage of nonuse values seems to be related to the distrust in the science of measuring these types of MES values and that how they are defined was too vague to be useful.   Dr. Li indicated that further analysis of the data will be done.

Other related projects/research

Dr. Jungho Nam gave a presentation on work that South Korea is doing to incorporate MES information into marine spatial management and planning activities. He discussed the various types of MES valuation research done in South Korea and early efforts to incorporate non-market MES values into coastal and marine spatial management decision-making. In particular, he described the Marine Assessment and Planning Support System (MAPS) and how marine ecosystem service valuation research is used in that framework. Some issues discussed included the spatial mapping of ecosystem services, its use for the determination of conflicting uses, and the use of MES economic values in trade-off analysis.

AGENDA ITEM 4
Finalizing projects and assignments

Discussion continued about how to complete the working group projects. As noted above, given the uncertainty about Project 2 for Canada and U.S., the possibility of putting the results of the China survey into the Project 1 MES review report as part of the Discussion section was suggested. Most of the discussion about next steps occurred with respect to Project 1, the MES review. A discussion about the likely outlets for the MES review was discussed, with a PICES Press article and a PICES Scientific Report the first products expected to be generated from the report. A peer- reviewed journal article is also a possibility, but it was suggested that we wait to see how the report develops to evaluate the feasibility of that.

A timeline for completing Project 1 was established:

- A rough draft of the full MES report by PICES-2021
- Time at the business meeting at PICES-2021 will be used to deal with any remaining issues
- After PICES-2021
  - The lead writers will iterate to develop a final draft of the full MES report
  - The lead writers will develop the PICES Press article from the report (short summary/overview of MES)

Current assignments for reports sections are presented in the table in *WG 41 Endnote 3*. This includes a list of the lead writers for each section of the report and the other contributors for each section. This table was completed during the meeting after querying those in attendance about whether they would be able to contribute. Individuals in the table with a question mark (?) have not yet been confirmed. Note also that Dr. Nam indicated that he thinks he knows one or more people from South Korea who would be good to add as contributors. Dr. Lew indicated it would be most helpful for any new contributor from South Korea to help with the case study since we currently do not have anyone able to work on the case study for South Korea. Dr. Wakamatsu, the working group's newest member, agreed to help with the case study for Japan and with the economics sub- section.

Dr. Lew indicated that he will complete a revised draft of sections 1-3 and will distribute them to Drs. Dudas and Leong (and likely others) for comments in the near future. He also said that he plans to write up the discussion of pluralistic/transdisciplinary approaches for evaluating/assessing MES and will share it with the other section 4 leads.

A proposal was made to increase the intersessional communication within the working group to aid in completing the report, which had widespread support in the group. Specifically, an intersessional WG41 virtual meeting held via WebEx was proposed for January 2021. That meeting would include progress updates and provide an opportunity for the working group to discuss specific issues that arise in the case studies and in writing the other sections of the report. Moreover, the "team" leads would try to attempt one or more team virtual meetings to aid with writing up individuals sections of the report.

Day 2: September 29, 2020
AGENDA ITEM 3
Next steps

The Working Group discussed several issues related to the future of the group.   These included the Topic Session on "*Marine Ecosystem Services – Connecting science to decision making*", originally scheduled for PICES-2020, that has been postponed to PICES-2021.   Dr. Dudas (Canada) and Dr. Li (China) are the co-conveners.   There was support for using the topic session to report on the findings of the Working Group that will be reported in the Project 1 review of MES report and the write-up of the Project 2 MES surveys.

There was a short discussion about whether and how to continue the working group beyond a one-year extension.   This talk was couched in terms of the UN Decade of Ocean Science (https://www.oceandecade.org) and PICES's desire to contribute to that. There was support for possibly proposing a working group related to implementing and operationalizing the ecosystem services approach in a transdisciplinary way, and generally, for advocating support for the inclusion of cultural ecosystem service information (either in the MES context or more broadly in terms of sociocultural ecosystem indicators). It was agreed that because we are requesting a one-year extension to finish our projects, the development of a new working group should wait until next year.

The Working Group did not collaborate with any other PICES expert groups during the past year.

AGENDA ITEM 4
Other business

No issues were raised.

AGENDA ITEM 5
Meeting adjournment

Dr. Lew thanked the members and attendees for their valuable contributions and indicated he was looking forward to continued collaboration on the projects.   The meeting was then adjourned.

WG 41 Endnote 1

WG 41 participation list

Members

Dan Lew (USA, Co-Chair)
Sarah Dudas (Canada)
Changsu Lee (Korea)
Kirsten Leong (USA)
Jingmei Li (China)
Wei Liu (China)
Gisele Magnusson (Canada)
Jungho Nam (Korea)
Aoi Sugimoto (Japan)
Hiroki Wakamatsu (Japan)

Members unable to attend

China: Shang Sunny Chen, Benrong Peng
Korea: Hye Seon Kim, Seung-Hoon Yoo
USA: Kristy Wallmo

Observers

Meng Su (China)
Julia Yazvenko (PICES)

WG 41 Endnote 2

WG 41 meeting agenda

Day 1: September 28, 16:00–19:00 Pacific Time
1. Introduction: introductions, adoption of agenda, review of terms of reference, goals and structure of the business meeting
2. Review of project descriptions
   a. Project 1: Review of MES report
   b. Project 2: MES survey
3. Project updates (presentations by WG members)
   a. Project 1 (Lew, Leong, Dudas, Magnusson, Su)
   b. Project 2 (Lew, Li)
   c. Other related projects/research updates
4. Discussion of steps to take to finalize projects and assignments
5. Meeting adjourns until Day 2

Day 2: September 29, 16:00–19:00 Pacific Time
1. Introduction - recap of Day 1, goals for Day 2
2. Continue any discussions from Day 1 that are needed
3. Discussion of next steps for WG (also discuss what has worked and not worked about WG)
   a. Interactions/collaborations with other working groups
   b. 1-year extension to finish projects?
   c. Terms of reference for renewing WG-MES or setting up a new working group?
   d. Topic session scheduled for PICES-2021; any others?
4. Other business
5. Meeting adjourns

WG 41 Endnote 3

Current Assignments for Project 1

Section	Lead writer	Other contributors
1. Introduction	Lew	
2. Bibliometric analysis	Lew	
3. What are MES?	Lew	
4. Assessing MES (introduction)	Lew	Dudas, Leong
4a. Ecological	Dudas	Kieran, Fu(?), Littles(?), Chen(?)
4b. Economic	Lew	Magnusson, Li, Wakamatsu(?)
4c. Sociocultural	Leong	Nakachi, Sugimoto
5. Case study – Aquaculture	??	Lew, Su, Wakamatsu(?), maybe S. Korea (TBD), Magnusson, Dudas(?)
6. Discussion	Lew	Dudas, Leong
7. Conclusion	Lew	