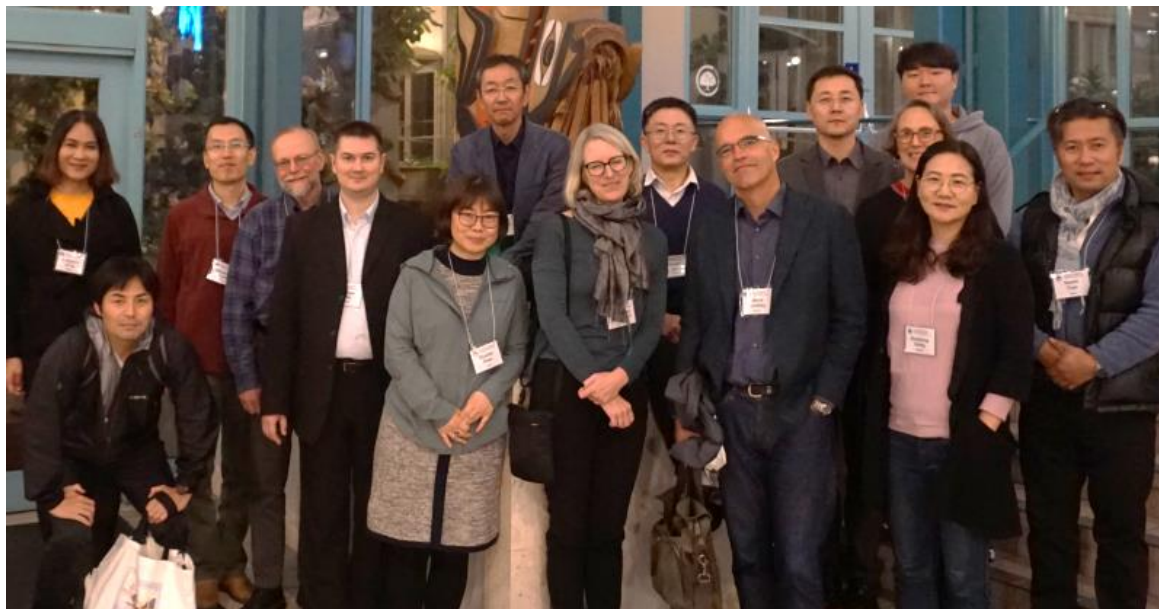


Report of the Fishery Science Committee

The meetings of the Fishery Science Committee (FIS) were held on Sunday, October 20 (18:00–20:00) and Wednesday, October 23, (14:00–18:00), 2019 in Victoria, Canada. FIS Chair Dr. Xianshi Jin called the meeting to order and welcomed members and observers (*FIS Endnote 1*). All members in attendance introduced themselves and absent members were noted. The draft agenda was reviewed by the participants and was adopted without revisions (*FIS Endnote 2*). Dr. Jacquelynne (Jackie) King volunteered to be rapporteur.



Participants at the FIS Committee meeting, PICES-2019. From left: Sukgeun Jung, Nobuaki Suzuki, Qingshan Luan, Gordon Kruse, Vladimir Kulik, Xiujuan Shan, Toyomitsu Horii, Elizabeth (Libby) Logerwell, Xianshi Jin, Steve Lindley, Zhuojun Ma, Jackie King, Hyunjoo Lee (back), Sukyung Kang, Naoki Tojo.

AGENDA ITEM 3

Changes to FIS membership

- Dr. Anya Dunham (Canada) stepped down as member;
- Dr. Toyomitsu Horii (Japan) is a new member, replacing Dr. Masahito Hirota who stepped down.

AGENDA ITEM 4

Volunteers for ECS Award Committee for PICES-2019

- Best Oral Presentation Award for an early career scientist in a FIS-sponsored Topic Session: Gloria S. Duran (Agraria La Molina National University, Lima, Peru), “*Spatiotemporal interannual variabilities of swordfish catch in relation to fronts and eddies in the Northwestern Pacific*” in FIS/POC/BIO/HD Topic Session (S11) on “*Incorporating ecosystem variability and climate change into fisheries management: Progress and challenges for EBFM in the 21st century*” (Judges: Dr. Steve Lindley and Dr. Sukyung Kang);
- Best Poster Award to an early career scientist in a FIS-sponsored Topic Session/Workshop: Kei Nakaya (Kagoshima University, Japan), “*Early life history of Japanese horse mackerel *Trachurus japonicus* in the north Satsunan area, southern Japan*” in FIS Paper Session (Judge: Dr. Gordon Kruse)

AGENDA ITEM 5

Reports from FIS workshops

1. PICES-2019 FIS Paper/Topic Sessions and Workshops

FIS sponsored/co-sponsored:

- A ½-day FIS contributed Paper Session;
- A 1-day Topic Session (S8): *Creating more effective Integrated Ecosystem Assessments (IEAs) in PICES countries*;
- A 1½-day Topic Session (S11): *Incorporating ecosystem variability and climate change into fisheries management: Progress and challenges for EBFM in the 21st century*;
- A 1-day Workshop (W2): *Integrating biological research, fisheries science and management of Pacific halibut and other widely distributed fish species across the North Pacific in the face of climate and environmental variability*;

Dr. Josep Planas (IPHC) provided a report on W2, the 1-day workshop (October 18) co-sponsored by IPHC. Co-convenors included Josep Planas, Gordon Kruse (USA), Chris Rooper (Canada), Roman Novikov (Russia) and Naoki Tojo (Japan). The workshop was attended by 45 participants, with 3 Invited Speakers, 13 oral presentations and 8 posters. The workshop covered biology, management, bycatch. Selected papers from the workshop will be submitted for a Special Issue of *Fisheries Research* for publication at the end of 2020. Submissions opening: November 1, 2019; closing July 1, 2020.

There is interest in creating a Joint PICES/IPHC Working Group, to address emerging issues on key fish species with broad distribution across the entire North Pacific Ocean through integrative approaches. A proposal for a Study Group will be submitted at PICES-2020 linked to a proposal for workshop on “*Integrating biological research, fisheries science and management of broadly distributed flatfish species across the North Pacific Ocean in the face of climate and environmental variability*” that was submitted at PICES-2019.

- A ½-day Workshop (W3): *Let’s play the GAME! (to achieve sustainable fisheries development in the PICES regions)*
No oral report was presented.
- A ½-day Workshop (W11): *PICES/NPFC collaborative research: The influence of environmental changes on the potential for species distribution shifts and population dynamics of Pacific saury*
Dr. Chris Rooper (Canada) presented a report on W11, October 16. The 1-day workshop was convened by Chris Rooper (Canada), Eddy Kennedy (Canada), Kazuhiro Oshima (Japan), Vladimir Kulik (Russia), Yong Chen (USA), Chih-hao Hsieh (Chinese Taipei).

The workshop was a result of a Joint PICES/NPFC Study Group for *Scientific Cooperation in the North Pacific Ocean [framework](#)* for enhanced scientific collaboration in the North Pacific. The workshop covered three topics, had 3 Invited Speakers for a total of 9 speakers, and 2 discussion sessions. The collaborative nature of the workshop allowed for a greater exchange of research ideas and consideration of ecosystem impacts between the two organizations than the usual NPFC stand-alone stock assessment meetings.

Recommendations from the workshop include:

- 1) There should be further studies and analyses to build on the empirical relationship that have been identified to determine mechanistic processes controlling the distribution and abundance of Pacific saury;
- 2) Environmental relationships should be explored in future stock assessments for Pacific saury;
- 3) Research to link projections under different climate change scenarios and hindcasts of regional ocean models to projections of Pacific saury abundance should be undertaken;

- 4) Analyses should consider the impacts of the environment on setting biological reference points and harvest control rules for Pacific saury.

In support of progress on Recommendation 3), a 1-day Topic Session on “*Environmental variability and small pelagic fishes in the North Pacific: exploring mechanistic and pragmatic methods for integrating ecosystem consideration into assessment and management*” was submitted for PICES-2020. The proposal requests FIS sponsorship with anticipation that NPFC will jointly support this session at their annual meeting in July 2020.

- A 2-day Workshop (W16): *Developing a collaborative, integrated ecosystem survey program to determine climate/ocean mechanisms affecting the productivity and distribution of salmon and associated pelagic fishes across the North Pacific Ocean.*

Dr. Vladimir Radchenko (NPAFC) gave a report on this 2-day Workshop. It was convened by Mark Saunders (Canada), Hal Batchelder (PICES), Dick Beamish (Canada), Ed Farley (USA), Suam Kim (Korea), Chrys Neville (Canada), Evgeny Pakhomov (Canada), Shigehiko Urawa (Japan), Laurie Weitkamp (USA) and Alex Zavalokin (NPFC). The primary focus of the workshop was to review preliminary results from the March 2019 high seas expedition for Pacific salmon biology and distribution in the central Gulf of Alaska. Some presentations and discussion focused on planning a February 2021 five-nation follow-up survey across the North Pacific. In support of one of the recommendations of the workshop, a proposal for a Topic Session on “*Implementing a collaborative, integrated ecosystem high seas survey program to determine climate/ocean mechanisms affecting the productivity and distribution of salmon and associated pelagic fishes across the North Pacific Ocean*” was submitted for PICES-2020 to present final results from the 2019 expedition.

AGENDA ITEM 6

Status reports from FIS-sponsored expert groups

- a) WG 34: Joint PICES/ICES Working Group on *Ocean Conditions and the Distribution and Productivity of Highly Migratory Fish*

Dr. Barbara Muhling (USA) has taken over from Dr. Gerard DiNardo (USA) as Co-Chair as of June 2019. The Working Group co-convened a 1½-day Topic Session (S11) (EBFM) at PICES-2019. This Working Group was extended for 1 year, to October 2019 to complete its final report (see **FIS Endnote 3** for list of achievements). The draft final report is complete and was circulated to WG 34 for comments. The final report is anticipated to be about 12 pages, with Appendices and will likely be handed to the FIS Committee by the end of November 2019. Dr. Jin will provide primary feedback on revisions.

- b) S-CCME: Joint PICES/ICES Section on *Climate Change Effects of Marine Ecosystems*

Dr. King (Canada) is Co-Chair of S-CCME and provided an update on the 2019 activities completed and those planned for 2020.

- Dr. Shin-ichi Ito (Japan) completed his second term as Co-Chair. S-CCME elected Dr. Xiujuan Shan (China) as new Co-Chair. Within ICES, both Co-Chairs, Myron Peck (Germany) and John Pinnegar (UK), completed their second terms. So far, only one replacement Co-Chair, Christain Möllmann (Germany) has been identified.
- At PICES-2019, S-CCME supported the proposal for Joint ICES/PICES Working Group Working Group on Impacts of Warming on Growth Rates and Fisheries Yields (WG-GRAFY). Additionally, S-CCME members identified climate change impacts on aquaculture as an important issue to S-CCME and to the host nation of PICES-2020. S-CCME members proposed a Topic Session on this topic (*Impacts of climate change on aquaculture*) for PICES-2020.

- S-CCME noted that this is the second year with no Russian member available to attend the S-CCME meeting. There is currently only one Russian member in S-CCME (from POC). S-CCME requests a Russian member from either BIO or FIS be added to the Section.
- In 2020, S-CCME will draft a Phase IV Implementation Plan (2021–2023). However, S-CCME requests that instead of Plans having a 3-year phase, that it be granted a 5-year phases (*i.e.*, Phase IV from 2021–2025) as the frequent need to meet inter-sessionally to develop an IP is overtaxing. For the upcoming Phase IV planning, S-CCME should include a colleague involved in FishMIP and a colleague involved in CMIP6 in order to link to their efforts. S-CCME request a 1-day meeting following the MSEAS 2020 Symposium (May 25–29, 2020, Yokohama Japan). There will be several S-CCME members and FishMIP and CMIP6 colleagues attending MSEAS 2020.
- S-CCME requests ½-day meeting at PICES-2020.

AGENDA ITEM 7

Reports from other organizations and programs

ESSAS (Ecosystem Studies of the Subarctic and Arctic Seas) program

Dr. Franz Meuter provided an overview of ESSAS, an ecosystem-based IMBeR program. ESSAS is comprised of four Working Groups: Paleo-ecology of Subarctic Seas; Bioenergetics of Arctic and Subarctic Fishes; Natural Analogues of an Arctic in Rapid Transition; Human Dimension.

ESSAS requests \$7.5K support from PICES for their 2020 Annual Meeting (June 1–3, 2020, Hokkaido University, Sapporo, Japan). The support will help with student and early career scientist travel to the meeting. At that meeting there will be a forum for open discussion between scientists and stakeholders from local Japanese government agencies, companies and NGOs with an interest in the Arctic. The products of the forum are directly relevant to FIS and HD Committees, FUTURE, WG 39 and the proposed Working Group on Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea the Bering-Chukchi LME.

Recommendation: FIS recommends support for the ESSAS Annual Meeting.

AGENDA ITEM 8

Expert group proposals

1) Working Group on Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi (IEA-NBS)

Co-Chairs: Libby Logerwell (USA), Yury Zuenko (Russia)

This Working Group has been suggested based on recommendations from the PICES-2019 Workshop (W17) “*Scoping an IEA of Northern Bering-Chukchi Seas LME*” where 19 participants from Canada, China, Japan, Russia and USA discussed and agreed to propose the new Working Group. ICES, IASC, NOAA IEA, PAME, Arctic Council and Bering Sea Elders Group have all expressed support for this Working Group. See *FIS Endnote 4*.

The output of this Group will be of interest to all PICES member countries: in the Russian and US EEZ; China, Japan, and Korea are interested for teleconnections to fisheries migratory species and pollution. The Working Group Terms of Reference supports the FUTURE Science Plan, specifically: How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future? How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems? With ocean warming and loss of the sea ice, the traditional PICES border will extend northward and connect to the Arctic. This complements WG 39 (Joint PICES/ICES/PAME Working Group on *Integrated Ecosystem Assessment for the Central Arctic Ocean*), which focuses on a separate yet

adjacent geographical area. Pending approval by Science Board and Governing Council, this Working Group requests a 1-day meeting at PICES-2020 and a 1-day inter-sessional meeting in late summer 2020.

Recommendation: FIS supports this Working Group proposal and agrees to serve as a Parent Committee.

2) *Joint ICES/PICES Working Group on Small Pelagic Fish (WG-SPF)*

Parent Committee: FIS

This Working Group was approved by ICES at SCICOMM in September 2019.

Two topic sessions on small pelagic topics are proposed for PICES-2020 in addition to this Working Group. An additional workshop proposal was submitted by NPFC, and NPFC will have linkages to this proposed WG (see *FIS Endnote 5*). It should be ensured that there is an NPFC member appointed to the membership, even if it is not a formal joint PICES/ICES/NPFC expert group, since they have great expertise to offer. Pending approval by Science Board and Governing Council, this Working Group requests a 1-day meeting and ½-day Workshop at PICES-2020. Mirror meetings and workshop will occur at ICES ASC 2020, and FIS Committee requests PICES support for one PICES scientist to attend ICES 2020 ASC.

Recommendation: FIS supports this Working Group proposal and agrees to serve as a Parent Committee.

Requests:

- FIS requests support for one PICES scientist to attend the mirror meeting and workshop at ICES ASC 2020;
- Pending Science Board/Governing Council approval, the WG requests \$7K to kick off the WG at a spring inter-sessional meeting in 2020.

3) *Joint ICES/PICES on Working Group on Impacts of Warming on Growth Rates and Fisheries Yields (WGGRAFY)*

Parent Committee: FIS

The Working Group was approved by ICES at SCICOMM in September 2019.

S-CCME supported this Working Group (see *FIS Endnote 6*) at its meeting on October 20, 2019, and S-CCME member Shin-ichi Ito (Japan) agreed to serve as Co-Chair, while S-CCME member Sukgeun Jung (Korea) agreed to join the Working Group as a member. The WG will conduct most meetings in conjunction with PICES/ICES annual meetings, or other opportunistic international meetings.

The FIS Committee noted that the growth (length-at-age) portion is best developed. The portion of the project dealing with fish productivity seems reliant on changes in size-at-age alone in a yield-per-recruit (Y/R) analysis. FIS noted that climate change that is strong enough to result in changes in growth might also be strong enough to result in changes in mortality, another key factor in Y/R analysis (and fish productivity). Moreover, such climate change may also result in changes in recruitment itself, which is not addressed in Y/R analysis. The proponents of the Working Group were requested by FIS to include these additional factors in the Terms of Reference. Pending approval by Science Board and Governing Council, this Working Group requests a 1-day meeting at PICES-2020.

Recommendation: FIS supports this Working Group proposal and agrees to serve as a Parent Committee.

Request: FIS requests support for one PICES scientist to attend the WG meeting at ICES ASC 2020.

4) *Study Group on Correlating Habitats using Artificial Intelligence, Numerical Models and Gathered Empirical Data (SG-CHANGE)*

Reporting to: Science Board

This proposal (see Science Board report) was developed as a follow-up to PICES 2019 Workshop (W15) on “*Application of machine learning to ecosystem change issues in the North Pacific*”. It could link to the ICES Working Group on Machine Learning in Marine Science (WGLEARN). Dr. Sukgeun Jung volunteered to find Korean member to join the Study Group. If approved, the Study Group would meet through bimonthly conference calls, but the FIS Committee cautioned that reliance on trans-Pacific conference calls would require extensive follow up by email. Additionally, the FIS Committee noted that there were too many members identified, particularly from Canada, and that the list be narrowed to 1 to 2 members from each PICES member country.

Recommendation: FIS supports this Study Group proposal

5) *SCOR-sponsored Summer School*

- SCOR Summer School: Changes in coastal upwelling systems and their impact on marine resources
- Proposed by Dr. Ryan Rykaczewski
- Proposed Dates: May 4–12, 2020 (9 days)
- Location: Dakar, Senegal
- Additional targeted sponsors are SCOR, NSF, IRD, Senegal Department of Higher Education, Senegal Environmental Department, IMBeR, ICTP, ECLAIRS, IOC/UNESCO, ICES, SFB, CNRS, EGU, SOLAS, OA (Monaco), OCB, National Funds (Peru), NRF (South Africa), TWAS, TARA, and the Nippon Foundation
- Resources requested from PICES: \$5,000 USD travel support for an early career scientist(s) to attend.

FIS made no recommendation due to lack of time to discuss.

AGENDA ITEM 9

Topic sessions and workshops for PICES-2020

Due to a lack of time, the FIS Committee identified only those Topic Sessions and Workshops that were of interest to FIS, particularly for co-sponsorship.

FIS gave highest priority for the following:

1. Topic Sessions:

- Proposal 5: *Environmental variability and small pelagic fishes in the North Pacific: exploring mechanistic and pragmatic methods for integrating ecosystem considerations into assessment and management*

FIS Committee noted that there were two additional proposals, but for workshops, on pelagic fish (W6 and W7). FIS Committee felt three proposals, along with a Working Group proposal, indicated that small pelagic fish is a topic of great interest to PICES scientists. In order to maximize impact across Workshops and Topic Sessions, the FIS Committee recommended one of each. Since W7 is in support of a new Working Group, that workshop was selected. As such, W6 (Pelagic and forage species) could be combined with S5.

- Proposal 11: *Impacts of climate change on aquaculture*

This was proposed by S-CCME and would be of interest to PICES-2020 host nation. FIS Committee ranks this as a high priority.

- Proposal 15: *Integrating biological research, fisheries science and management of broadly distributed flatfish species across the North Pacific Ocean in the face of climate and environmental variability*

This will be a good workshop that may lead to developing a Working Group on flatfish. W2 on halibut was well attended at PICES-2019. Flatfish facilitate cooperation internationally and are of interest to all PICES member countries.

- Proposal 16: *Species migration and shifts responding to climate change: linking physics, plankton dynamics and fish ecology*

The Topic Session on “*Management and conservation of species on the move*” was heavily attended at [ECCWO-4](#) in 2018, so it is a topic of great interest. The description was a bit too short, so it was difficult to assess. The abstract needs to expand to species distribution shifts to get at what the title seems to be attempting.

2. Workshops:

- W3: *Can we link zooplankton production to fisheries recruitment?*

Should be co-sponsored by BIO. FIS Committee ranked this as a high priority.

- W6: *Pelagic and forage species – predicting response and evaluating resiliency to environmental variability*

FIS Committee suggests that this workshop be combined with S5 (*Environmental variability and small pelagic fishes*) and be retained as a Topic Session.

- W7: *Research priorities for understanding the population dynamics of small pelagic fish in the North Pacific*

This Workshop was requested by the anticipated FIS WG on Small Pelagic Fish.

The FIS Committee noted that the current set-up for the online ranking system is misleading to have a column with the membership in Expert Groups for the person proposing the topic session or workshop. There is no indication what Committee is being asked to sponsor the session or workshop, and the membership of the person proposing the session or workshop.

Request: revise the format for PICES-2021 online submissions to add a field for what committee the session/workshop is directed to, and delete the affiliation of the person who is proposing the session/workshop.

FIS was provided a list of theme sessions for potential PICES co-sponsorship at ICES ASC 2020. FIS gave the highest ranking to:

1-*Top predators, food webs, and ecosystem-based fisheries management;*

2-*Biomass, biodiversity, ecosystem services and potential fisheries in the mesopelagic zone.*

AGENDA ITEM 10

FIS Committee Action Plan

The FIS Committee discussed the need for an Action Plan. Many members did not even know that it existed, and it has not been used the past 4 years as a source of ideas or support for workshops, topic sessions or Expert Group decisions. The FIS Committee finds the bottom-up suggestions from scientists for workshops, topic sessions or Expert Groups to be preferable than the Committee soliciting or ranking based on an Action Plan that has detailed tasks. FIS Committee suggests that instead of an Action Plan, we develop a Mission Statement and Terms of Reference (which we can revisit each year to ensure they are still relevant).

AGENDA ITEM 10

Other business

PICES should offer teleconference or WebEx options for Committee Business Meetings when members cannot attend in person due to last minute emergencies or due to visa issues. It would also be useful to have a list of alternate members that can step in for official members.

FIS Endnote 1

FIS participation list

Members

Xianshi Jin (China, Chair)
Jacquelynne (Jackie) King (Canada, Vice-Chair)
Toyomitsu Horii (Japan)
Sukgeun Jung (Korea)
Sukyung Kang (Korea)
Gordon Kruse (USA)
Vladimir Kulik (representing Russia)
Steve Lindley (USA)
Elizabeth Logerwell (USA)
Zhuojun Ma (China)
Nobuaki Suzuki (Japan)
Naoki Tojo (Japan)

Members unable to attend

Canada: Anya Dunham
China: Jie Kong
Korea: Jaebong Lee
Russia: Elena P. Dulepova, Alexander I. Glubokov,
Mikhail A. Stepanenko

Observers

Hyunjoo Lee (Korea)
Qingshan Luan (China)
Xiujuan Shan (S-CCME Co-Chair)
Josef Planas (IPHC)
Vladimir Radchenko (NPAFC)
Chris Rooper (USA)

FIS Endnote 2

FIS meeting agenda

Sunday, October 20, 18:00–20:00

1. Introductions and adoption of agenda
2. Nomination of a rapporteur
3. Changes to FIS membership
4. Volunteers for ECS Award for PICES-2019
5. Reports from FIS workshops

Wednesday, October 23, 14:00–18:00

6. Status reports from FIS-sponsored expert groups
7. Reports from other organizations and programs
8. Expert group proposals
9. Topic sessions and workshops for PICES-2020
10. FIS Committee Action Plan
11. Other business

FIS Endnote 3**Joint PICES/ISC Working Group (WG 34) on Ocean Conditions and the Distribution and Productivity of Highly Migratory Fish achievements**

Term: October 2015–October 2019 (extended at PICES-2018 – Decision 2018/S/4)

Achievements with respect to workshops/sessions

- FIS Workshop W4: “*Methods relating oceanographic conditions to the distribution of highly migratory species*”. PICES-2016, San Diego, United States.
- FIS Workshop W3: “*Linking oceanographic conditions to the distribution and productivity of highly migratory species and incorporation into fishery stock assessment models*”. PICES-2017, Vladivostok, Russia;
- WG members had presentations at the PICES/ICES/IOC/FAO 4th Symposium on “*The effects of climate change on the world’s oceans*” (ECCWO-4; June 4–8, 2018; Washington, DC, USA);
- FIS Topic Session S12: “*Applying ecosystem considerations in science advice for managing highly migratory species*”. PICES-2018, Yokohama, Japan;
- FIS/POC/BIO/HD Topic Session S11: “*Incorporating ecosystem variability and climate change into fisheries management: Progress and challenges for EBFM in the 21st century*”. PICES-2019, Victoria, Canada.

Achievements with respect to [Terms of Reference](#)Term of Reference #1

- **Muhling B. A.**, Brodie, S., Jacox, M., Snodgrass, O., Dewar, H., Tommasi, D., Edwards, C. A., Xu, Y., Snyder, S., and Childers, J. (2019) Dynamic habitat use of albacore and their primary prey species in the California Current System. *Calcofi Reports* 60.
- Runcie, R. M., **Muhling, B. A.**, Hazen, E. L., Bograd, S. J., Garfield, T., and **DiNardo, G.** (2019). Environmental associations of Pacific bluefin tuna (*Thunnus orientalis*) catch in the California Current system. *Fisheries Oceanography* 28: 372–388.

Term of Reference #4

- **Muhling, B. A.**, Tommasi, D., Ohshimo, S., Alexander, M. A., and **DiNardo, G.** (2018). Regional-scale surface temperature variability allows prediction of Pacific bluefin tuna recruitment. *ICES Journal of Marine Science*, 75(4), 1341–1352.

Term of Reference #7

- Publish a final report summarizing the results of the WG as a PICES Scientific Report.

FIS Endnote 4**Proposal for a new Working Group on Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea (IEA-NBS)**

Reporting to: BIO, FIS, HD, POC, and/or FUTURE

Term: Nov. 2019- Nov. 2022

Linkage(s) to previous PICES Expert Groups or activities (if any):

Complements other current or recent past PICES Expert Groups

- WG39 Joint PICES/ICES/PAME Working Group on Integrated Ecosystem Assessment for the Central Arctic Ocean
- WG 35 North Pacific Ecosystem Status Report
- WG 19 Ecosystem-based management science and its application to the North Pacific

- WG 28 Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors
- S-CCME Climate Change Effects on Marine Ecosystems
- S-MBM Marine Birds and Mammals

Complements WG 39 (WGICA)

This project would complement, not duplicate, the work of WG39 IEA of the Central Arctic Ocean (CAO). The two projects do not overlap geographically. The CAO is LME 13 in the map above, and the Northern Bering Sea – Chukchi Sea is LME 12. It is true that the WGICA considers adjacent shelf systems such as the Chukchi Sea to the extent that ocean currents and migratory species cross from the shelf to the CAO basin. But the WGICA does not explicitly examine all components and processes in adjacent shelf areas. An IEA of the Northern Bering Sea – Chukchi Sea LME would complement the IEA of the CAO by providing better resolution and understanding of the processes that drive currents and migratory species into the CAO. As an inflow shelf, the Chukchi Sea provides essential sources of nutrients, freshwater and heat to the Arctic Ocean, affecting processes in adjacent shelf systems as well as the deep basin.

This project has some unique features that further distinguish it from WG39. Compared to the CAO, there is a wealth of scientific knowledge in the Northern Bering-Chukchi LME. These data come from surveys of oil and gas lease areas, studies of whale foraging areas, groundfish assessment surveys, oceanographic and plankton surveys and Integrated Ecosystem Surveys. In addition, there are a number of indigenous Alaskan and Russian communities that are ready and interested in providing specialized Indigenous and Traditional Knowledge unavailable from other sources about characteristics and changes of the Northern Bering – Chukchi Sea LME.

The Northern Bering – Chukchi LME is a relatively shallow, shelf system and is therefore expected to have different key elements and processes from the deep basin of the Central Arctic Ocean. Each project will also carry forward different management implications from the knowledge gained. One key difference with management implication is that the CAO is largely outside the EEZs of the Arctic nations, whereas the Northern Bering-Chukchi LME is in the US and Russian EEZs.

In addition, PICES countries are engaged through the Arctic Observing Network (AON), the Sustaining Arctic Observing Networks (SAON) and the Arctic Observing Summit (AOS).

Linkage(s) to other organizations and programs (if any):

- Co-sponsoring Organizations
- ICES (TBC; support has been expressed)
- IASC (TBC; support has been expressed)
- NOAA IEA (TBC; support has been expressed)
- Protection of the Arctic Marine Environment (PAME), Arctic Council (TBC; support has been expressed)
- Bering Sea Elders Group
-
- A preliminary list of potential partners for this Working Group:
- Alaska Seagrant – Nome office
- Arctic Monitoring and Assessment Programme, AMAP (Arctic Council)
- Arctic Marine Biodiversity Observing Network (AMBON)
- Arctic Observing Summit
- Arctic Observing Network (AON)
- Association of Village Council Presidents (AVCP) and associated Federally recognized Tribes
- Bering Sea Elders Group
- Conservation of Arctic Flora and Fauna, CAFF (Arctic Council)
- Distributed Biological Observatory (DBO)
- Ecosystem Studies of Subarctic and Arctic Seas (ESSAS)
- Interagency Arctic Research Policy Committee (IARPC)
- International Arctic Science Committee (IASC)

- Inuit Circumpolar Council (ICC)
- Kawerak, Inc. and associated Federally recognized Tribes
- Maniilaq Association and associated Federally recognized Tribes
- National Park Service – Kotzebue and Nome regions; Berengia
- Native Village of Kotzebue
- Northwest Arctic Borough
- North Slope Borough Department of Wildlife Management
- Oceans North
- Pacific Arctic Group (PAG)
- The Pew Charitable Trusts
- Protection of the Arctic Marine Environment, PAME (Arctic Council)
- S-CCME (PICES)
- Sustaining Arctic Observing Networks
- United Nations FAO
- University of Alaska International Arctic Research Center (IARC)
- Western Alaska Landscape Conservation Cooperative
- World Wildlife Fund (WWF)
- Co-management entities (Eskimo Walrus Commission, Ice Seal Committee, Beluga Committee, Alaska Eskimo Whaling Commission, Kuskokwim Intertribal Fisheries Commission; Migratory Bird Commission)

In addition, this project provides an opportunity to partner with Arctic peoples to apply multiple knowledge sources towards evaluating future impacts, risk, and adaptation measures in a changing Arctic.

Linkage/Contributions to the FUTURE program (if any):

Supports the FUTURE Science Plan

An Integrated Ecosystem Assessment can help address two of FUTURE research themes: How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future? How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems? With ocean warming and loss of sea ice the traditional PICES area of interest in the Bering Sea is being extended northward and becoming more connected to the Arctic north of Bering Strait.

Motivation and Goals and/or Background

Prolog

This proposal is the result of W17 “Scoping an IEA of the Northern Bering-Chukchi Seas Large Marine Ecosystem (LME)”, held October 16, 2019. The workshop was chaired by Libby Logerwell (USA), Kirstin Holsman (USA), Raychelle Daniel (USA, The Pew Charitable Trusts) and Yutaka Watanuki (Japan). There were 19 attendees representing PICES member nations (USA, Japan, Russia, China and Canada), partner organizations (ICES and IASC), funding agencies (North Pacific Research Board), international collaborators (IMR Norway) and Indigenous organizations (Bering Sea Elders Group). Plenary and breakout group discussions accomplished an effective scoping of an Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea LME. The scoping entailed:

- Review of recent research, scope of Indigenous Knowledge available, activities and priorities related to an IEA of Arctic Ecosystems;
- Review of the scientific interest, community interest, data availability and overall feasibility of conducting such an IEA for the Northern Bering-Chukchi Sea region;
- Assessment of the opportunities to partner with other organizations to address the issues identified above.

The participants of the workshop unanimously agreed to pursue a new Working Group to conduct an Integrated Ecosystem Assessment of the Northern Bering Sea – Chukchi Sea (NBS-CS) LME. In particular, participants from WG39 (WGICA) on the Central Arctic Ocean, PAME, and ICES, noted that:

- A PICES WG on the Northern Bering-Chukchi Sea region would provide detailed assessment of the Pacific Arctic gateway, and would be a complement to the Atlantic gateways IEAs supported through ICES, all of which are linked through the PICES Central Arctic Ocean WG.
- It would also provide detailed information that will inform understanding of connectivity of climate and ocean processes, species movements, shelf foodweb dynamics, fishing, trade, subsistence and food security, and human activities beyond the focal scope of WG39/WGICA but of critical importance to the CAO (and therefore identified as a needed component of future analyses).
- In turn a PICES WG on the NBS-CS would be informed by the findings of WG39/WGICA beyond the scope of the new WG but of increasing importance, especially for the NBS where multiple Pacific stocks are increasingly redistributing poleward under warming conditions.

Background

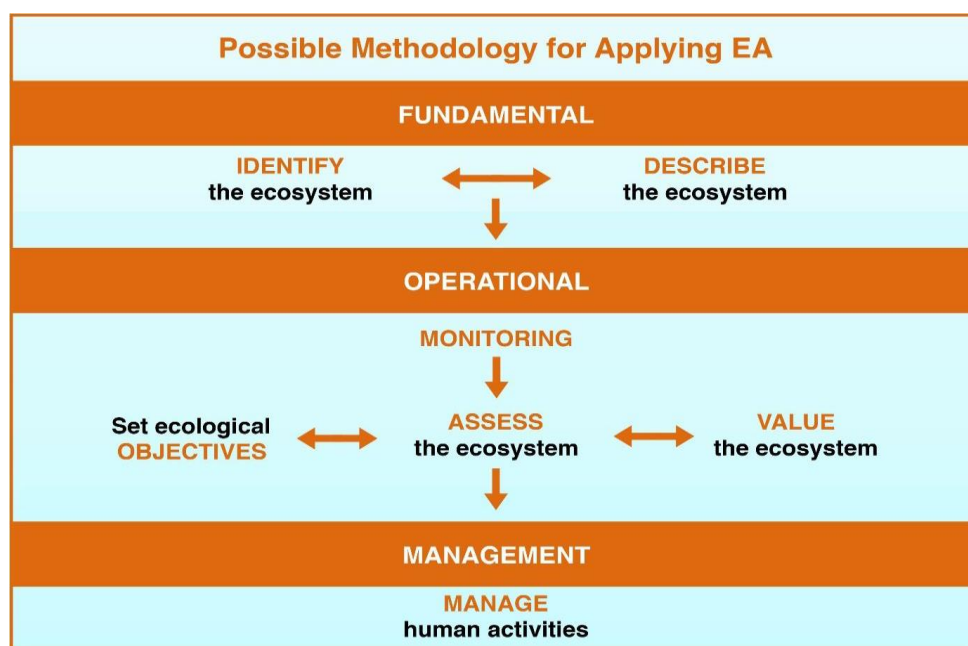
Why now?

The Northern Bering Sea-Chukchi Sea (NBS-CS) region is experiencing unprecedented ocean warming and loss of sea ice as a result of climate change. Seasonal sea ice declines and warming temperatures have been more prominent in the northern Bering and Chukchi seas as almost all other portions of the Arctic. Chronic and sudden changes in climate conditions in this Arctic gateway are increasingly impacting marine species and food-webs and expanding opportunities for commercial activities (shipping, oil and gas development and fishing), with uncertain and potentially wide-spread cumulative impacts. There are strong concerns about the impacts of climate change and industrial activities, and these impacts may be particularly pronounced in Arctic indigenous communities dependent on the health and stability of the ecosystem. The combination of unprecedented, rapid change and increased interest in the Arctic in general and the NBS-CS specifically make this an opportune time for a synthesis of issues and knowledge. An Integrated Ecosystem Assessment (IEA) can accomplish this synthesis.

Conceptual frameworks

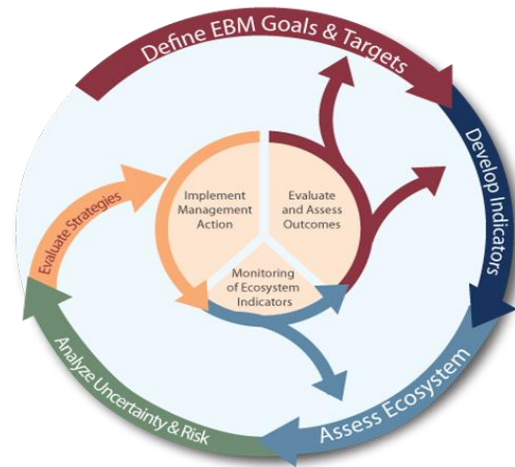
Arctic Council Protection of the Marine Environment (PAME) Ecosystem Approach

The Arctic Council has developed a framework for implementation of the Ecosystem Approach to management (EA) of human activities in Arctic marine and coastal environments. The EA framework consists of six related elements (see figure). While they are numbered, the elements do not necessarily need to be sequential although they are eventually linked in an iterative and adaptive operational management cycle. Monitoring is an essential component of EA as illustrated in the schematic representation of the framework.



Integrated Ecosystem Assessment.

Integrated Ecosystem Assessments (IEA) synthesize understanding regarding all components of an ecosystem, including humans, to inform the decision-making process and provide Ecosystem- Based Management advice. While IEAs are policy relevant they are not policy prescriptive. A key element of each step of the IEA process (see figure) is collaboration and co-production of knowledge. IEAs can be useful for coordinating synthesis, consideration of multiple perspectives, informing management decisions, and evaluating tradeoffs, risk, and cumulative impacts.



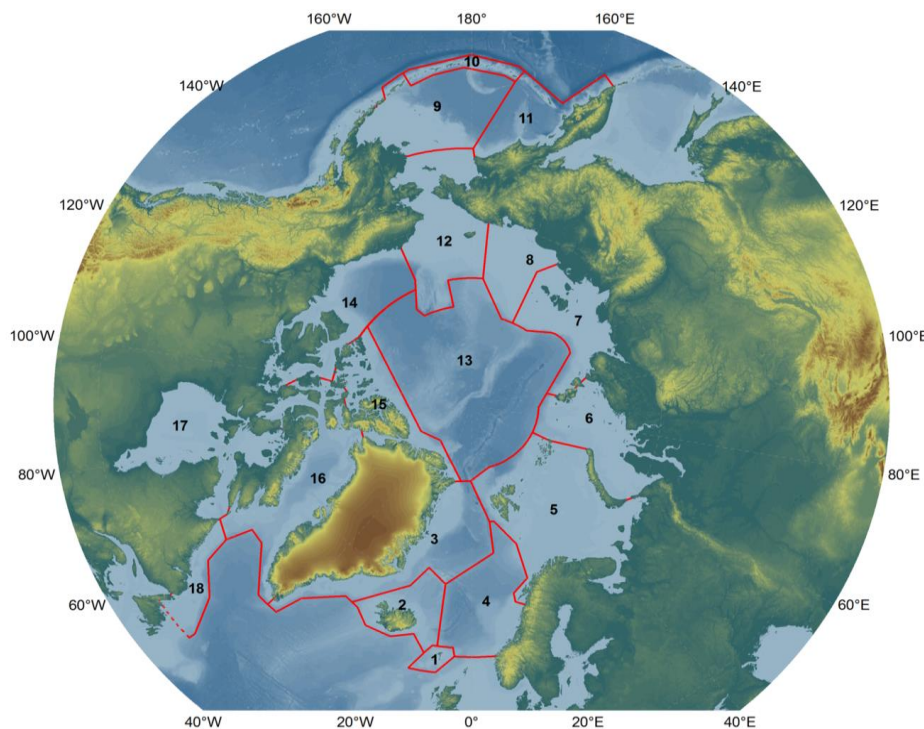
Indigenous Peoples Knowledge Systems and the co-production of knowledge approach

A strong theme in discussions at EA workshops is that Indigenous Peoples knowledge systems are important to different aspects of EA from developing guidelines to implementing the approach. Another recurring theme is the importance of communication, participation and inclusivity. EA benefits from including rightsholders, knowledge and stakeholders in the different stages of the process. This includes co-production of knowledge, which can provide a more comprehensive and holistic understanding of the Arctic ecosystems and the changes that are occurring. An inclusive process will help build interest, expand participation and create settings for those who live and operate in the Arctic to be part of the EA process. “Communicate and engage early and often” is the message from Indigenous Peoples and local Communities.



The Northern Bering Sea – Chukchi Sea LME

The 18 LMEs in the Arctic (see figure) provide a delineation and boundaries, which are useful for implementation of the EA in the Arctic. The LME boundaries define areas of coherent ecological and geophysical processes and provide an appropriate scale for assessing the structural and functional integrity of ecosystems, including the separate and cumulative impacts of human activities. The Northern Bering Sea – Chukchi Sea LME that is the focus of this proposal is Area 12 in the figure below.



Data sets and knowledge available

A preliminary list of the data sets and knowledge potentially available:

<u>Survey</u>	<u>Nation(s)</u>
Aerial Surveys of Arctic Marine Mammals (ASAMM)	US
Arctic Marine Biodiversity Observation Network (AMBON)	US
Arctic Integrated Ecosystem Survey	US
Arctic Ecosystem Integrated Survey	US
Chukchi Sea Acoustics, Oceanography, and Zooplankton (CHAOZ)	US
Chukchi Sea Environmental Studies Program	US
Chukchi Sea Ecosystem Observatory	US
Chukchi Sea Offshore Monitoring in the Drilling Area—Chemical and Benthos study and Hannah Shoal	US
Distributed Biological Observatory	US, Korea, Japan, Canada, Russia, China
K-PORT Project for Understanding and Utilizing Environmental Change in the Polar Regions	Korea, US and Canada
Indigenous Knowledge/Local and Traditional Knowledge	Russia and US
Local Environmental Observer Network	Canada and US
AFSC Groundfish Assessment Program	US
Outer Continental Shelf Environmental Assessment Program	US
Oshoro Maru surveys	Japan
Russian-American Long-term Census of the Arctic (RUSALCA)	Russia and US

Shell Oil and Gas Lease surveys	US
TINRO surveys	Russia
Western Arctic Shelf–Basin Interactions (SBI) Project	US
MV Xue Long (Snow Dragon) surveys	China

Relevance to other integrative and international projects

Fisheries Experts of the Central Arctic Ocean (FisCAO)

Scientific experts on fish stocks in the central Arctic Ocean from the Kingdom of Norway, the United States of America, Canada, the People's Republic of China, the Republic of Korea, Japan, Iceland, the European Union, and the international scientific organizations ICES and PICES, meet on an *ad hoc* basis to develop information supporting diplomatic negotiations to prevent unregulated commercial fishing on the High Seas of the central Arctic Ocean. One of their recent products is a strategy for monitoring indicators of fish stocks and ecosystem components. A key component of the strategy is using existing national programs that monitor adjacent shelf areas (such as the NBS-CS) to provide an early warning of changes in the adjacent CAO that would merit a survey effort in those, international waters. An IEA of the NBS-CS as proposed for this WG could provide such an early warning.

Integrated Ecosystem Assessment of the Northern Bering Sea

The North Pacific Research Board, which funded the recent (2017-2019) Integrated Ecosystem Research Project (IERP), a series of ecosystem at-sea surveys of the Chukchi Sea, will next fund an IERP for the Northern Bering Sea. The IEA of the NBS-CS proposed here can provide information on connectivity between the two IERP regions (NBS and CS). It can also provide a knowledge gap analysis useful for developing the call for proposals and/or evaluating proposed projects.

United Nations Decade of Ocean Science for Sustainable Development (2021-2030)

The United Nations has proclaimed a Decade of Ocean Science for Sustainable Development (2021-2030) to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in creating improved conditions for sustainable development of the Ocean. As mandated by the UN General Assembly, the Intergovernmental Oceanographic Commission (IOC) of UNESCO will coordinate the Decade's preparatory process, inviting the global ocean community to plan for the next ten years in ocean science and technology. Our new WG could contribute to efforts of the science and sustainable develop community to define priorities and plan for the global ocean science agenda, develop new science and technologies needed to achieve the Decade's objectives as well as connect ocean science activities with the 2030 Agenda for Sustainable Development.

Relevance to PICES

Of interest to PICES member countries

An IEA of the Northern Bering – Chukchi Sea LME would obviously be of interest to the US and Russia. Both nations conduct fish assessment and ecosystem surveys in the region; and both have commercial fisheries adjacent to the region. Japan, China and Korea have also been carrying out surveys in the Northern Bering and Chukchi Seas. These nations consider themselves to be stakeholders in the Arctic because of tele-connections to fisheries, migratory seabirds, pollution, loss of sea ice and climate change.

Audience and communication

There will be a diverse audience for the knowledge generated by this WG. We plan to communicate to scientists, communities, NGOs, intergovernmental forums and students (elementary – college). We also plan to communicate to managers although we emphasize that our results can inform management but will not be policy prescriptive.

Supports the FUTURE Science Plan

An Integrated Ecosystem Assessment can help address two of FUTURE research themes: How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future? How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems? With ocean warming and loss of sea ice the traditional PICES area of interest in the Bering Sea is being extended northward and becoming more connected to the Arctic north of Bering Strait.

Terms of Reference:

General Terms of Reference

- Convene an interdisciplinary and international working group membership
- Include Arctic peoples and Indigenous Knowledge systems
- Identify and consult with partners and institutions

Specific Terms of Reference/Timeline

3-year plan

The first activity will be to define the scope of the project (goals, definitions, opportunities). This work was accomplished during Workshop 17. Thus, the product will be a detailed workshop report. Expected completion: December 2019.

Year 1

- Kawerak, Inc. and partner organizations conduct a cultural awareness training workshop for members of the WG
- Determine approach and methodology for conducting an IEA in the Northern Bering – Chukchi Sea LME.
- Compile an inventory of scientific data sets and indigenous knowledge available
- Compile an inventory of institutions and programs active in the region.

Year 2

- Describe the key physical, biological and human elements of the ecosystem
- Develop shared conceptual models including both Indigenous Knowledge and science; and review of hypotheses for ecosystem dynamics
- Identify potential indicators of the above key elements
- Describe the goals & targets
- Describe the objectives & values

Year 3

- Assess ecosystem status and trends
- Identify potential impacts/risks at the LME-scale; and at the local scale with emphasis on human use and Indigenous Knowledge
- Knowledge gap analysis

Extended to 5-year plan

Should PICES and other cooperating organizations support continued work, we anticipate proposing the following for years four, five or beyond:

- More detailed assessment of impacts and risks at local and ecosystem scale
- Description of interactions between local and ecosystem scale
- Development of ecosystem model(s)

Deliverables

Year 1

- Inventory of metadata, knowledge, institutions and programs relevant to the Northern Bering Sea-Chukchi Sea LME. PICES or ICES Report.

Year 2

- Ecosystem description from both Indigenous world views and science (shared conceptual models), indicators and hypotheses. PICES or ICES Report. Contribution to Arctic Report Card and or ecosystem status report.
- Report on Ecological Objectives (co-produced with PAME)
- Report on Ecological Values Workshop (co-produced with PAME)

Year 3

- Integrated Ecosystem Assessment for the Northern Bering Sea-Chukchi Sea LME. PICES or ICES Report. Contribution to NPESR. PAME-AMAP-CAFF Report. Contribution to Arctic Report Card
- Journal articles
- Outreach activities

Audience and communication

There will be a diverse audience for the knowledge generated by this WG. We plan to communicate to scientists, communities, NGOs, intergovernmental forums and students (elementary – college). We also plan to communicate to managers although we emphasize that our results can inform management but will not be policy prescriptive.

Proposed membership:

First Name	Last Name	Country	Institution	Expertise
Matthew	Asplin	Canada	ASL Environmental Sciences Inc.	Physical oceanography
Changun	Xu	China	Third Institute of Oceanography, Ministry of Natural Resources	Fish/fisheries
Taka	Hirata	Japan	Hokkaido University	Biological oceanography
Yutaka	Watanuki	Japan	Hokkaido University	Seabirds
Shigeto	Nishino	Japan	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	Physical oceanography
La	Hyoung Sa	Korea	Korean Polar Research Institute	Zooplankton, acoustics
Kirill	Kivva	Russia	Russian Federal Research Institute of Fisheries and Oceanography	Fish/fisheries
Aleksey	Somov	Russia	Pacific Scientific Research Center	Fish/fisheries
Andy	Whitehouse	USA	NOAA Alaska Fisheries Science Center	Food web modeling
Matthew	Baker	USA	North Pacific Research Board	Fish/fisheries
Lyle	Britt	USA	NOAA Alaska Fisheries Science Center	Fish/fisheries
Lee	Cooper	USA	International Arctic Science Committee; University of Maryland Center for Environmental Science	Benthos
Raychelle	Daniel	USA	The Pew Charitable Trusts	Indigenous/Traditional Knowledge
Lisa	Eisner	USA	NOAA Alaska Fisheries Science Center	Biological oceanography
Megan	Ferguson	USA	NOAA Alaska Fisheries Science Center, Marine Mammal Laboratory	Marine mammals
Jackie	Grebmeier	USA	Pacific Environmental Group; University of Maryland Center for Environmental Science	Benthos
Chris	Harvey	USA	NOAA Northwest Fisheries Science Center	Integrated Ecosystem Assessment
Alan	Haynie	USA	NOAA Alaska Fisheries Science Center	Economics
Mellisa	Heflin	USA	Bering Sea Elders Group	Indigenous/Traditional Knowledge
Kirstin	Holsman	USA	NOAA Alaska Fisheries Science Center	Integrated Ecosystem Assessment
Henry	Huntington	USA		Indigenous/Traditional Knowledge
Katrin	Iken	USA	Arctic Marine Biodiversity Observing Network (AMBON); University of Alaska	Benthos
Kathy	Kuletz	USA	US Fish and Wildlife Service	Seabirds

First Name	Last Name	Country	Institution	Expertise
Carol	Ladd	USA	NOAA Pacific Marine Environmental Laboratory	Physical oceanography
Franz	Mueter	USA	Arctic Marine Biodiversity Observing Network (AMBON); University of Alaska	Fish/fisheries
Eriksen	Elena	Norway	ICES	Integrated Ecosystem Assessment

Proposed Leadership:

Co-chair: Libby Logerwell (USA)

Co-chair: Yury Zuenko (Russia)

FIS Endnote 5**Proposal for a Joint ICES/PICES Working Group on Small Pelagic Fish (WG-SPF)****Group Name:** ICES/PICES Working Group on Small Pelagic Fish (WG-SPF)**Reporting to:** Fishery Science Committee (FIS) and FUTURE Scientific Steering Committee (FUTURE-SSC) within PICES**Term:** November 2019 – October 2022**Linkage(s) to previous PICES Expert Groups or activities**

- PICES Working Group 3 on Dynamics of Small Pelagics in Coastal Ecosystems (<https://meetings.pices.int/members/working-groups/disbanded/wg3>);
- ICES/PICES Symposium on “*Forage fish interactions: Creating the tools for ecosystem-based management of marine resources*”, Nantes, France, November 12–14, 2012;
- PICES/ICES Symposium on “*Drivers of dynamics of small pelagic fish resources*”, Victoria, BC, Canada, March 6–11, 2017.

Linkage(s) to other organizations and programs

- Joint partnership between ICES and PICES: the proposal is simultaneously submitted to both organizations;
- GLOBEC Regional Program on Small Pelagic Fish and Climate Change (SPACC; 1994–2009; <http://www.globec.org/index.php?id=118>);
- FAO General Fisheries Commission for the Mediterranean (GFCM; <http://www.fao.org/gfcm>): Working Group on Stock Assessment of Small Pelagic Species;
- North Pacific Fisheries Commission (NPFC; <https://www.npfc.int/>): Technical Working Group on Pacific Saury Stock Assessment (TWG PSSA) and Technical Working Group on Chub Mackerel Stock Assessment (TWG CMSA);
- UN Decade of the Oceans: The mandate of this joint ICES/PICES activity is relevant to the objectives of the UN Decade of Ocean Science for Sustainable Development and UN Strategic Development Goals (*e.g.*, SDG 14, Life Below Water).

Linkage/Contributions to the the PICES and ICES Strategic Plans

Because small pelagic fish (SPF) are highly valued by society and exhibit variability associated with changes in climate forcing, ecosystem structure, and fishing pressure, efforts to understand their dynamics require an integration of knowledge across oceanographic disciplines. Human society cannot expect to prepare a plan for sustainable development of the oceans unless we can improve our understanding of the largest component of ocean fisheries—the small pelagic fish. Consideration of the dynamics of these species, their sensitivity to exploitation and climate change, and the implications of such changes for the human populations that they support is essential to promote ocean sustainability and guide adaptation. The activities of the proposed joint working group will contribute primarily to the first three of the six goals identified in the [PICES Strategic Plan](#): (1) Foster collaboration among scientists within PICES and

with other multinational organizations; (2) Understand the status and trends, vulnerability, and resilience of marine ecosystems; and (3) Understand and quantify how marine ecosystems respond to natural forcing and human activities (Goals 2 and 3 are similar to the two research themes in the PICES integrative scientific program on Forecasting and Understanding, Trends, Uncertainty and Responses of North Pacific Marine Ecosystems (FUTURE)). The activities of the joint working group also align with at least five of the seven ICES science priorities set in the [ICES Strategic Plan](#), including:

(1) Ecosystem science, (2) Impacts of human activities, (3) Observation and exploration, (4) Seafood production and (5) Conservation and management science.

Motivation and Goals and/or Background

Small pelagic fish (SPF) account for more than 30% by weight of the total landings of marine capture fisheries around the world. They also play an important role in the transfer of energy through mid-trophic levels in marine ecosystems and are key resources for the world's growing aquaculture industry. The oscillations in the populations of SPF are dramatic and cyclical in response to climate variability on multi-decadal time scales. However, mechanisms linking climate variability to population dynamics are still unresolved. Hence, there are many challenges to sustainable use of SPF production. As the population dynamics of SPF display basin-scale teleconnections, synthetic and multidisciplinary studies are required to understand the processes and mechanisms to build predictive capacity.

International collaboration on SPF research was spearheaded by the GLOBEC Regional Program on Small Pelagic Fish and Climate Change (SPACC), launched in 1994 with a workshop in La Paz, Mexico. The SPACC program aimed to understand and predict climate-induced population dynamics of SPF in relation to physical and biological processes and included several major themes: long-term changes in ecosystems, retrospective analyses, comparative population dynamics, reproductive habitat dynamics, and economic implications of climate variability. The SPACC program culminated in 2010 with the publication of its review book. Since then, no international program specific to SPF has been launched, even though SPACC-II visions have been discussed (*e.g.*, Alheit (2010) and van der Lingen *et al.* (2010)). In the following decade, there has been substantial scientific progress made in several ecosystems: different hypotheses of mechanisms of population dynamics of SPF have been proposed, data from long-term monitoring and stock-assessment efforts have accumulated, numerical modelling approaches have progressed, and technologies such as genome analysis have rapidly developed. ICES and PICES co-sponsored a symposium on “*Forage fish interactions: Creating the tools for ecosystem-based management of marine resources*” (Nantes, France, November 12–14, 2012) leading to publication of 12 articles in the *ICES Journal of Marine Science* (Peck *et al.*, 2014). The need for a platform to organize intensive international collaboration was re-confirmed during the PICES/ICES Symposium on “*Drivers of dynamics of small pelagic fish resources*” (Victoria, BC, Canada, March 6–11, 2017). This symposium led to special issues in *Deep-Sea Research Part II* (Alheit *et al.*, 2019; 15 articles) and *Marine Ecology Progress Series* (Alheit and Peck, 2019; 22 articles). The platform for international collaboration will allow the marine science community to more rapidly address challenging goals such as to:

1. Perform a synthesis of mechanisms linking climate variability to population dynamics of SPF among different ecosystems to reconcile various recruitment hypotheses;
2. Gain an holistic, ecosystem-level view of the causes and consequences of fluctuations in SPF populations such as how different factors (physical forcing, trophodynamics, and fishing pressure) interact to control the dynamics of populations;
3. Unite various fields (climate science, oceanography, plankton and fish ecology, quantitative fisheries stock assessment, sociology and economics) to build interdisciplinary approaches to examine SPF in social–ecological systems;
4. Incorporate new monitoring (*e.g.*, environmental DNA) and modelling (*e.g.*, end-to-end) technologies to better understand and manage pelagic ecosystems;
5. Provide projections of the effects of climate change on the distribution and productivity of SPF;
6. Propose strategies to safeguard marine ecosystem services stemming from SPF including conservation concerns related to SPF and their predators.

Terms of Reference

1. To review recent progress on understanding how various drivers (environmental and/or anthropogenic) impact the population dynamics of SPF in different ecosystems and whether and how potential drivers shift with changes in ecosystem state.

2. To create a networking environment for international and multidisciplinary collaboration to foster the establishment of similar study frameworks and comparative analyses of SPF across different social–ecological systems, based on updated time series data sets of climate indices, environmental factors and fisheries biology and ecophysiological information (feeding, growth and survival), and inter-model comparisons. We will form task forces within the joint working group that focuses on these elements across different SPF habitats.
3. To identify, prioritize and coordinate research most needed to advance our knowledge and capacity to predict the population dynamics of SPF at both short (seasonal to inter-annual) and long (decadal to centennial) time scales. To this effort, the joint working group will generate a “perspectives” type report highlighting a few key questions in the dynamics of SPF, why these questions are critical to the research topics, and the opportunities for improvements in our understanding on the issue.
4. To provide recommendations for strategies of marine ecosystem monitoring and fisheries management of SPF which will contribute to sustainable ecosystem-based fisheries management, through biophysical, ecosystem and/or socio–economical models. Recommendations for monitoring and management strategies will be coupled with the research priorities perspectives document generated with ToR#3.
5. To organize a joint ICES/PICES symposium on SPF at regular intervals (*e.g.*, once every 4 years) leading to the publication of findings in special issues of primary journals. Additionally, WG members will propose and convene topic sessions at PICES Annual Meetings and ICES Annual Science Conferences focused on advances in SPF science.

Proposed membership

PICES

Canada

1. Jennifer Boldt (Fisheries and Oceans Canada) [Jennifer.Boldt@dfo-mpo.gc.ca]
2. Francis Juanes (University of Victoria) [juanes@uvic.ca]
3. John Dower (University of Victoria) [dower@uvic.ca]

China

1. Yongjun Tian (Ocean University of China) [yjtian@ouc.edu.cn]

Japan

1. Akinori Takasuka (The University of Tokyo) [atakasuka@mail.ecc.u-tokyo.ac.jp]
2. Sachihiko Itoh (The University of Tokyo) [itohsach@aori.u-tokyo.ac.jp]
3. Motomitsu Takahashi (Japan Fisheries Research and Education Agency) [takahamt@affrc.go.jp]
4. Haruka Nishikawa (Japan Agency for Marine-Earth Science and Technology) [harukan@jamstec.go.jp]
5. Momoko Ichinokawa (Japan Fisheries Research and Education Agency) [ichimomo@affrc.go.jp]

Korea

1. Sukyung Kang (National Institute of Fisheries Science) [sukyungkang@korea.kr]

Russia [TBD]

USA

1. Ryan Rykaczewski (NOAA PIFSC) [ryan.rykaczewski@noaa.gov]
2. Matthew Baker (North Pacific Research Board) [Matthew.Baker@nprb.org]
3. Isaac Kaplan (NOAA Northwest Fisheries Science Center) [isaac.kaplan@noaa.gov]
4. Desiree Tommasi (NOAA Southwest Fisheries Science Center) [desiree.tommasi@noaa.gov]

ICES

Canada

1. Pierre Pepin (Fisheries and Oceans Canada) [pierre.pepin@dfo-mpo.gc.ca]
2. Dominique Robert (Université du Québec à Rimouski) [Dominique_Robert@uqar.ca]

Denmark

1. Martin Lindegren (National Institute of Aquatic Resources) [mli@aqua.dtu.dk]

France

1. Arnaud Bertrand (IRD) [Arnaud.Bertrand@ird.fr]
2. Martin Huret (IFREMER) [Martin.Huret@ifremer.fr]
3. Yunne Shin (IRD) [yunne-jai.shin@ird.fr]

Germany

1. Myron A. Peck (University of Hamburg) [myron.peck@uni-hamburg.de]
2. Matthias Kloppmann (Thuenen Institute Sea Fisheries) [matthias.kloppmann@thuenen.de]
3. Rüdiger Voss (University of Kiel) [voss@economics.uni-kiel.de]

Netherlands

1. Martin Pastoors (Pelagic Freeze Trawlers Association) [mpastoors@pelagicfish.eu]

Norway [TBD]*Portugal*

1. Susana Garrido (Portuguese Institute for the Ocean and Atmosphere) [garridosus@gmail.com]
2. Gonçalo Silva (Instituto Universitário) [gsilva@ispa.pt]

Spain

1. Ignacio A. Catalán (Mediterranean Institute for Advanced Studies) [ignacio@imedea.uib-csic.es]
2. Marta Coll (CSIC) [mcoll@icm.csic.es]
3. Ana Sabates (CSIC) [anas@icm.csic.es]
4. Xabier Irigoien (AZTI) [xirigoien@azti.es]
5. Jose Maria Bellido (IEO) [josem.bellido@ieo.es]

United Kingdom

1. Jeroen Van Der Kooij (CEFAS) [jeroen.vanderkooij@cefass.co.uk]

USA

1. Rebecca Asch (East Carolina University) [aschr16@ecu.edu]

Non-ICES/PICES countries*Australia*

1. Iain Suthers (University of New South Wales) [i.suthers@unsw.edu.au]

Brazil

1. Jana Menegassi del Favero (Instituto Nacional de Pesquisas Espaciais) [delfaverojana@gmail.com]
2. Mario Katsuragawa (University of São Paulo) [mkatsura@usp.br]
3. June Ferraz Dias (University of São Paulo) [junedias@usp.br]

Greece

1. Stylianos (Stelios) Somarakis (Hellenic Centre for Marine Research) [somarak@hcmr.gr]

India

1. Vasant Kripa (Central Marine Fisheries Research Institute, India) [vasantkripa@gmail.com]

Mexico

1. Salvador Lluch-Cota (CIBNOR) [slluch@cibnor.mx]

Perú

1. Patricia Ayón Dejo (Instituto del Mar del Perú) [payon@imarpe.gob.pe]
2. Renato Guevara Carrasco (Instituto del Mar del Perú) [rguevara@imarpe.gob.pe]
3. Dimitri Gutiérrez Aguilar (Instituto del Mar del Perú) [dgutierrez@imarpe.gob.pe]
4. Miguel Ñiquen Carranza (Instituto del Mar del Perú) [mniquen@imarpe.gob.pe]
5. Jorge Tam Málaga (Instituto del Mar del Perú) [jrtam@imarpe.gob.pe]

Philippines

1. Cesar Villanoy (University of the Philippines) [cesarv@msi.upd.edu.ph]

South Africa

1. Carl van der Lingen (Department of Agriculture, Forestry and Fisheries) [CarlVDL@daff.gov.za]

Other (Intergovernmental organizations)

1. Miguel Bernal (FAO GFCM Secretariat) [miguel.bernal@fao.org]
2. TBD (NPFC)

Proposed Leadership:

Ignacio A. Catalán (ICES/Spain) [ignacio@imedea.uib-csic.es]

Myron A. Peck (ICES/Germany) [myron.peck@uni-hamburg.de]

Ryan Rykaczewski (PICES/USA) [ryan.rykaczewski@noaa.gov]

Akinori Takasuka (PICES/Japan) [atakasuka@mail.ecc.u-tokyo.ac.jp]

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Alheit, J. and Peck, M.A. (2019) Drivers of dynamics of small pelagic fish resources: biology, management and human factors. Marine Ecology Progress Series (special issue), 617/618: 1–6.

Peck, M.A., Neuenfeldt, S., Essington, T.E., Trenkel, V.M., Takasuka, A., Gislason, H., Dickey-Collas, M., Andersen, K.H., Ravn-Jonsen, L., Vestergaard, N., Kvamsdal, S.F., Gårdmark, A., Link, J., and Rice, J.C. (2014) Forage Fish Interactions: A symposium on “Creating the tools for ecosystem-based management of marine resources”. ICES Journal of Marine Science (special issue), 71: 1–4.

FIS Endnote 6

**Proposal for a
Joint ICES/PICES Working Group on Impacts of Warming on Growth Rates and Fisheries Yields
(GRAFY)**

Group Name: Working Group on ICES/PICES Working Group on Impacts of Warming on Growth Rates and Fisheries Yields

Reporting to: FIS

Term: October 2019 – October 2022

Linkage(s) to previous PICES Expert Groups or activities (if any):

Linkage(s) to other organizations and programs (if any):

Motivation and Goals and/or Background

Terms of Reference:

See ICES proposal

Proposed PICES membership: TBD

Proposed leadership:

C. Tara Marshall (ICES/UK)

Paul Spencer (PICES/USA)

A Joint ICES-PICES **Working Group on Impacts of Warming on Growth Rates and Fisheries Yields** (WGGRAFY), chaired by C. Tara Marshall, UK (ICES), Paul Spencer, USA (PICES), Alan Baudron (ICES) and John Morrongiello, Australia (Guest) will work on ToRs and generate deliverables as listed in the Table below.

The ToRs describe a programme of co-ordinated research to be undertaken by a global network of scientists. The ToRs have been developed jointly through discussions at an earlier workshop (Aberdeen 2018). Given the specific nature of the ToRs it is the intention of the co-chairs to minimise the need for face-to-face meetings. Instead work on the ToRs is progressed via remote working and communicated via technological means, including email and skype. WG meetings will be timed to coincide with other international meetings that the co-chairs are attending. Meetings will use video conferencing to allow other WG members to participate remotely. This has several practical advantages. It minimises the requirement for WG participants to secure the substantial funding required for international travel. Secondly, it minimises cumulative carbon emissions of the WG thereby constituting a more climate-friendly programme of research. This working practice will be challenge but is logical given that the WG concerns climate impacts.

	MEETING DATES	VENUE	REPORTING DETAILS	COMMENTS (CHANGE IN CHAIR, ETC.)
Year 2019	September	ICES ASC, Sweden		Information meeting with co-chairs and prospective members attending the ASC. Develop strategy for securing participants meeting WG needs
Year 2020 (Year 1)	September	TBA		(ICES ASC- progress reporting on ToR activities; chairs attend, optional attendance by member)
Year 2021 (Year 2)	October	TBA		(PICES ASC- progress reporting on ToR activities; chairs attend, optional attendance by member)
Year 2022 (Year 3)	September	TBA		(ICES ASC- progress reporting on ToR activities; chairs attend, optional attendance by member)
Year 2022	November	Seattle, Washington (proposed)		Final meeting to complete publications (ToRs a,b,c) and strategy document (ToRd)
Final report by January 2023				

ToR descriptors¹

ToR	DESCRIPTION	BACKGROUND	<u>SCIENCE PLAN</u> <u>CODES</u>	DURATION	EXPECTED DELIVERABLES
a	Assess the capacity of statistical models to incorporate temperature-dependency of growth, and then compare their predictions of growth variation across specific warming scenarios and locations		1.3, 1.7, 2.5	Year 1	Paper suitable for peer-reviewed fish journal
b	Analyse long-term growth patterns across multiple large marine ecosystems that are experiencing different trends in temperature, using a common modelling approach		1.7, 5.2, 6.1	Years 1, 2 and 3	Papers suitable for peer-reviewed, high impact generic journal
c	Assess the impacts of warming on past yield per recruit of commercial fisheries, and forecast trends in future yield given plausible warming scenarios		1.3, 5.2, 6.1	Year 3	Paper suitable for peer-reviewed, high impact generic journal
d	Identify options for expanding scientific community access to global length-at-age data that are routinely collected by fisheries agencies worldwide.		3.2	Years 1,2,3	Strategic plan assessing options for widening access to length-at-age data collected routinely (similar to how data can be accessed via Datras)

Summary of the Work Plan

YEAR 0	INITIAL INFORMATION MEETING WILL TAKE PLACE IN SEPTEMBER 2019 AT THE ICES ASC WHICH WILL BE ATTENDED BY ALL FOUR CO-CHAIRS AND INTERESTED INDIVIDUALS. THE MEETING WILL PRESENT AND DISCUSS THE LONGTERM GOALS OF THE WG, THE INDIVIDUAL TORs AND THE SPECIFIC REQUIREMENTS FOR PROSPECTIVE WG MEMBERS. FOLLOWING ON FROM THIS MEETING TARGETTED EMAIL WILL BE SENT TO INDIVIDUAL SCIENTISTS WHO ARE FELT TO HAVE ACCESS TO RELEVANT DATA AND/OR VALUABLE MODELLING SKILLS. MEMBERS OF THE WG WILL COME FROM BOTH ICES AND PICES COMMUNITIES BUT ALSO A BROADER ARRAY OF GLOBAL SCIENTISTS FROM REGIONAL SEAS EXPERIENCING WARMING, COOLING OR UPWELLING WHO HOLD LONGTERM LENGTH-AT-AGE DATA (E.G., CHILE).
Year 1	A meeting may take place at the ICES Annual Science Conference to review progress towards ToRa and ToRd. Sub-groups meet remotely as required; full WG remotely meets once per year for progress reporting

¹ Avoid generic terms such as “Discuss” or “Consider”. Aim at drafting specific and clear ToR, the delivery of which can be assessed

Year 2	A meeting may take place at the PICES Annual Science Conference to discuss progress towards ToRs a, b and d. Planning for an international theme session will be convened (tentatively in Year 3 at ICES ASC). Sub-groups meet remotely as required; full WG remotely meets once per year for progress reporting
Year 3	A week-long meeting of the full WG will be held to complete writing of papers and will possibly be held at the University of Washington (UW). This location will facilitate discussion of data archiving using the arrangements for maintenance of RAM Legacy database UW as an example.

Supporting information
