PICES Contracting Parties:
Canada, People's Republic of China
Japan, Republic of Korea, Russian
Federation, United States of America

FUTURE – Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems

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FUTURE
Science Program

FUTURE Terms of Reference

- Work with PICES Committees and Expert Groups to ensure collective and integrated delivery of FUTURE;
- Integrate, promote and stimulate national activities around the vision statement and core science questions of FUTURE;
- Identify and facilitate interactions with national/international research programs from which FUTURE could benefit;
- Communicate FUTURE research and products in order to translate them into high level impacts for PICES and its member countries.

Themes

1. What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing and how might they change in the future?

1. What are the important physical, chemical and biological processes that underlie the structure and function of ecosystems?
2. How might changing physical, chemical and biological processes cause alterations to ecosystem structure and function?
3. How do changes in ecosystem structure affect the relationships between ecosystem components?
4. How might changes in ecosystem structure and function affect an ecosystem's resilience or vulnerability to natural and anthropogenic forcing?
5. What thresholds, buffers and amplifiers are associated with maintaining ecosystem resilience?
6. What do the answers to the above sub-questions imply about the ability to predict future states of ecosystems and how they might respond to natural and anthropogenic forcing?

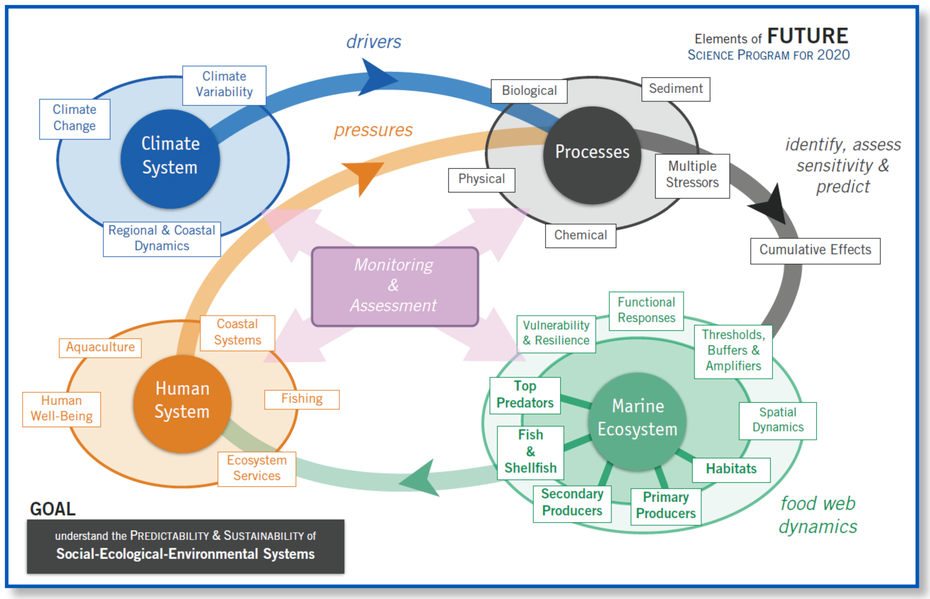
2. How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future?

1. How have the important physical, chemical and biological processes changed, how are they changing, and how might they change as a result of climate change and human activities?
2. What factors might be mediating changes in the physical, chemical and biological processes?
3. How does physical forcing, including climate variability and climate change, affect the processes underlying ecosystem structure and function?
4. How do human uses of marine resources affect the processes underlying ecosystem structure and function?
5. How are human uses of marine resources affected by changes in ecosystem structure and function?
6. How can understanding of these ecosystem processes and relationships, as addressed in the preceding sub-questions, be used to forecast ecosystem response?
7. What are the consequences of projected climate changes for the ecosystems and their goods and services?

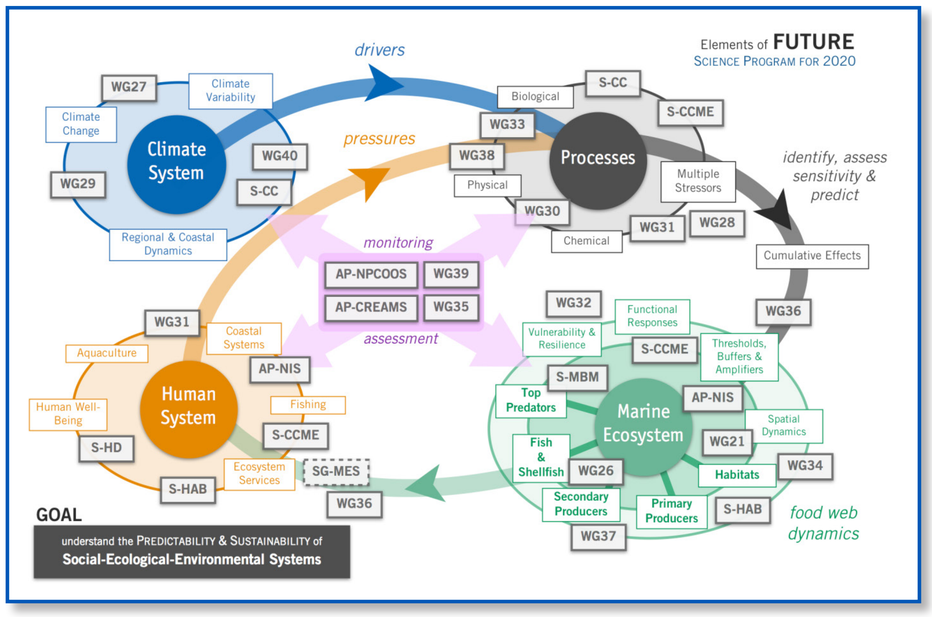
3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

1. What are the dominant anthropogenic pressures in coastal marine ecosystems and how are they changing?
2. How are these anthropogenic pressures and climate forcings, including sea level rise, affecting nearshore and coastal ecosystems and their interactions with offshore and terrestrial systems?
3. How do multiple anthropogenic stressors interact to alter the structure and function of the systems, and what are the cumulative effects?
4. What will be the consequences of projected coastal ecosystem changes and what is the predictability and uncertainty of forecasted changes?
5. How can we effectively use our understanding of coastal ecosystem processes and mechanisms to identify the nature and causes of ecosystem changes and to develop strategies for sustainable use?

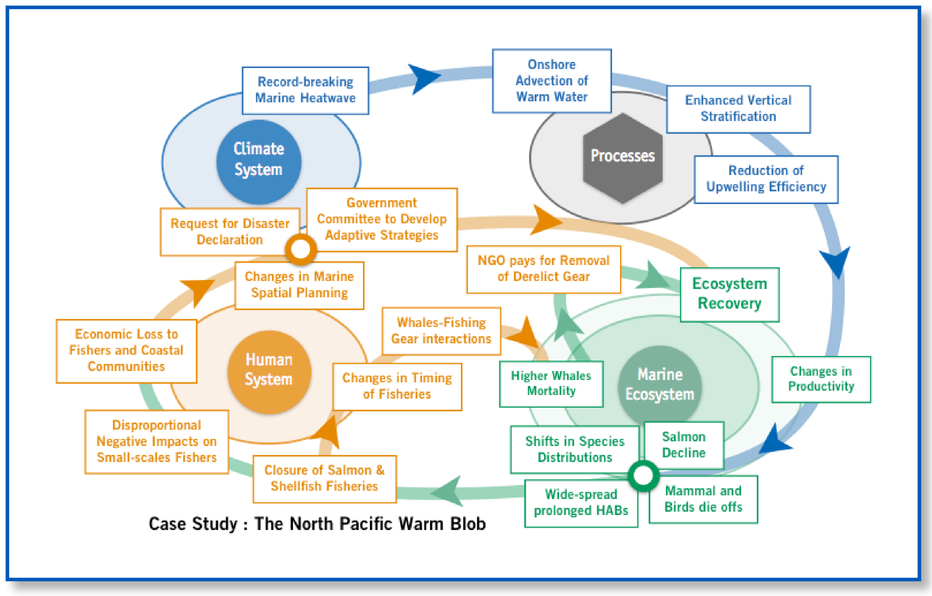
The FUTURE Schematic (sans Expert Groups) includes the climate system which forces oceanographic processes. Changes in processes impact ecosystems through individual effects, multiple stressors and cumulative effects. Marine ecosystems have many trophic levels, components and attributes, with selective impacts. Because our paradigm is that humans and marine ecosystems are intertwined with multiple feedbacks in both directions, the state of the marine ecosystem impacts humans, and humans impact marine ecosystems by effects on processes and pressures on biological components (such as fishery removals). With this schematic of how this Social-Ecological-Environmental System (SEES) is structured we are beginning to understand the predictability of the North Pacific SEES.



FUTURE Schematic as above, with PICES Expert Groups overlain where they are providing insights and/ or products related to their specific research questions. AP=Advisory Panel; WG=Working Group; S=Section; SG=Study Group; The expert groups in the purple center are responsible for essential elements of assessment and monitoring, of all four of the SEES elements. Note that almost all of PICES EGs are providing information related to the FUTURE schema.



The case study shown at right displays the sequences of events that have been linked using the FUTURE SEES framework applied to the record-breaking marine heatwave (aka the North Pacific Warm Blob) of 2014-2016 in the Northeast Pacific. Sequence is to start in climate, follow blue arrows (arrow color is same as the source); changes in green (marine ecosystems) propagate to human system (orange). Feedback from human systems to marine ecosystems are in orange arrows. Arrows that pass beneath rectangular boxes may have an impact on those properties.



Case Study : The North Pacific Warm Blob