About FUTURE
-history, themes, implementation objectives, organization

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Intersessional FUTURE WS
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Integrated science program of PICES

… Yet integration of scientific knowledge on the North Pacific Ocean, along with its marginal seas, has not occurred as a coherent effort in the past. The North Pacific Marine Science Organization (PICES) has undertaken this task, by bringing together scientific expertise from the Contracting Parties to synthesize and disseminate knowledge and design appropriate multi-national research programs in response to identified needs.

-PICES Strategic Plan

The 1st Integrative Science Program of PICES

CCCC (Climate Change and Carrying Capacity)

- PICES-GLOBEC Project
- 1994-1996 Preparation
- 1996-2006 Implementation
- 2006-2008 Synthesis phase

Goals of CCCC

- To provide a strategy for determining the carrying capacity for higher trophics in the subarctic North Pacific (salmon, pollock, birds, mammals, *etc.); and*
- To develop a plan for a cooperative study of how changes in ocean conditions affect the productivity of key fish species in the subarctic North Pacific and coastal zones of the Pacific rim.

Central scientific issues of CCCC

- **Physical Forcing**
- **Lower Trophic Level Response**
- **Higher Trophic Level Response**
- **Ecosystem Interactions**

Legacy of CCCC program (1996-2006)

(Batchelder, 2007)

Physical Forcing

What are the characteristics of climate variability, can interdecadal patterns be identified, how and when do they arise?

Progress and Products

- 2000 Progress in Oceanography (North Pacific Climate Regime Shifts)
- 2005 Fisheries Ecosystem Responses Recent Regime Shifts (FERRRS) Report
- Many scientific papers on regime shifts

Lower Trophic Level Response

How do primary and secondary producers respond in productivity, and in species and size composition, to climate variability in different ecosystems of the subarctic Pacific?

Progress and Products

- Ecological Modelling special issue on NEMURO model
- Contributions to North Pacific Ecosystem Status Report
- Development of NEMURO through many workshops. Great progress on LTL and linkage to climate
- Activities leading to SCOR WG 125 (Global Comparisons of Zooplankton)
- New CPR program in North Pacific

Higher Trophic Level Response

How do life history patterns, distribution, vital rates, and population dynamics of higher trophic level species respond directly and indirectly to climate variability?

Progress and Products

- Linkage of NEMURO to higher trophics, esp. fish, NEMURO.FISH
- Cross-regional comparisons of species responses to climate — e.g., herring, sardine, pollock
- ECOSIM/ECOPATH efforts of BASS Task Team to examine differences in higher trophic food webs of eastern and western subarctic gyres.

Ecosystem Interactions

How are subarctic Pacific ecosystems structured? Is it solely through bottom-up forcing, or are there significant intra-trophic level and top-down effects?

Progress and Products

- Prog. Ocean. special issue on "Mechanisms that regulate North Pacific ecosystems: Bottom-up, top-down, or something else?"
- ECOSIM/ECOPATH efforts of BASS Task Team to examine differences in higher trophic food webs of eastern and western subarctic gyres.
- Iron Fertilization Experiments in Western and Eastern Subarctic Pacific that were coordinated through IFEP advisory panel.

PICES

North Pacific Marine Science Organization

The 2nd Integrative Science Program of PICES

FUTURE

Forecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems

- 2003-2006 initial planning & discussion
- 2007-2008 writing-up of Science Plan
- 2008-2009 writing-up of Implementation Plan
- 2009-2019 Implementation

Objectives in Developing FUTURE

- Build upon the successful *CCCC* program (1996-2006)
- From climate variability to global change
- From the coast to the open ocean, and explicitly include the inter-relationship of marine ecosystem and social systems

- Key Elements -- Forecasts, human dimension, mechanisms, scenarios

FUTURE

Move beyond previous research programs by:

- investigating the *mechanisms* underlying ecosystem response to natural and anthropogenic forcings;
- Improving *forecasting* capabilities and providing estimates of the *uncertainty* associated with these forecasts; and
- developing more effective ways to *convey* knowledge and predictions.

PICES

North Pacific Marine Science Organization

THEME for FUTURE

To understand and forecast responses of North Pacific marine ecosystems to climate change and human activities at basin and regional scales, and to broadly communicate this scientific information to members, governments, resource managers, stakeholders and the public.

"What is the future of the North Pacific given current and expected pressures,?"

Three research themes

- What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing?
- 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?

1. What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing?

1.1. What are the important physical, chemical and biological processes that underlie the structure and function of ecosystems?

1.2. How might changing physical, chemical and biological processes cause alterations to ecosystem structure and function?

1.3. How do changes in ecosystem structure1 affect the relationships between ecosystem components?

1.4. How might changes in ecosystem structure and function affect an ecosystem's resilience or vulnerability to natural and anthropogenic forcing?

1.5. What thresholds, buffers and amplifiers are associated with maintaining ecosystem resilience?

1.6. 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?

2.1. How has 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?

2.2. What factors might be mediating changes in the physical, chemical and biological processes?

2.3. How does physical forcing, including climate variability and climate change, affect the processes underlying ecosystem structure and function?

2.4. How do human uses of marine resources affect the processes underlying ecosystem structure and function?

2.5. How are human uses of marine resources affected by changes in ecosystem structure and function?

2.6. How can understanding of these ecosystem processes and relationships, as addressed in the preceding sub-questions, be used to forecast ecosystem response?

2.7. 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?

3.1. What are the dominant anthropogenic pressures in coastal marine ecosystems and how are they changing?

3.2. 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?

3.3. How do multiple anthropogenic stressors interact to alter the structure and function of the systems, and what are the cumulative effects?

3.4. What will be the consequences of projected coastal ecosystem changes and what is the predictability and uncertainty of forecasted changes?

3.5. 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?

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Primary regional interests of FUTURE

Boundary Currents
- California
- Alaska
- E.Kamchatka/Oyashio
- Kuroshio

Marginal Seas
- Bering
- Okhotsk
- Japan/East Sea
- Yellow Sea
- East China Sea

Gyres
- Gulf of Alaska
- Western Subarctic gyre
- Subtropical gyre

Transition Zones
- North Pacific
- Oyashio-Kuroshio Convergence
- BC Bifurcation

Ecosystem elements of significant interest to FUTURE

- Physical Forcing (Time series and seasonality)
- Location of major fronts/current boundaries
- Atmospheric pressure gradients (winds and storms)
- Air-sea heat exchange (insolation, cloud cover)
- Major physical features (e.g., fresh water input, ice)
- Mixed layer temperature (MLT), depth (MLD)
- Velocity of major currents
- Eddies
- Vertical and horizontal mixing, fine structure
- Lower trophic levels (primary, including microbial; secondary)
- annual and seasonal productivity
- temporal and spatial pattern of plank ton dynamics and nutrient fields
- Identification of major taxonomic gro ups
- population parameters for key specie s (or taxonomic groups)
- Higher trophic levels and ecosystem interactions
- Abundance trends and distributions of life stages of key species and their predators and prey
- Population parameters (growth, mort ality, reproduction)
- Food web structure (including diets a nd trophodynamic linkages of key sp ecies)
- Production and productivity structure

New requirements for FUTURE implementation

- Communicate scientific understanding and predictions to broader communities
  → Products and engagement as a separate objective

- Closer involvement and coordination in the organization
  → work will be done by existing structure (expert groups, e.g., WGs)
  → review and coordination by advisory panels
  → SB will act as FUTURE SSC

FUTURE Objectives

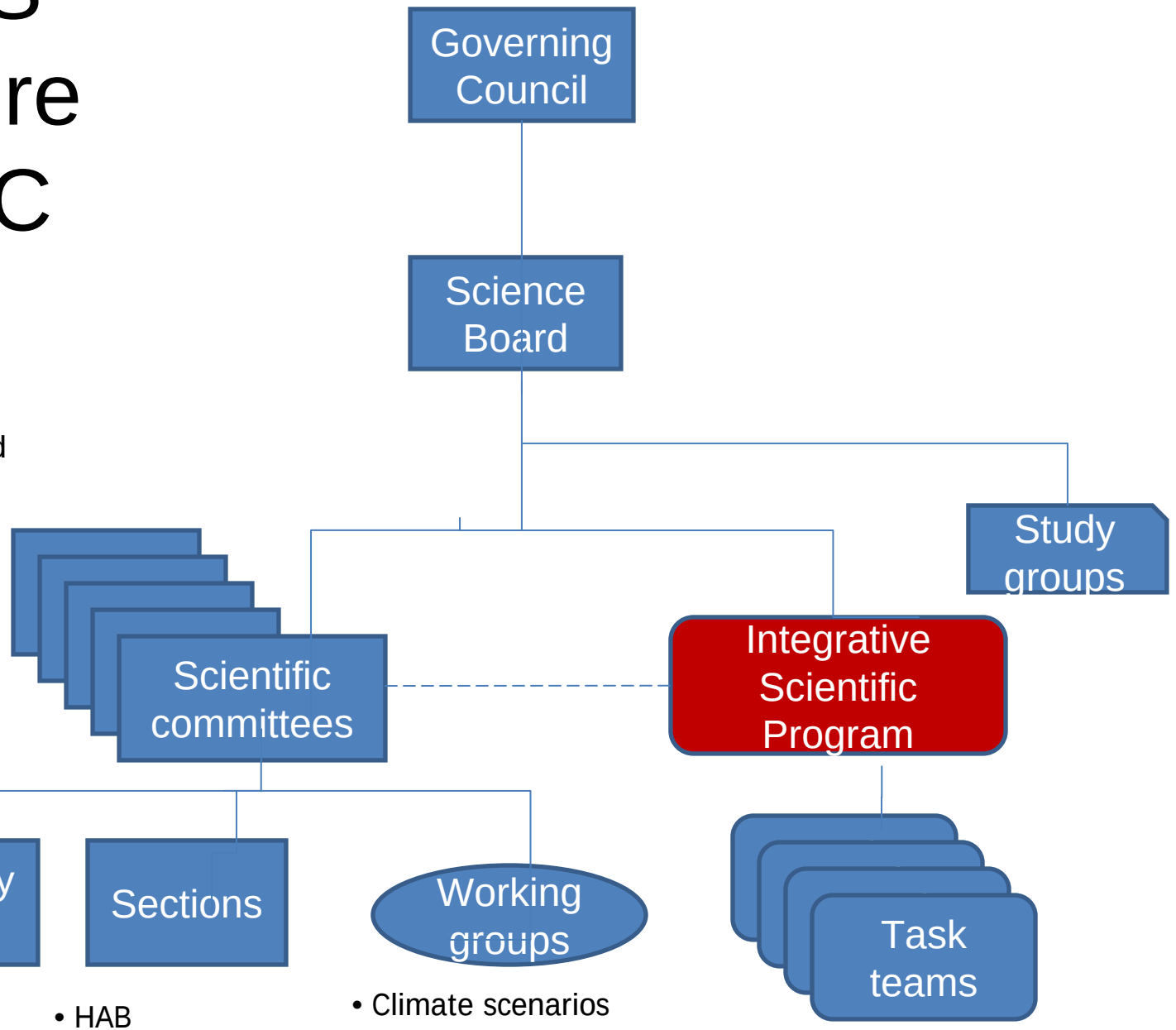
Objective 1 (scientific understanding)

- Answer the three key scientific questions

Objective 2. Status Reports, Outlooks, Forecasts and Engagement

- The production of *Status Reports, Outlooks and Forecasts.*
- *Engagement:*
  - *Establish Dialogs with Recipients of Potential FUTURE Products*
  - *Communicate with clients*

PICES structure (CCCC era)



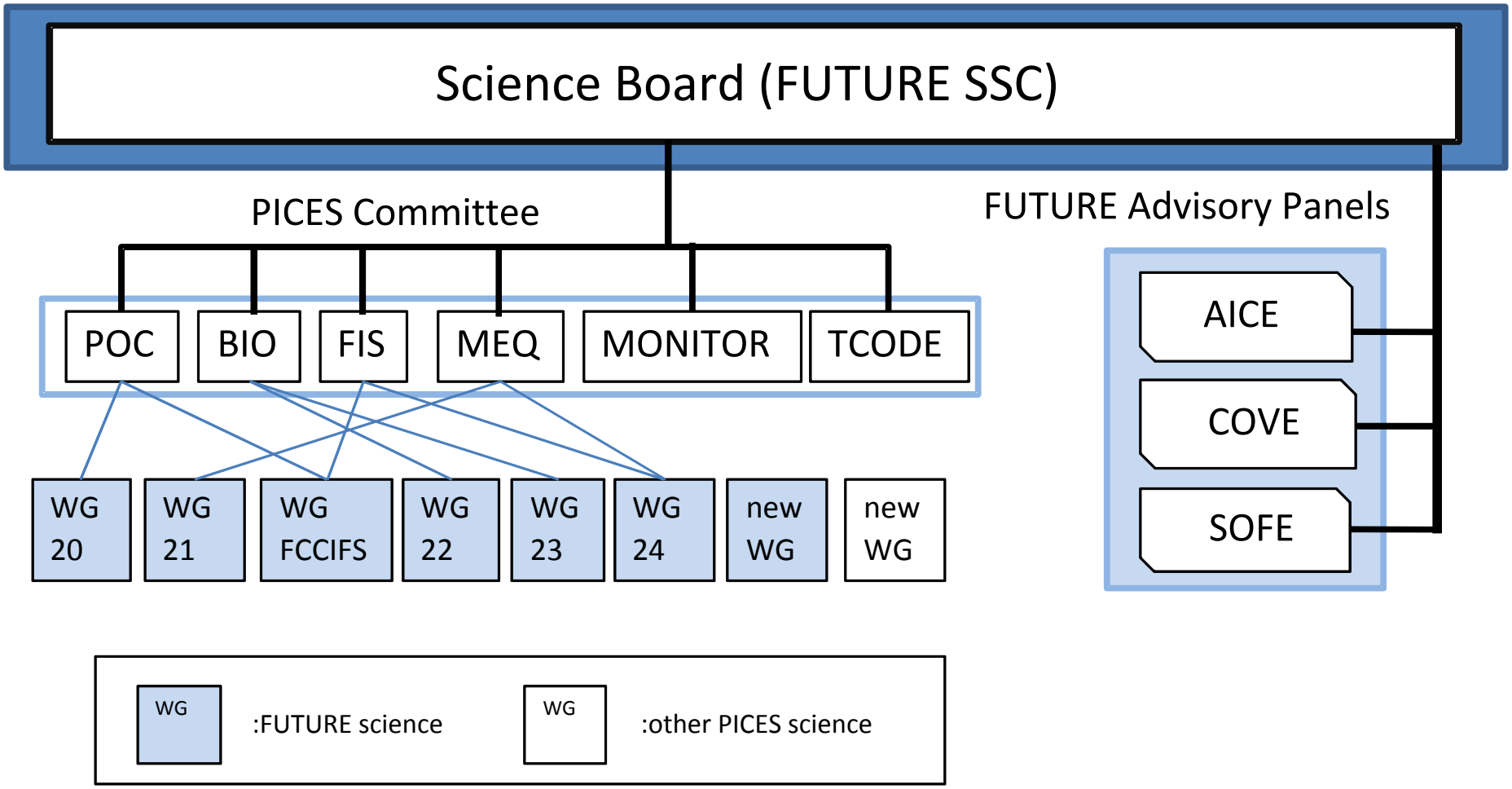
- Physical oceanography and climate
- Biological oceanography
- Marine Env. Quality
- Fisheries oceanography
- Data exchange
- Monitoring

- CREAMS
- Marine Bird & Mammal

- HAB
- Carbon & climate

- Climate scenarios
- Non-indigenous sp.
- Comparative Krill Biology
- Iron fertilization

FUTURE Structure



WG-20: Working Group on "Evaluations of Climate Change Projections" *(2006 - 2009)*
WG-21: Working Group on "Non-indigenous Aquatic Species" *(2006 - 2012)*
WG-22: Working Group on "Iron supply and its impact on biogeochemistry and ecosystems in the North Pacific Ocean" *(Oct. 2007 - Oct. 2010)*
WG-23: Working Group on "Comparative ecology of krill in coastal and oceanic waters around the Pacific Rim" *(Oct. 2007 - Oct. 2010)*
WG-24: Working Group on "Environmental Interactions of Marine Aquaculture" *(Oct. 2008 -)*
WG-FCCIFS: Joint PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish *(Jan. 2009*

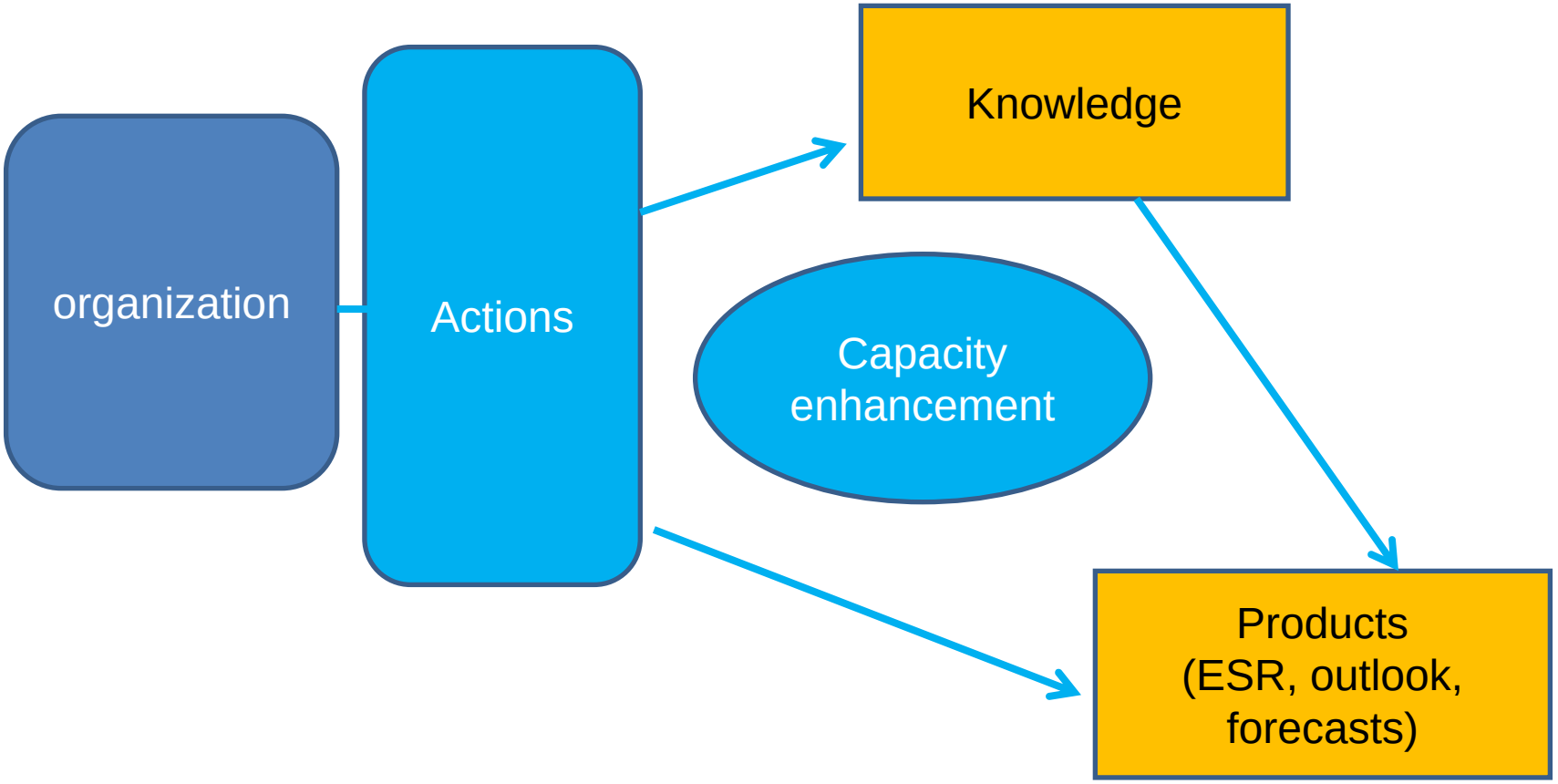
FUTURE Implementation

Advisory Panels to achieve the Objectives

- Objective 1 (scientific understanding)
  - AICE (***A****nthropogenic* ***I****nfluences on* ***C****oastal* ***E****cosystems*): focusing primarily on human influences on coastal ecosystems, such as runoff, pollution, effects of fishing, existence of non-indigenous species, and loss of habitat.
  - COVE (***C****limate and* ***O****ceanographic* ***V****ariability and* ***E****cosystems*): focusing on regional to basin scale ecosystem processes and Pacific basin teleconnections.

- Objective 2
  - SOFE (***S****tatus,* ***O****utlook,* ***F****orecast and engagement):*
    - recommend Expert Groups (working groups and study groups of PICES) to identify major sources of uncertainty and impediments to improving the skill of assessments and forecasts,
    - suggest research areas for priority development, and provide coordination of potential PICES products.
    - provide for a PICES final peer review on information and interpretations,
    - and interact with the PICES Communications and Human Dimensions Study Groups on how to engage potential users of North Pacific ecosystem and climate information, including the quality of information and uncertainty.

Elements of implementation



- Identify necessary actions
- Review existing capacity
  - Organizational structure (ExGs)
  - Knowledge gaps (capacity limits)
  - National contributing projects
- Prioritize actions
- Revise ToR of ExGs and/or create new ExGs
- Coordinate national activities