W7: Climate Forcing and Marine Ecosystems Workshop
Friday, October 13, 2006

Co-Convenors
• Kerim Aydin (U.S.A.)
• Jacquelynne King (Canada)
• Akihiko Yatsu (Japan)
Workshop Objectives

Afternoon session

• methods of classifying ecosystems
• approaches for comparing ecosystem responses
• discussion on future ecosystem comparison work for CFAME
  – building on the overviews and conceptual models identified today
  – overall theme and focus
  – suggest topics for inter-sessional meetings
• in order to complete the “Scenarios” portion of the workplan and future CFAME/POC collaboration:
  – identify climate variables required from POC modelling work

• W7 workshop report and assignment of tasks
Workshop discussion

- methods of classifying ecosystems
- approaches to comparing ecosystem responses
- Indicators from climate to top-predators
- Mechanisms: data-based (conceptual) and model-based (e.g. Ecosim)
Conceptual model of 1976/77 RS effects on lower production

Wintertime climate and winter-spring production

After 1976/77 Regime shift

PDO pattern dominated

Aleutian Low intensified

Gulf of Alaska warmed
Northward flow +
stratification +
light +
biol. production +

subarctic circulation intensified

California coast warmed
Southward current –
coastal upwelling –
nutrients –
biological production –

Kuroshio/subtropical
wind stress +
vertical mixing +
nutrients +
biol. production: win – sp +
timing of spring bloom: late

Oyashio southward shift

Oyashio cooled
wind stress +
vertical mixing +
light –
biol. production: win – sp –
timing of spring bloom: late

propagation of cold temperature anomaly by Rossby wave

Kuroshio/spinned-up

Central Pacific
wind + cooled
nutrients +
biological production +

* changes in the Kuroshio occurred with 5–6 yr lag after the regime shifts

Drawing by Dr Sanae Chiba
Mechanisms

• Climate to zooplankton: mainly bottom-up
• Fish recruitment: optimum window for survival
  – Spawning time and locations - match/mismatch to subsequent food, predator and habitat conditions
  – Temperature, salinity, transport/retention
• Density dependence (Ricker, BH, etc.)
• Predation: top-down, NB: switching
• Indirect species interactions

Deterministic vs stochastic processes
Ecosystem Indicators
(Cury and Christensen, 2005 ICES JMS)

• Environmental indicators
  – Climate: global and local
  – Human impact: habitat degradation, fishing, etc

• Ecological indicators: characterize functioning and dynamics of ecosystems
  – Species composition
  – Size distribution
  – Trophodynamics
Ecosystem Indicators continued
(Cury and Christensen, 2005 ICES JMS)

• Environmental and low-trophic-level indicators: bottom-up effects
• Top predators or high-trophic-level indicators: top-down effects, related to exploitation
• Trophodynamics indicators: strength of interactions, ecosystem structure, NB: sensitive to choice of trophic level
• Size-based indicators: promising for characterizing fish community dynamics
Abundance Biomass Comparison (ABC) curves

(Yemane et al., ICES JMS)

Theoretical background: classical K-selection (slow-growing, large, late maturing) species will dominate in undisturbed ecosystems than r-selection species

Needs time series for each ecosystem
Size-based indicators (Shin et al., ICES JMS)

Using abundance indices and mean and maximum length

Needs time series for each ecosystem
Structural differences in lower trophic ecosystems - standing stock in summer (modified from Taniguchi (1999PiO))

Annual primary production

Oyashio/KOTZ 325gCm⁻²yr⁻¹

Kuroshio 220gCm⁻²yr⁻¹

California Current 380gCm⁻²yr⁻¹

Standing stock (mg C m⁻³)

-20 0 20 40 60 80 100

Oyashio WSAG Bering Sea (basin) South Aleutian GOA

Mesozooplankton Microzooplankton Chlorophyll Nitrate (x0.01)
Anoxia is created by basins that was formed by removal of sand/mud for reclamation.
### Size-based indicators

(Shin et al., ICES JMS)

<table>
<thead>
<tr>
<th>Trends observed in SBI</th>
<th>Possible causes</th>
<th>Complementary indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\overline{L_i}$</td>
<td>Abundance of large fish</td>
<td>$L_{\text{max},i}$</td>
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<td></td>
<td>Recruitment</td>
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<td>Environmental effects (e.g. food)</td>
<td>$L_{\text{max},i}$</td>
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<td>Abundance index</td>
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<td>$\overline{L_{i,a}}$</td>
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<td>$K_i$</td>
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<td>$\overline{L}$</td>
<td>For dominant species, abundance of large fish</td>
<td>$L_{\text{max},i}$</td>
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<tr>
<td></td>
<td>Recruitment</td>
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<td></td>
<td>Abundance of small species</td>
<td>$L_{\text{max}}$</td>
</tr>
<tr>
<td></td>
<td>Abundance of large species</td>
<td>$L_{\text{max}}$</td>
</tr>
</tbody>
</table>

Figure 2. Possible causes leading to a decrease in mean length of population $i$ ($\overline{L_i}$), and in mean length of the community ($\overline{L}$), as confirmed by complementary indicators (see text).
<table>
<thead>
<tr>
<th>Indicators</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
<th>Case 6</th>
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</thead>
<tbody>
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</tbody>
</table>

Figure 3. Six cases showing different reference directions for mean length ($\bar{L}_i$), maximum length ($L_{\text{max},i}$), and an index of abundance of population $i$ leading to different interpretations of population state (white, state improving; light grey, state uncertain; dark grey, state deteriorating; see also text).
Workshop discussion

- recommended future ecosystem comparison work for CFAME
  - overall theme and focus
  - topics for interim meetings
- CFAME-POC collaboration
  - suggested climate variables required from POC modeling work
- workshop report and assignment of tasks
### Selection of target ecosystems

**California current**: BC/UW  
**Gulf of Alaska**: BC TD  
**Eastern Bering Sea**: TM-ice? MO  
**Okhotsk Sea**: ice?  
**Western SA Gyre**: BC  
**Kuroshio/Oyashio**: BC MO?  
**Tsushima Curr / Liman Curr***: BC MO?  
**Yellow Sea / East China Sea**: TM  
**Transition Zone**: PG

<table>
<thead>
<tr>
<th>Classification</th>
<th>By physical structure</th>
<th>By dynamics</th>
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<tbody>
<tr>
<td><strong>Upwelling</strong></td>
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<td>Bottom-up</td>
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<td><strong>Boundary current</strong></td>
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<td>Top-down (top-heavy)</td>
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<tr>
<td><strong>Pelagic</strong></td>
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<td>Middle-out (wasp-waist, Beer-berry)</td>
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<td><strong>Ice-dominated</strong></td>
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<td>Others?</td>
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<td><strong>Freshwater-driven</strong></td>
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<td><strong>Solae/crowd</strong></td>
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* Лиман течения
## PICES Ecosystem Status Report - regional chapters

<table>
<thead>
<tr>
<th>Region</th>
<th>Climate</th>
<th>Hydrography</th>
<th>Chemistry</th>
<th>Plankton</th>
<th>Benthos</th>
<th>Fish and invertebrates</th>
<th>Marine birds and mammals</th>
<th>Contributors</th>
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<tbody>
<tr>
<td>Tsushima / Liman C</td>
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<td>Okhotsk Sea</td>
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<td>Okyushio / Kuroshio C</td>
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<td>Western subarctic gyre</td>
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<td>Transition Zone</td>
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<td>J US</td>
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</tbody>
</table>

**Contributors:**
- **K:** Korea
- **J:** Japan
- **R:** Russia
- **Ch:** China
- **US:** United States
- **UK:** United Kingdom
- **M:** Mexico
- **Ca:** Canada
- **J:** Japan

“Big Picture” Summary

- North Pacific is dominated by variability at seasonal, interannual, and decadal scales – is in contrast to the Tropics.

- Major climate influences on the North Pacific in recent 5 years have been:
  - switch in the atmospheric and oceanographic patterns that are indexed by the PDO
  - Strong La Niña in 1999 and modest El Niño in 2002

- Plankton productivity in the western Pacific has declined over past 30 years, but increased in the eastern Pacific, in part due to a shoaling of the upper mixed layer in the eastern Pacific. Occurrences of HABs are increasing around the North Pacific.

- Demersal fish species have declined significantly throughout the North Pacific over the past 30 years. Pelagic species have undergone high variability, with species replacements common. Sardine collapsed in western Pacific, but began to increase in eastern Pacific, about 1990.

- Stellar sea lion populations around the North Pacific have declined significantly over the past 30 years. Some populations show recovery.

- Major direct-human forcing on the North Pacific as a whole is fishing.