From physics to predators: Monitoring North Pacific ecosystem dynamics

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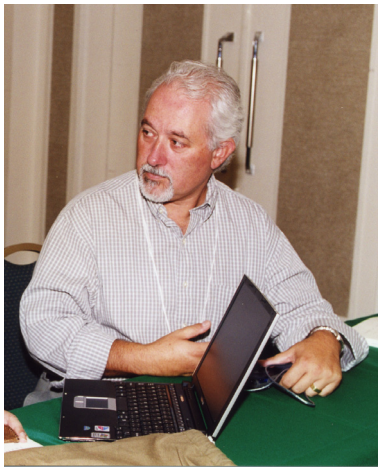

Dr. William Sydeman is the Director of the Marine Ecology Division at PRBO Conservation Science (previously Point Reyes Bird Observatory). His research interests include the biological oceanography and evolutionary ecology of top marine predators (marine birds, pinnipeds and cetaceans) in variable marine systems, particularly the California Current System. Dr. Sydeman has been involved in long-term studies of climate/ecosystem fluctuations in the North Pacific for the past 23 years. He serves as Co-Chairman for the PICES Marine Birds and Mammals Advisory Panel, and is also a member of the PICES MONITOR Task Team.

Over the past 50 years, there has been growing appreciation of climate/ecosystem fluctuations in the world's oceans. Nowhere is this more important than in the highly dynamic, ever-changing large marine ecosystems of the North Pacific. Why are these fluctuations of fundamental significance? The simple answer is that because North Pacific marine communities are not constant in space and time, management decisions based on ecosystem homeostatis could be flawed; the distribution and abundance of marine species vary according to current or shifting environmental conditions. Consequently, we are faced with a serious scientific challenge: to recognize, document, and interpret, in real-time, the temporal and spatial variations in climate, patterns of ocean productivity, and food web structure that influence marine populations of interest. An understanding of the ecological consequences of climate variability could be integrated within an adaptive management framework for North Pacific living marine resources. Conceptually, what is needed is a continuing information loop, with new information regularly supplanting old, in support of annual decision-making processes. Ecosystem considerations, based on real time monitoring, could then become a primary first-step management tool for setting harvest quotas for fisheries in relation to the environmental variability that is known to shape plankton, fish, and top predator life histories and populations in the region.

But, how can we accurately assess climate-ecosystem fluctuations in such a timely fashion? Many scientists in the PICES community have been actively engaged in considering this question. It has three basic components:

- How should we monitor North Pacific marine ecosystems?
- What are the appropriate temporal and spatial scales of observation? and
- What indicators might best describe system 'state'?

Attempting to answer these questions is by no means a simple task. In a series of workshops held during the past 5 years, the PICES community has been gaining insight into approaches for ocean monitoring, and an appreciation of the variables that can be measured simply and inexpensively over long periods of time, to allow for more informed management decisions about marine populations (PICES Scientific Report Nos. 17, 18, 20, 21 and 26). The latest in this series was a workshop, convened by David Mackas, Sei-ichi Saitoh, Phillip Mundy, Vyacheslav Lobanov and myself, at the PICES Twelfth Annual Meeting in Seoul, Republic of Korea, on October 10-11, 2003. This article summarizes, reviews, and evaluates some of the notable results from this workshop, which included presentations from marine scientists from the Atlantic and Southern Oceans, as well as many contributors from the North Pacific.

Indeed, this workshop follows from the successful efforts of many scientists who contributed to previous workshops and special symposia. In 2003, this work culminated in the first draft "North Pacific Ecosystem Status Report (NPESR)", a multi-investigator effort led by Drs. Ian Perry (Chairman, PICES Science Board) and Skip McKinnell (PICES Secretariat). The draft NPESR formed a basis for discussion and was highlighted in the title of the Seoul workshop – *Examine and critique a North Pacific Ecosystem Status Report*.

The workshop began as the conveners discussed the goals and potential products of the workshop. They sought novel recommendations from participants on how to weave and synthesize disparate, ongoing marine monitoring programs into one for the entire North Pacific, to discuss issues of multi-system and multi-investigator database management, and finally, to define the role of the PICES MONITOR Task Team relative to ecosystem status reporting in the future. Three plenary presentations filled the morning session, including Keith Brander, of ICES (International

Council for the Exploration of the Sea), who spoke on *Choosing, presenting and maintaining indicators for marine ecosystem monitoring – experience from the NE Atlanti;* Keith Reid, of the British Antarctic Survey, who spoke on *The CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources) ecosystem monitoring program: Application to the management of krill fisherie;* and Ian Perry, PICES Science Board Chairman, who presented a talk on *The Draft PICES North Pacific Ecosystem Status Report: Synthesis.* Lively discussion ensued on the value of matching indicators from the North Atlantic, North Pacific and Southern Ocean, the role of upper trophic-level predators in ocean ecosystem monitoring, and a critique of the draft NPESR.

It was noted that maintaining methodological consistency within time series is usually more important, and more feasible, than altering ongoing programs to obtain standardization among time series, but that key variables should be obtained and reported for all systems. In the Pacific, key basin-scale environmental indices currently include the Pacific Decadal Oscillation, Aleutian Low Pressure Index, and the Arctic Oscillation; the latter two reflect sea level pressures, and aid in understanding winds, upwelling/downwelling, frontal formation, and current structures. The role of monitoring marine birds and mammals to help to assess the abundance and demographics of lower trophic level taxa *(i.e.*, prey) was clearly illustrated by studies of diet and reproductive success of penguins and fur seals at Bird Island, South Georgia. But, at only one study site was the functional relationship between penguin productivity and euphausiid abundance (based on hydroacoustic surveys and net tows) established. The group noted that additional calibration of these relationships is required to fully utilize the predator information in real time monitoring of key food web components, such as krill and forage fish. The synthesis chapter of the NPESR was critiqued, and most noted the exceptional job done by Dr. Perry and colleagues in producing the first-ever draft ecosystems report for the North Pacific. Questions arose concerning which of the large-scale environmental indices were most valuable, and how to interpret the reported FAO total fishery catches (rather than CPUE) in relation to climate variability when human effort needs to be considered as well. The afternoon session consisted of invited and contributed reports describing regional monitoring and ecosystem status assessment efforts in different parts of the North Pacific. Presentations were made by Kiyotaka Hidaka, Gennady Kantakov, George Shevchenko, Gong-Ke Tan, Ming-Yuan Zhu, Franz Mueter, Patricia Livingston, Gordon McFarlane, and Steven Bograd. Several of these presentations provided a more detailed look at the material contained in the draft NPESR. There were many examples of ecosystem changes driven by basin-scale and regional-scale climate forcing, as well as anthropogenic changes in nutrient loading and freshwater discharge patterns.

The second day included discussions of some new monitoring approaches and hypotheses of interest from a global (or near global) perspective. Initially, we heard a presentation summarizing evidence for global synchrony of zooplankton variability (Ian Perry). This talk was based on a synthesis of ideas and data from the joint ICES/PICES/GLOBEC Zooplankton Production Symposium, held in May 2003, in Gijón, Spain. This was followed by an analysis of ecosystem structure, from copepods to sea birds, based on multi-ecosystem, multi-trophic level monitoring made from ships-of-opportunity in the North Pacific (Sonia Batten), and a description of broad-scale ecosystem-level information made available based on dietary analyses of North Pacific marine birds and mammals (Julie Thayer and Hidehiro Kato, respectively). These contributions clearly demonstrated the remarkable potential for understanding simultaneous or lagged fluctuations in biological populations on a global-scale, and how various biological indicators, from plankton to predators, can be used to inform us on the amplitude and timing of ecological responses to climate variability and change. Moreover, the presentations also provided numerous examples of how complex studies of mid trophic-level organisms (*e.g.*, macro-zooplankton, forage fishes and squids) can be augmented and complemented by information on their predators. Reports of operational oceanography initiatives in western North Pacific marginal seas were also presented, including *Circulation Research in the East Asian Marginal Seas* (CREAMS) (Kuh Kim), and *North-East Asia Regional GOOS* (NEAR-GOOS) (Vyacheslav Lobanov). Both of these ongoing programs are entering a second phase of design and implementation, and both are becoming multi-disciplinary in focus. For both programs, there was much noted success with real-time data collation, transfer and analysis. Data management for other North Pacific ecosystem monitoring programs is now in development under the auspices of the Integrated Ocean Observing System (IOOS) and may be modeled after these successful initiatives.

Extensive plenary discussion of how to produce future editions of the PICES NPESR continued in the afternoon. Topics included NPESR content (what is in the report now, what should be added next time), update interval and format ('as available' on the web, ~3-5 year interval as a printed document), quality/completeness checks and peer-review mechanisms (combination of internal and external), tools for outreach to 'users' and feedback from 'users', and broadening the base of PICES contributors. The role of MONITOR in NPESR preparation and review was discussed. Task Team members agreed that this is an important work for MONITOR. Potential actions and activities by MONITOR include:

- contribute expertise to "scientific peer-review"
- initiate future NPESR editions (however, this role assumes a 'permanent' mandate for MONITOR, probably extending beyond the duration of the CCCC Program)

- help future chapter authors find relevant ‘data’ and ‘specialist expertise’
- contribute to ‘outreach’ communication

Although much was accomplished, there is still much work to be done. In particular, workshop participants recommended that a formal analysis on information needs and gaps should be conducted. While participants agreed that ongoing time series and monitoring programs should not be redirected to obtain ‘standardization’, there is a need to coordinate basic data collection and analysis at the regional level to facilitate cross-system analyses and interpretations. Augmenting ongoing programs with new variables would seem to be a reasonable approach to enhancing these efforts. Other questions pertaining to the coupling of interannual to interdecadal climate variability and effects on marine systems, *e.g*, El Niño in a cold regime such as that witnessed in 2003, remain to be addressed; what do we need to measure to disentangle these effects? Additional thoughts on operational oceanography is also required: for example, how and when should scientists advise managers of ecosystem changes and what indicators of change may be most appropriate for management needs. Finally, there are continuing questions about database management: how can the PICES community work together to access, coordinate, and synthesize vast and disparate data sets? Who will fund this?

In conclusion, the latest workshop convened by the MONITOR Task Team was a great success. Recommendations and scientific criticisms made by dozens of participants will enable the PICES community to reach new heights in applied ecosystem monitoring and operational oceanography. Participants from across the globe brought insights from various ecosystems that greatly strengthened discussions and made for dynamic interactions. To all, we offer sincere appreciation.