OSM Session on "*Challenges in communicating science and engaging the public*"

by Phillip R. Mundy and Harold P. Batchelder

The FUTURE OSM session on the afternoon of April 15, 2014, was organized by the Advisory Panel on *Status, Outlooks, Forecasts and Engagement* (AP-SOFE) to showcase examples of the FUTURE goal of engaging human societies by providing useful products on ecosystem change. SOFE has found that such products are typically delivered by a four-step process that consists of 1) identifying climate driven ecosystem services, 2) defining processes and relationships between climate and ecosystem services, 3) developing products based on the relationships, and 4) developing timely and reliable communication with stakeholders. Stakeholders are the target audience for whom the products are intended. Stakeholders are, by and large, people who make decisions regarding human uses of living marine resources (LMR) and the habitats on which the LMR depend. These stakeholders function at various levels of resource use and regulation, from the top government policy-makers who prescribe the principles on which resources are to be regulated, through the managers who apply the regulations, to the individuals who work within the regulations in the course of earning a living. To take some examples, stakeholders are individual fisherman who need to know where and when to fish for particular species, or fishery managers who need to inform harvest decisions that result in the long-term sustainability of those species. Other examples of decision-makers in need of climate-change products include those who regulate sensitive coastal habitats and the policy-makers who develop the regulations governing human activities in coastal zones. Regardless of the specific human activities that depend on LMR, and regardless of differences in national approaches, all stakeholders need trustworthy information about how climate drives the ocean-provided services with which they are concerned, which in turn requires effective communication at all levels.

Effective communication is the common theme that unites the eight presentations and the preceding keynote address of Session S3 on "*Challenges in communicating science and engaging the public*". The keynote address and two other talks provided examples of *communicating effectively* with stakeholders to understand the products necessary to deal with climate driven resources (Peterson *et al*., Ito and Yamada, Orsi and Mundy). Three of the talks were concerned with building consensus among stakeholders through *effective communication* using diverse methods of reaching common understandings (Seino, Barbeaux and Lee, Volk *et al*.). In the realm of human dimensions, two of the talks dealt with *communicating effectively* through understanding the diversity of values and motivations among stakeholders (Yagi *et al*., Kurilova). Using models to integrate the complex suite of environmental drivers of natural resources to *effectively communicate* the consequences of climate change on LMR was addressed by one talk (Zhang *et al*.).

The keynote talk of Bill Peterson (USA) in the morning plenary session, "*A case study from the northern California Current*", illustrated SOFE's four-step process for producing useful products on climate driven LMR. Improvements in salmon management have been achieved by communicating more precise estimates of the numbers of salmon available to the fisheries. Increases in precision have been made possible by considering ocean conditions in the first summer of ocean entry, including hydrography and forage base from a long-term set of observations (now 19 years). Outlooks (the O in SOFE), or qualitative forecasts of coho and spring Chinook salmon adult abundance, and corresponding quantitative forecasts (the F in SOFE) have been developed based on a multivariate suite of ocean and ecological indicators. Simple-to-understand qualitative aids to communication include "stoplight charts" with green indicating favorable, yellow intermediate, and red unfavorable conditions of a particular input indicator. Years with many favorable (green lights) should be ocean entry years that favor survival of salmon, and predictions might indicate high returns of coho the following year, and of Chinook in two years. These aids are quantitatively supported on the web site with descriptions of the indicator and why it is related to salmon survival—usually described mechanistically as top-down or bottom-up linkages in the marine food web.

S3 Plenary speaker, Dr. William Peterson, speaking on the three pillars of SOFE related to providing management advice on Columbia River salmon.

Communication of the qualitative and quantitative information is through oral presentations to the public and managers. Uptake of the approach has been mixed, with some audiences very receptive, while others are reticent to alter the existing practices to salmon return forecasting, even in light of evidence that the approach may be more reliable, and because of a concern that the underlying data supporting the approach are produced by a research program rather than on an ongoing permanently funded operational basis.

Emphasizing the points made in Peterson's keynote, Orsi and Mundy (both USA; presented by Joseph Orsi) and Ito and Yamada (Japan) also illustrated by example the four-step process of SOFE in direct application to fishery management. Orsi and Mundy use data types and methods identical to those of Peterson over longer periods of time, applying physical and biological oceanographic observations to provide qualitative and quantitative forecasts that enhance fishery management capabilities. Orsi reported on his research resulting in a pink salmon abundance forecast for southeast Alaska that has been issued for eleven years (since 2004) based on a fisheries oceanography study that started in 1998 (17 years). The unprecedented precision of the annual pink salmon forecast has enabled the fishing industry to better prepare for the large fluctuations in annual abundance typical of pink salmon fisheries. Both Peterson and Orsi and Mundy identify approaches based on ocean sampling of the early marine life cycle stage of salmon to enable fishery management with more precise forecasts of abundance in the subsequent fisheries. Orsi also described Mundy's use of a long time series (52 years) of physical and biological observations to pinpoint the timing of marine exit of Chinook salmon, which allows fishery managers to estimate the abundance of the Chinook returns using data from the freshwater fisheries. Both Peterson and Orsi and Mundy communicate the uncertainty associated with quantitative harvest forecasts using simple qualitative rankings, various kinds of meetings, and via the web.

Dr. Shin-ichi Ito describing the information needs of the set net fishery.

Using an approach similar to that of Peterson *et al*. and Orsi and Mundy, Ito and Yamada (Japan) used ocean data to enable coastal fisheries in the area most impacted by the 2011 Great East Japan Earthquake and tsunami. Demonstrating the tightly environmentally dependent nature of these fisheries, the tsunami severely damaged fishery production by destroying vessels and gear and the harbors and aquaculture facilities on which production depends. Set net fisheries, especially those targeting salmon, are key fishing industries in coastal villages of northeastern Japan. Illustrating SOFE's four-step process, the problem was identified as environmentally damaged fisheries, the solution was to apply advanced technologies to recover the former marine harvest capacity, the approach was to build monitoring based on the needs of fisherman for ocean data, and the problem was solved by communicating to the fishers the information in real-time from sensors using phone apps and the web. Identified key data sets for the set net fishery were current velocity, wave height and direction, and wind velocity and direction. High current velocities can submerge the trap making recovery difficult and enabling escapement of trapped fish, and data on waves and winds is used to plan recoveries of gear. Prior to the tsunami, most implemented monitoring was for temperature (and mostly for aquaculture needs), but aquaculture and fishers are able to get temperature data from other sources, whereas current velocities are not readily available elsewhere. Conversations with the stakeholders identified a previously unknown priority to set net fishers, which could be met in deploying replacement monitoring systems. Peterson, Orsi and Mundy and Ito and Yamada provided compelling real-world examples of the value of the types of scientist-stakeholder engagement for which SOFE was established.

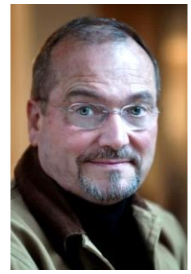
An important aspect of effective communication is building consensus among stakeholders using diverse methods to reach common understandings. Presentations by Seino, Barbeaux and Lee, and Volk *et al*. provided examples of this critical aspect of SOFE's four-step process for developing useful products to inform stakeholders about climate change. Seino (Japan) introduced the topic by describing how several international conventions and treaties, such as the Convention on Biological Diversity, and international trends, such as in coastal and wetland conservation, have enabled new multi-sectorial environmental conservation and restoration frameworks in Japan. Seino noted that domestic coastal environmental issues have become very complicated, and social sectors are demanding more integrated approaches to management and increased communications across sectors. Seacoast habitats, especially rocky shores, are of immense cultural and aesthetic value in Japan. For example rocky coastal areas are the workplace of highly respected and iconic elderly women who gather seaweed and harvest shellfish. Communication between managers and their constituents is important in shaping the evolution of coastal policy in Japan. Building consensus among stakeholders was highlighted by Volk *et al*. (USA), who described the exhaustive process and intricate organizational framework that was essential to effectively communicate with diverse stakeholders who were concerned about inequities of regional harvest patterns of chum and sockeye salmon in the fisheries of Western Alaska. The Western Alaska Salmon Stock Identification Program (WASSIP) was implemented to inform participants regarding the origin of salmon in commercial and subsistence salmon fisheries. Residents of western Alaska were very concerned that fisheries in other parts of Alaska were removing so many salmon that their opportunity to harvest was precluded. WASSIP used accepted genetic methods to identify the origins of salmon in the contested areas, thereby gaining widespread trust among regional interests. The key to success at resolving the disputes was effective communication with stakeholders about the fundamentals of sampling design and statistical analysis protocols. The common understandings achieved on the reliability of sampling and statistical methods of analysis satisfied stakeholder concerns to the extent that the results were accepted as a basis for agreement. Consensus building between managers and harvesters was further illustrated by Barbeaux (USA), who described joint USA-Korea cooperative research projects using Korean managed fisheries. The research was intended not only to collect data for fisheries management, but also to foster communication and broaden stakeholder engagement in fisheries research. Consensus was achieved by developing a trusted common data base, as was also the key to success on the studies described by Seino and Volk *et al.* The respected common database was built by providing relatively inexpensive temperature loggers on fishing gear (headropes of commercial trawlers; red snow crab pots; and soon commercial longliners and purse seines). Opportunistic acoustic data archiving to hard drives was collected to describe animal density, depth and seasonal distribution. Lessons learned from the consensus-building exercise are that fisherman and stakeholders in Korea and USA are eager to participate in cooperative monitoring/ research, that stakeholders develop greater trust in science when engaged in data collection, and that the resulting consensus improves communication. In addition, formulating and communicating clear and reasonable objectives for researchers and participating stakeholders is essential to successful participatory science, as is developing realistic expectations among fishers and managers. Cultural differences matter. For instance, in Korea, small mistakes are more likely to discourage stakeholder cooperation, whereas in the USA, such missteps are considered learning opportunities that contribute to the successful evolution of consensus building projects.

In the realm of human dimensions, the session established the principle that communicating effectively requires understanding the diversity of values and motivations among stakeholders (Yagi *et al.*, Kurilova). Yagi (Japan) contrasted the results of a socioeconomic survey of coastal and inland communities in Japan regarding the importance of marine ecosystem services and its influence on human behavior. He identified three factors important in regulating behaviors with regard to marine ecosystem services: essential benefits (supporting services of the Millenium Ecosystem Assessment [MA]), indirect benefits (analogous to regulating and provisioning services of MA), and cultural benefits (corresponding to cultural benefits of MA). For people in both coastal and inland areas, cultural benefits were most linked to behavioral intentions, including funding marine conservation—even more so than essential benefits. Cultural benefits, moreover, were the only significant influence in inland regions. Conversely, essential benefits also influenced behavior in coastal populations. The survey results suggest that enhancement of cultural benefits will most impact future marine conservation efforts. Reinforcing the importance of understanding the values and motivations of stakeholders, Kurilova (Russia) described that the mechanism of communication in remote coastal Russian communities depends on the strong regional cultural differences of small ethnic communities, which often have unique local concerns. Her conclusion was that the message and method of communication depends on the audience; therefore, understanding the diversity of values and motivations among stakeholders that directly determine the level of satisfaction from ecosystem services is essential to effective communications.

Models are a powerful means of effectively communicating the consequences of climate change on living marine resources and the human uses of those resources. Zhang (Korea) described the current status of Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME) as a framework supporting ecosystem approach for fishing. He reviewed the ecosystem effects of fishing, which in addition to harvest mortality (the direct effect), have indirect, perhaps undesirable side effects of bycatch, habitat modification or destruction, and biological interactions. IFRAME involves assessment of ecosystem structure and risk, forecasting structure and risk, and evaluating and implementing management. The implementation is iterative, with feedbacks from management on assessment and forecasting. New to IFRAME is the use of semi-quantitative or qualitative analysis when knowledge level of the ecological systems is low. Zhang showed examples of how IFRAME methods contribute to FUTURE objectives and questions, how AICE and COVE could contribute to the assessments, forecasting and management aspects, and how SOFE should be used to disseminate outlooks and forecasts from IFRAME, and solicit feedback from management strategies.

Dr. Phil Mundy, one of the co-convenors of S3, addressing the audience.

Each of the nine presentations described above illustrates successful application of SOFE's four-step process for fulfilling the FUTURE premise that it is possible to deliver useful and timely products on climate driven ecosystem change to resource stakeholders. The validity of this premise was a cornerstone of the rationale for creating the PICES FUTURE program. The session has provided extensive examples that validate the fundamental FUTURE premise. A potential stumbling block for extending the application of the FUTURE premise is the daunting nature of the data collection efforts necessary to build the long time series of observations that underpinned the examples of success presented in this session. Moving toward full operational status will require secure long-term funding to continue the observational framework that enables forecasts and outlooks of the type described in this session.



Dr. Phillip Mundy (Phil.mundy@noaa.gov) is Director of Auke Bay Laboratories (ABL), Juneau, Alaska. As a division of NOAA's Alaska Fisheries Science Center, ABL collects observations on the physical and biological properties of the Gulf of Alaska, Bering, Chukchi and Beaufort Seas to provide information for management of living marine resources. Phil received his Ph.D. in Fisheries Science from the University of Washington. He served on the faculty of Old Dominion University and the University of Alaska Fairbanks. He has served as a scientific advisor to the North Pacific Fishery Management Council and the Pacific Salmon Commission. Phil was a charter member of the North Pacific Research Board who contributed to developing the Bering Sea Integrated Ecosystem Research Program. His most compelling current interest is implementing the ecosystem approach to management in the Arctic, which he pursues as a U.S. delegate to the Arctic Council. In PICES, he serves as Chairman of the Advisory Panel on Status, Outlooks, Forecasts, and Engagement and Advisory Panel on the Continuous Plankton Recorder Survey in the North Pacific, and is a member of Science Board and MONITOR.

Dr. Hal Batchelder (hbatch@pices.int) is the Deputy Executive Secretary of PICES (since February 2014). Prior to assuming that position he was a Professor in the College of Earth, Ocean and Atmospheric Sciences (CEOAS) at Oregon State University. Hal has contributed to PICES in diverse ways previously: Co-chairman of the Climate Change and Carrying Capacity integrative science program and Science Board member; member of several study groups and working groups; member of AP-SOFE; and U.S. delegate to the PICES Governing Council. His research specialization is biological oceanography and ocean ecology, with emphasis on zooplankton population and community ecology, and the coupling of ecological processes to ocean physics using numerical models. Recent interests have included design of Marine Protected Areas, and the changing incidence of hypoxia on the U.S. west coast and its potential impacts on shelf organisms.

(Continued from page 11)

on the region and dynamics of interest. Furthermore, it may be necessary to adjust model resolution after an initial exploratory investigation. Another topic during the discussion was on the need and future of ensemble modeling in regional settings and the unique challenges that could emerge. Of note was the conversation on the expected number of ensemble members and the need for multi-model ensembles. Finally, the participants discussed the topic of bias propagation from global to regional models and from physics to biogeochemistry. The discussion focused on ways to identify and quantify model biases in the different model components.

Dr. Enrique Curchitser (enrique@esm.rutgers.edu) is an Associate Professor at the Department of Environmental Sciences and the Institute of Marine and Coastal Sciences at Rutgers University, USA. His main research interests are at the intersection of climate and ecosystems. His current projects range from downscaled coupled bio-physical modeling in the California Current and Bering Sea, the impact of climate change on coral bleaching in the Coral Triangle and on the role of the Gulf Stream in the climate and social systems of the northeast U.S. He is a member of the PICES Physical Oceanography and Climate Committee, Working Group 27 on Climate Variability and Change in the North Pacific and co-chairs Working Group 29 on Regional Climate Models.

Dr. Jang Joo Chan (cjjang@kiost.ac) has been a Principal Research Scientist in the Ocean Circulation and Climate Research Division of the Korea Institute of Ocean Science and Technology since 2011. His research interests include analysis and modeling of climate change in the North Pacific Ocean, focusing on Korean waters, circulation–ecosystem couple modeling, and turbulence modeling. He is a member of the PICES Physical Oceanography and Climate Committee, Working Group 27 on Climate Variability and Change in the North Pacific and co-chairs Working Group 29 on Regional Climate Models.