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Editorial

The importance of understanding ecosystem processes in the Eastern Bering Sea

At the risk of belaboring the obvious, the eastern Bering Sea is an amazing place. It has an equally amazing group of people conducting science in and on it. This ecosystem and cadre of scientists are well known, but not as well as they should be. This special issue, and the ones that preceded it (Ashjian et al., 2012, 2013, 2014), will help to further showcase this important ecosystem and this important body of work.

The research presented here, as part of a series of reports resulting from Bering Sea Project, focus on the mechanisms underpinning how climate change and reduced ice cover can significantly impact the Bering Sea ecosystem and its component biota (Sigler et al., 2010). To the uninitiated, this high latitude ecosystem is very productive and supports one of the largest fisheries in the world. There are major features of Pacific physical and chemical oceanography that come together in this ecosystem, and the interface of that oceanography with waters from the Arctic make this one of a few critical transition regions in the world. In essence, this ecosystem is ground zero when it comes to climate change impacts, especially regarding the southern extent and duration of sea ice in the Bering Sea and associated ice-edge effects (e.g., change in salinity, primary production, etc.). It may very well be that the eastern Bering Sea is the gateway for commercially important biological taxa among three main ocean basins—the Arctic, the Atlantic, and the Pacific (Wisz et al., 2015). There are clear records of major changes to this ecosystem that have occurred on sub-decadal time scales, relatively fast time frames for such major shifts. The amplitude and frequency of such shifts are not likely to lessen in any projected future. Iconic species associated with pristine Arctic and sub-Arctic systems abound in this ecosystem. Local communities in this region have some of the strongest connections to their marine ecosystem compared to anywhere in the world, with a rich and well-preserved history of local and traditional ecological knowledge. The resources in this ecosystem support a significant part of the regional, national and even international economies.

Thus, whether one is familiar with it or not, the eastern Bering Sea ecosystem is indeed unique, critical and important to understand.

From my perspective as the National Oceanic and Atmospheric Administration's leading voice for Ecosystem Science and Management, the Bering Sea Project has other important facets also worth noting. What makes this collective body of work particularly attractive is that it is interdisciplinary, spanning a wide range of taxa, processes and features. It is rare to see works spanning and connecting taxa ranging from euphausiids to walrus to kittiwakes to the micro-zooplankton nexus to arrowtooth flounder to fur seals to *Pseudocalanus* to Pacific cod to, of course, walleye pollock. How these taxa potentially link together is explored by a range of studies examining processes such as hydrodynamics, recruitment, growth, migration, ice-melt, harvest, stratification, or consumption, among others. The broad and inclusive scope of such key features of the Bering Sea is laudable.

This body of work is also laudable in that it is integrative, seeking to connect all of the major facets of ecosystem dynamics. It attempts to link patterns to underlying processes, epitomizing process-oriented research and the need to continue to conduct such research. This body of work also capitalizes on long-term investments, especially monitoring and surveying that is not always the most attractive to maintain but results in absolutely critical time series of multidisciplinary information. Without such time-series, works like those described in this special issue would have no context; would be hard-pressed to have patterns emerge, from which processes or mechanisms can be hypothesized; and would have insufficient data from which integrative models and stories could be developed. Collectively this research contains a marvelous blend of field, laboratory, analytical, and modeling work.

Also noteworthy is that this body of work has a strong consideration of— and clear application to— resource management, driven equally by end-use research and hypothesis-driven considerations. Particularly appealing is the mixture of hypothesis testing with synthesis of major features of the eastern Bering Sea. Also worth highlighting is the collaborative nature of these works across a wide range of institutions. The products from this set of efforts are clearly the result of well-executed partnerships; the work resulting from the contributions (both financial and otherwise) of NSF, NPRB, NOAA and others represents what interagency and multi-organization cooperation can and should produce. Knowing how these large projects can go, undoubtedly there were challenges along the way if for no other reason than the usual “herding the cats” associated with some 100 principal investigators, but the perseverance and commitment by all project partners resulting in the suite of papers in the four special issues, together with the many Bering Sea Project papers published in other journals and book chapters (totaling nearly 200 to date), is extremely laudable.

This special issue, the fourth (and final) in the series of collections from this project contains contributions that are delightful to read. The inclusion and consideration of lower trophic level organisms and feeding ecology is too often neglected in the science and management of upper trophic level species that have commercial or conservation importance. That there was serious effort and copious works in this special issue to address zooplankton and trophodynamics is an encouraging sign that

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these other sources of information will be even more duly considered in a fisheries management context for this ecosystem. Studies that examine the responses of upper trophic levels relative to environmental drivers, directly or as mediated by food web dynamics, are useful and worth showcasing. The synthetic set of modeling investigations also warrants highlighting, as this information needs to be increasingly incorporated into advice that will assist managers in making decisions regarding this ecosystem.

There remains a healthy tension inherent to end-use driven research. On one hand, we often need to ask whether we know enough to decisively act for a particular set of management decisions. Yet on the other hand, we also want to ensure that we are still asking the right scientific questions and not just providing answers without continued scientific exploration. For instance, is there still the allure of discovery remaining in this ecosystem? Is that concurrent with advancing our knowledge enough to help solve ongoing societal challenges, principally as demand for fish continues in the face of global climate change? To me that tension shall always remain, and projects like this one need to continue to strike a delicate balance of seeking both mechanistic understanding and providing advice that can be used to manage our trust species and ecosystems. In many respects, this project has indeed been cognizant of, and navigated well, this ongoing delicate balance.

As a champion of marine ecosystem work, I continually look for case studies that exemplify how we can do the science necessary to support ecosystem-based management (Link and Browman, 2014). Does such work consider climate? Does such work consider ecological interactions? Does such work consider tradeoffs across species? Does such work consider socio-economic responses to changes in the ecosystem, including that which ranges from small community considerations (subsistence, cultural uses) to very large-scale commercial fishing? Does such work consider the entire integrated system of processes and taxa and uses? Does such work explore a full suite of drivers and responses, beyond typical single sectors or drivers? The collective work herein provides an excellent example of such considerations.

The eastern Bering Sea ecosystem shall remain a critical place as global changes continue. As we continue to move forward with ecosystem-based management, it is precisely studies such as those found herein as part of the Bering Sea Project that will provide the requisite information to underpin future choices we make in this and other marine ecosystems.

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