Salmon-Oriented Ecosystem Monitoring in the California Current using Autonomous Survey Technology

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Figure 1: Scientists from Oregon State University (John Barth, left) and NOAA (David Huff, right) launch the Slocum Glider. It'll fly through the ocean for weeks collecting data on physical characteristics, acoustically tagged salmon, krill, and oxygen. Photo credit: *Kristian Foden-Vencil / OPB;* https://www.opb.org/news/article/climate-change-pacific-ocean-science-oregon/

NOAA Fisheries is applying emerging technologies to develop ecosystem-based management (EBM) approaches to U.S. Fisheries (Figure 1). Salmon, with their complex and diverse life histories, geographic range, critical role in the ecosystem and culturally and economically important fisheries, will benefit from EBM – management strategies that consider all the direct and indirect factors related to salmon (Figure 2). The next few decades of research and survey efforts will seek to inform the management of salmon in the context of their ecosystem. We will focus on a number of specific processes critical to recruitment of salmon and changes in ocean conditions and their predators and prey.

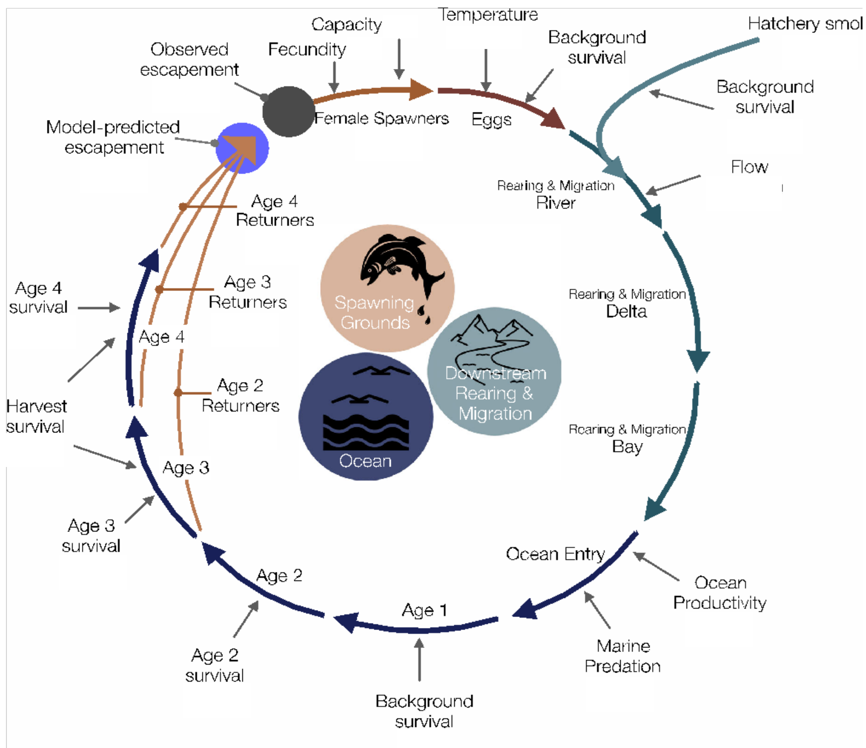

Figure 2: Data from this survey effort is directly applicable to life-cycle models that researchers are developing and managers are using to test management strategies. Specific life-history aspects this research informs include, Ocean Productivity, Marine Predation, Survival, and Return dynamics. Image credit: *Whitney Friedman, PhD, NOAA*

With funding and logistic support from the NOAA Office of Marine & Aviation Operations (OMAO) Uncrewed Systems Operation Center, scientists from the NOAA Fisheries', Fisheries Ecology Division, Southwest Fisheries Science Center (SWFSC) are expanding the sampling capabilities of autonomous underwater gliders. The SWFSC will use autonomous vehicles (primarily Slocum gliders) equipped with acoustic instruments to augment data collection along the California and Washington coasts. This will demonstrate the efficacy of these tools to quantify how the ecosystem affects salmon and how ecosystem components rely on salmon. Understanding how salmon populations respond to changing ecosystems, including impacts of climate change and predator demand, will inform managers as they seek to meet mandated salmon restoration goals. However, providing ecosystem-informed advice requires new approaches to monitoring and research. Autonomous vehicles and other advanced technologies will provide data at a fraction of the costs of traditional ship-based surveys after initial investments are made.

Predator-prey interactions and salmon. In recent decades, marine mammal and seabird populations in the California Current have increased substantially, and EBM strategies to mitigate increasing predation on salmon will support restoration and recovery of salmon (and other) populations. Further, the combined effects of climate change and increased consumption of salmon by predators requires an understanding of trade-offs in the restoration and recovery of salmon and salmon-dependent predators. However, we presently lack realistic models to evaluate outcomes of management scenarios, including risks of failure. The AUVs will help improve the models.

The role of oceanographic features to promote trophic hotspots. Forage species are concentrated at oceanographic fronts and upwelling shadows, especially inshore of these features. Salmon may take advantage of these feeding conditions. For example, salmon condition and abundance are greater inside of the Columbia River Plume front, and there is greater feeding success by salmon near upwelling fronts. The productivity of salmon is greatest when fronts are more common, suggesting that fronts benefit salmon through population-level responses. What is less understood and likely of great importance is oceanographic features that draw predators, increasing their interaction with salmon sufficient to offset any trophic benefits. This is of particular concern because consumption of salmon by predators has increased substantially over recent decades, and climate events can create conditions in which salmon might be forced to concentrate at fewer, less-productive fronts. AUV technology is well suited to sample these ephemeral, small features.

We use AUVs (primarily Slocum gliders) equipped with acoustic instruments to augment data collection along the California and Washington coasts. This effort demonstrates the efficacy of these tools to quantify how the ecosystem affects salmon and how ecosystem components rely on salmon, thereby moving the agency towards informed EBM. The incorporation of ecosystem considerations in fish stock assessment has been slow. Identifying ecological processes that underlie observed statistical relationships will improve confidence forecasts of salmon recruitment and resilience under future climate change and ecosystem variability. Specifically, quantifying variability in food webs and impacts on salmon as the environment and predator/prey fields' change is a critical requirement to move towards EBM. Our survey uses Slocum gliders to collect data on oceanography, salmon forage (i.e., scientific echo sounders), and salmon behavior (i.e., acoustic receivers of tagged salmon). In situ biological sampling including trawl samples to validate acoustics, environmental DNA (eDNA), and visual salmon predator observations (piscivorous seabirds and marine mammals) will augment the gliders. Sampling occurs during three consecutive weeks in April/May in California at the Gulf of the Farallones and three consecutive weeks in May/June in Washington at Grays Harbor; two productivity hotspots along the California Current. This sampling corresponds to salmon outmigration timing from each region. Our crewed efforts collect relevant biological data at this finer-scale to quantify the trophic dynamics inside, on, and beyond these features. This design will improve our understanding of the ecosystem and parametrization of ecosystem-level processes.