Environmental monitoring of Pacific halibut (*Hippoglossus stenolepis*) habitat in the north Pacific and Bering Sea

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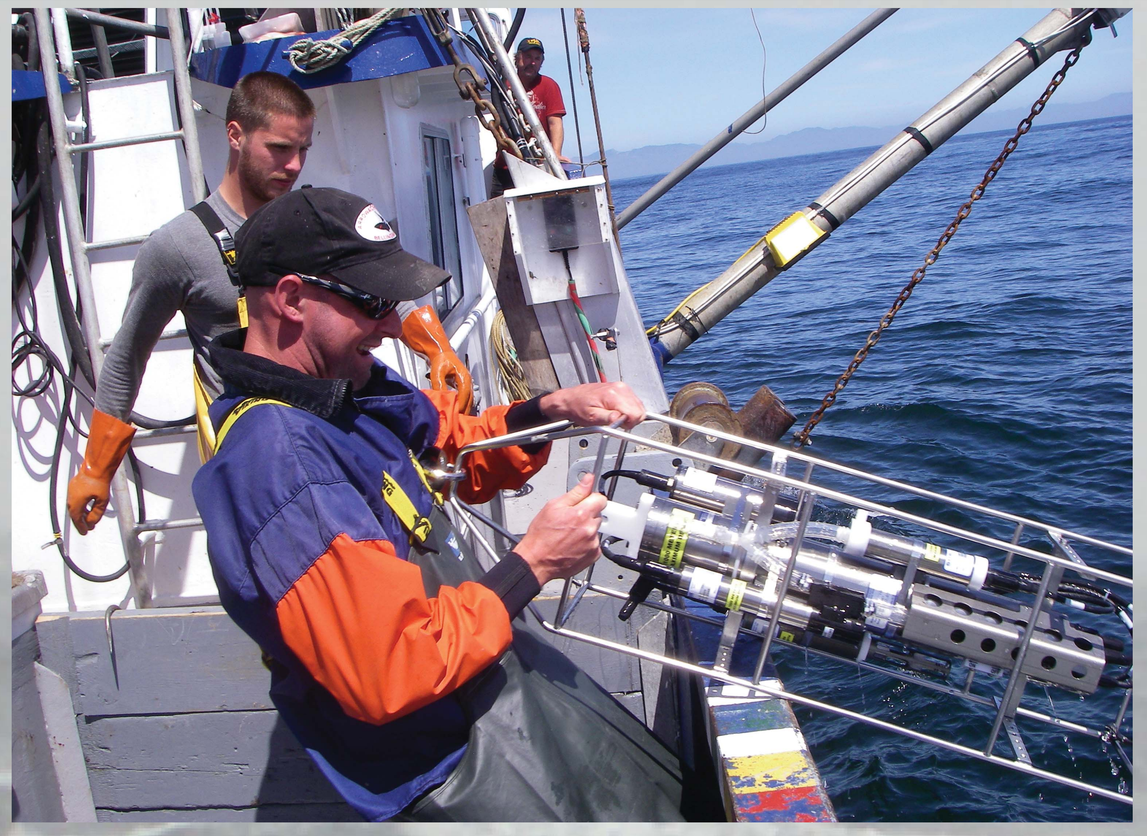
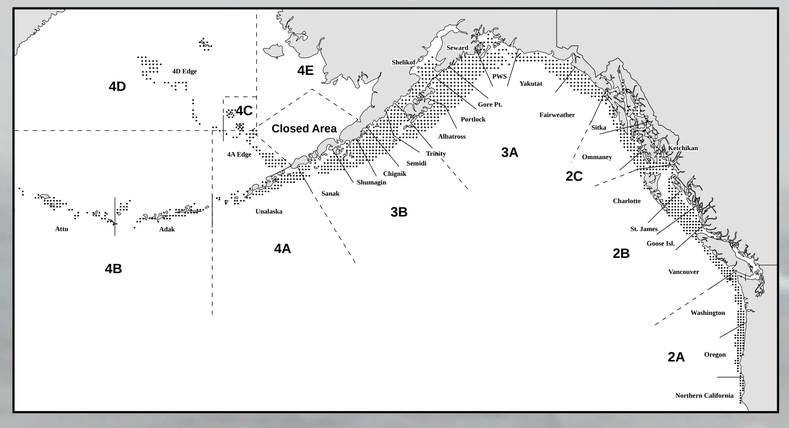
Introduction

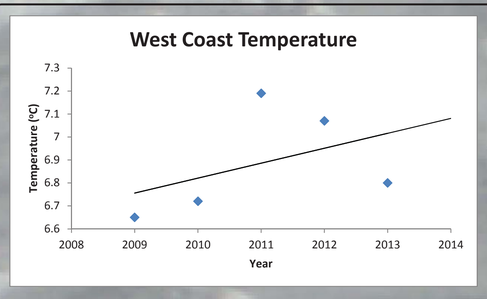
In 2009, the International Pacific Halibut Commission (IPHC) launched a coastwide environmental monitoring program. With the help of grants from the National Oceanic and Atmospheric Administration and the Oregon Department of Fish and Wildlife, the IPHC purchased 15 water column profilers from Seabird Electronics Inc. The profilers have been deployed from IPHC survey vessels at over 1200 stations annually (stations shown as dots on the map). The instruments collect surface to near-bottom data on temperature, salinity, dissolved oxygen (DO), pH, and chlorophyll, and are deployed just prior to hauling the gear at each survey station. The near-bottom readings from the profilers can then be matched with catch information from the gear to better understand Pacific halibut (*Hippoglossus stenolepis*) habitat, and environmental effects on halibut catch-per-unit-effort.

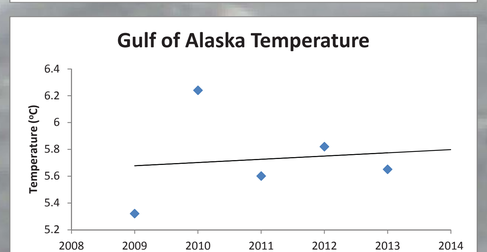


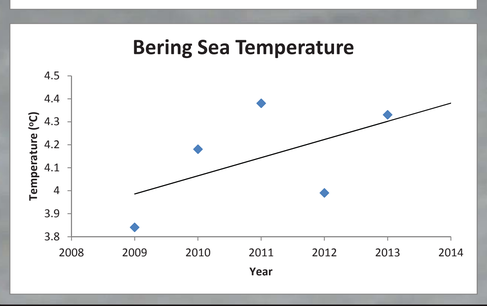
Background

The IPHC has managed the Pacific halibut stock in U.S. and Canadian waters since 1923. The ongoing health of the resource has been successful in large part due to its cooperative involvement of scientists, stakeholders, and others to map out innovative ways to approach research and management. IPHC scientists recognized in the late 1990s that monitoring environmental conditions coincident with catch may eventually contribute clarity to the stock assessment and aid in management strategy evaluation. The addition of environmental data seemed particularly important given that the effects of climate change were already being documented around the globe, and baseline environmental data for North American continental shelf bottom habitats was extremely limited.







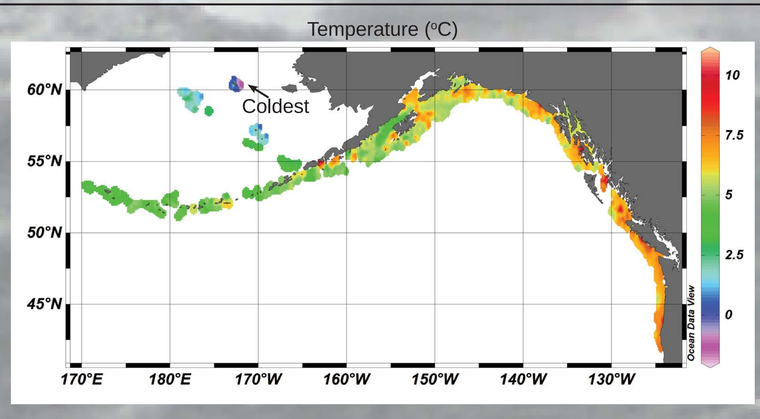


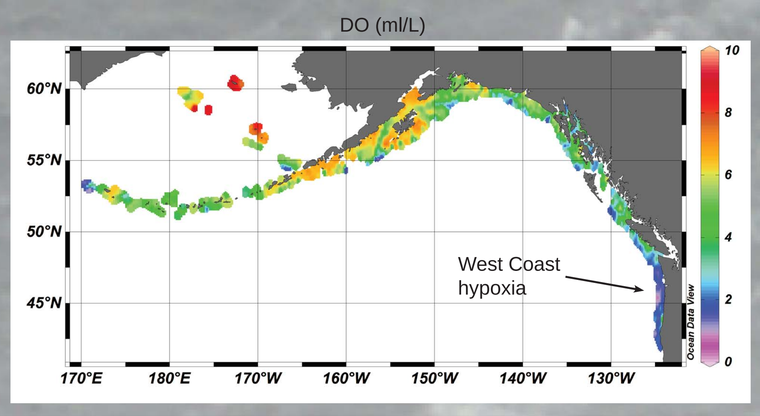
Patterns in the first five years

Five years of data are not enough to declare a trend, but IPHC data showing increasing temperature patterns of near-bottom habitat (figures to the left show mean values) on the West Coast and in the Bering Sea, are compelling.

Generally speaking, near-bottom conditions along the U.S. West Coast and British Columbia are characterized by low DO, low pH (more acidic water), wamer temperatures, and moderate amounts of primary production. Gulf shelf bottom waters tend towards the mid-range between West Coast and Bering Sea values. The Bering Sea and Aleutian Islands are characterized by cooler temperatures, higher DO except at very deep stations, moderate primary production, and a variety of pH conditions.

	Temperature(°C)			Salinity (psu)			DO (ml/L)			pH		
WC	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
2009	6.65	5.12	10.54	33.62	31.75	34.10	2.25	0.73	6.00	7.7	7.5	8.1
2010	6.72	4.77	10.00	33.61	31.82	34.14	2.36	0.59	5.76	7.9	7.6	8.4
2011	7.19	4.48	10.95	33.40	29.10	34.25	2.62	0.31	6.48	8.0	7.6	8.3
2012	7.07	5.29	10.48	33.52	30.92	34.13	2.68	0.57	6.25	7.9	7.6	8.5
2013	6.80	4.83	11.03	33.61	28.39	34.18	2.29	0.47	5.84	7.7	7.3	8.3
BS												
2009	3.84	0.17	6.34	32.90	31.28	34.07	5.41	0.46	7.84	8.0	7.5	8.4
2010	4.18	-0.33	7.07	32.98	30.91	34.15	5.11	0.42	7.41	8.0	7.6	8.4
2011	4.38	-0.26	8.11	32.84	31.06	34.16	5.34	0.39	9.87	8.1	7.4	8.4
2012	3.99	-1.44	9.26	32.84	30.59	34.15	5.61	0.47	9.19	8.1	7.6	8.7
2013	4.33	1.50	6.68	32.92	31.72	34.14	5.53	0.63	7.46	8.0	7.6	8.3
GOA												
2009	5.32	2.63	10.01	32.79	31.25	34.08	4.76	0.66	8.46	8.0	7.6	8.4
2010	6.24	3.93	11.65	32.67	29.99	34.05	4.94	0.60	7.79	8.1	7.5	8.5
2011	5.60	3.24	9.82	32.79	30.41	34.03	4.79	0.73	7.70	8.0	7.6	8.4
2012	5.81	3.43	10.57	32.69	29.52	34.12	5.07	0.49	7.88	8.1	7.6	8.6
2013	5.65	3.37	10.27	32.76	30.77	34.06	4.87	0.65	8.43	8.0	7.4	8.3

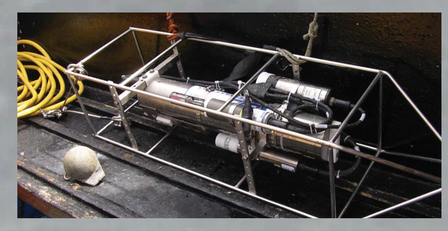




Near-bottom conditions

The plots to the left show near-bottom coastwide conditions in 2012, color coded. As in all other years, the coldest bottom temperatures were seen on the northeast side of St. Matthews Island in the Bering Sea. The pattern of warmer waters in the east and south and cooler waters to the north and west are clearly evident.

DO is lower to the east and then increases to the north and west. The hypoxic zone clearly seen here off of Washington and Oregon to the south, has been an annual feature in the area since before the survey began collecting environmental data coastwide.



Potential uses of environmental data in fishery management

Current halibut management focuses on age and length-class schedules along with accounting for removals from the stock as the primary means of predicting how many fish are available for harvest. Managers know that commercial catches can vary temporally and spatially based on a variety of factors, and are becoming increasingly aware regarding fluctuating oceanographic conditions and their impacts on fishes. Recent studies have shown that environmental factors can contribute to altered behavioral, distributional, and fitness characteristics in marine organisms.

Traditional species accounting methods alone, such as setline surveys and commercial catch monitoring, may be affected by varying oceanographic conditions when variability in those conditions results in changes to animal behavior. For example, Stoner et al. (2006) and Sadorus et al. (2014) found that temperature and DO, respectively, may affect the feeding behavior of halibut. Because the survey fishing gear is passive, and capturing the fish requires particular behavior from the animal, if that behavior is altered given varying conditions, then the gear is not fishing the same across all areas and grounds. Knowing how oceanographic variables affect animal response to the fishing gear, is necessary to interpreting these data accurately.

Overlay plots

The plots above illustrate one particularly useful way of looking at survey catch results in relation to environmental data results. Shown here is halibut survey number-per-unit-effort (circles) in relation to near-bottom DO concentration (colored isosurface). Hypoxia is shown in bright yellow off the west coast and clearly, there are fewer halibut being caught there than further to the north and south where DO is higher (golds and browns).

References

Schlitzer, R., 2010. Ocean Data View, http://odv.awi.de.

Sadorus, L. L., Mantua, N. J., Essington, T., Hickey, B., and Hare, S. 2014. Distribution patterns of Pacific halibut (Hippoglossus stenolepis) in relation to environmental variables along the continental shelf waters of the US West Coast and southern British Columbia. Fish. Oceanogr. (23)3: 225-241

Stoner, A. W., Ottmar, M. L., and Hurst, T. P. 2006. Temperature affects activity and feeding motivation in Pacific halibut: Implications for bait-dependent fishing. Fish. Res. 81: 202-209.

Acknowledgements

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Data availability

All profiler data are processed then posted by NOAA personnel. Interested researchers can access the data here http://www.ecofoci.noaa.gov/projects/IPHC/efoci_IPHCData.shtml