5.1 IPHC oceanographic monitoring program aboard the fishery-independent setline survey in 2016

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Abstract

This was the eighth consecutive year of the International Pacific Halibut Commission (IPHC) coastwide oceanographic data collection program. Oceanographic data are collected using water column profilers during the IPHC fishery-independent setline survey that spans the area from southern Oregon in the U.S. northward to British Columbia, into the Gulf of Alaska, Bering Sea, and Aleutian Islands. The IPHC has operated profilers since 2000 on a limited basis, and coastwide since 2009. Oceanographic data were collected at a total of 1,206 stations out of a possible 1,366. The coldest near-bottom water (-0.67°C) was detected, once again, around St. Matthew Island in the Bering Sea. The warmest near-bottom water (12.25°C) was the shallow water off the southern end of Kodiak Island. The U.S. West Coast once again had the lowest near-bottom dissolved oxygen of the surveyed area, but the hypoxic zone that was prevalent for several years (through 2013) was not detected.

Introduction

Since the expansion of its fishery-independent setline survey (survey) in 1997 to monitor the Pacific halibut (*Hippoglossus stenolepis*) population, the International Pacific Halibut Commission (IPHC) has annually conducted fishing operations at more than 1,200 stations ranging geographically from the U.S. West Coast to the Gulf of Alaska and Bering Sea, including waters off British Columbia (Fig. 1). Following a pilot program in the 2000s in which oceanographic data was collected coincident with survey fishing, the effort was expanded to all survey stations in 2009 and has since taken place annually (Sadorus et al. 2016). Oceanographic data is collected using water column profiling units manufactured by Sea-bird Electronics[1] that collect a suite of oceanographic data including pressure (depth), conductivity (salinity), temperature, dissolved oxygen, pH, and fluorescence (chlorophyll concentration). The models currently used are SBE19*plus*V2 units with auxiliary sensors. Sensor specifications are described in Sadorus et al. (2016).

All survey stations are located on the continental shelf and are arranged on an equidistant 10-nmi (18.52 km) grid (except for the Bering Sea flats area and a few stations in southeast Alaska). In addition to the standard grid used in the survey, stations are sometimes temporarily added because of a particular question or concern in areas not normally surveyed. The profiler is typically deployed at these additional stations, provided that the expected depth is < 500 m. Stations > 500 m are not profiled due to depth limitations of the rigging. A multi-year survey expansion was in its third year in 2016, and included additional stations along the continental shelf edge in the Bering Sea (Henry et al. 2017). Past years have included additional stations on the Bering Sea flats, as well as areas of the U.S. West Coast.

[1] Sea-bird Electronics Inc. 13431 NE 20th Street, Bellevue, WA 98005. http://www.seabird.com/

Expansion of the profiler program in 2009 was made possible through grants from the Oregon Department of Fish and Wildlife Restoration and Enhancement Program, and the National Oceanic and Atmospheric Administration (NOAA). The NOAA grant expired in September 2012 and ongoing maintenance costs are currently borne by the IPHC.

Methods

Instruments

The Seacat profiling units collect a suite of data throughout the water column. The sensors are protected by a stainless steel cage, 96 cm tall and specially designed for each unit. The primary units (pressure, conductivity, temperature) have titanium housings and are rated for deployment to depths of 7,000 m. The auxiliary sensors have maximum depth ratings ranging from 1,000-7,000 m which is sufficient for all standard IPHC survey stations. Part of the survey expansions that started in 2014 included stations with an estimated average depth as deep as 730 m. As a precautionary measure, the profilers are deployed at standard survey stations and expansion stations up to 500 m depth only.

To adapt the profiler for deployment from a Pacific halibut fishing vessel, a system was designed using weights and floats that permits the profiler to descend rapidly enough through the water column to collect valid data and also ensures that the unit will not crash into or become permanently attached to the ocean bottom (Hare 2001) . A sustained descent rate of 1-2 m/s is the target, and the weight of the assembly in the water is sufficient that, if the unit is allowed to free fall, the target descent rate is achieved.

A 15-meter anchor line is attached to the bottom of the profiler cage and a 40-pound longline anchor or cannonball is attached to the end of the line. A section of gangion line separates the profiler from the anchor line and acts as a weak link in case the anchor cannot be freed from the bottom. To the top of the cage, floats are attached that effectively offset the weight of the anchor in water. The floats are attached to standard buoy line which is almost neutrally buoyant (Fig. 2).

Deployment

A profiler unit was deployed at each eligible survey station, just prior to hauling the fishing gear. To deploy the unit, the anchor was lowered into the water followed by the profiler and cage, and then the buoy line and buoys. After a minimum 90-second acclimation period at the surface, the line was released, and the full setup allowed to free fall to the bottom. Each profiler took measurements from the surface to depth at a rate of four per second and a pump ensured consistent water flow past the sensors. Once the anchor hit the bottom, the remainder of the unit ceased descent shortly afterward due to the strong positive buoyancy of the floats. On board the vessel, it was usually evident when the anchor hit bottom because of a noticeable slackening of the line. At that time, the vessel's gurdy was engaged and the profiler was immediately hauled back aboard. Once on deck, a series of protocols were executed to clean the sensors and store the unit until the next deployment, as outlined in the Seacat operation manual (IPHC Unpub.).

Data capture

Each profiler was shipped into the field with a dedicated laptop computer. Approximately once per day, the profiler was connected to the computer, data were uploaded, and the profiler unit was then reset for the next day's casts. The data were sent remotely or via data storage cards

back to the Seattle office after each trip. To facilitate quicker retrieval and processing of the data, beginning in 2013 a cloud storage service has been used to transmit the data more efficiently to the IPHC office. Specifically, when the vessels arrived in port after each trip, the samplers (whenever possible) connected the laptops to the internet whereby data were automatically uploaded to a secured storage location in the cloud and were immediately accessible to office staff.

Results in 2016

Two of the profilers were lost at sea early in the program, and one remaining profiler was an older model that was used less often. One replacement profiler was purchased in both 2015 and 2016, and the older model was upgraded, bringing the total number of units to 15. There were some minor operating issues with the profilers in 2016, but most cases were successfully dealt with in the field with office assistance.

Data collection

In 2016, a total of 14 fishing vessels were chartered to complete the survey (Henry et al. 2017) and each vessel was outfitted with a profiling unit, a laptop computer, and accessory gear. Out of a possible 1,366 stations coastwide, 1,206 useable casts of environmental data were collected (Table 1), resulting in an 88% success rate.

Occasionally, data collection was unsuccessful or not attempted, and there were several reasons for this. The vessel captain and lead biologist together decided whether it was prudent to launch the profiler, given the conditions at each station. Poor weather and strong tides periodically resulted in missed casts. In one case, a metal cage that protects the pH sensor was accidentally lost overboard and the unit could not be deployed until a replacement could be sent to the vessel. Unfortunately, on that same vessel a few days later the profiler anchor was lost which also delayed deployment until a replacement could be acquired. Due to the laptop computer becoming separated from the rest of the gear, one vessel's profiler was deployed, but casts could not be uploaded. The laptop was retrieved after the first trip, but during upload, an incorrect command was mistakenly sent to the profiler and the data could not be retrieved in spite of efforts by office staff to troubleshoot the problem. On stations where tides were strong but the station was otherwise deemed viable, the samplers were allowed to incorporate up to 60 pounds (27 kg) total to the bottom of the assembly to achieve a more vertical descent.

The original laptop computers, most purchased in 2008, have exceeded their expected lifespan, due largely to the careful handling of these units by the field staff. Replacement began in 2015 with the replacement of three laptops, followed by three more in 2016. Additional replacement units are expected to be purchased over the next several years. Currently, both the port and survey programs are beta-testing field tablets for data capture, which may eventually be used for profilers as well. However, laptops will likely be kept active for the foreseeable future, either as the primary data capture or backup system.

Environmental conditions on the halibut grounds

The sample area encompasses a wide range of environmental conditions. Off the U.S. West Coast, there were a few stations less than 200 m depth where near-bottom waters were hypoxic ($\leq$ 1.4 ml/L). However, the widespread near-bottom hypoxic zone, typically seen from 2002 at the more shallow stations off Washington and Oregon has not been detected during the survey

since 2013. Hypoxia was recorded at a number of very deep stations coastwide, and the lowest near-bottom dissolved oxygen concentration detected (0.57 ml/L) was in the western Gulf of Alaska at 444 m depth. The coldest near-bottom temperature (-0.67°C) was found once again, off of St. Matthew Island in the Bering Sea. The warmest near-bottom temperature (12.25°C) was measured at a shallow station just south of Kodiak Island in the Trinity survey region. Chlorophyll concentrations are highly variable both temporally and spatially, and occur in small concentrations throughout the Pacific halibut range. The highest chlorophyll concentration at 25 m depth was measured in southeast Alaska in the Ommaney survey region, although that occurred on the shelf edge and did not appear widespread among adjacent stations. Primary production was detected to a greater geographic extent along the continental shelf edge in the Bering Sea around St. Paul Island extending northward, and along the Aleutian Island chain. A complete set of figures displaying iso-surface plots for each environmental variable collected can be viewed in the online appendices.

Data processing and availability

A primary goal of this project is to make the survey profiler data available to scientists worldwide. The IPHC is working with the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) at the University of Washington and NOAA's Pacific Marine Environmental Laboratory to process the oceanographic data and make them publicly accessible. Completed data are available at: http://www.ecofoci.noaa.gov/projects/IPHC/efoci_IPHCData.shtml

Acknowledgments

The success of the profiler project depends on the efforts and cooperation of many people. We would like to acknowledge the IPHC survey program staff for competently incorporating the profiler project into the survey protocols, Collin Winkowski and Bruce Biffard for making sure the gear was ready for the field, IPHC sea samplers for their hard work and attention to detail in collecting the data, the survey vessel captains and crews for making sure the profilers were safely retrieved after every cast, and Peggy Sullivan at NOAA/JISAO for her tireless work on the data and website.

References

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Henry, E., Geernaert, T. O., Soderlund, E., Ranta, A. M., Kong, T., and Forsberg, J. E. 2017. 2016 IPHC fishery-independent setline survey. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2016. IPHC-2016-RARA-26-R. 175-215.

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Table 1. Number of profiler casts completed during the 2016 IPHC fishery-independent setline survey, by IPHC regulatory area, survey region, and vessel.

		Stations		
Survey region	**Reg. area**	**Profiled**	**Possible**	**Vessel name**
Oregon	2A	31	47	Pacific Surveyor
Washington		43	57	Pacific Surveyor
Vancouver	2B	41	41	Free to Wander
Goose Island		43	43	Free to Wander
St. James		41	42	Pender Isle
Charlotte		44	44	Pender Isle
Ketchikan	2C	37	41	Pender Isle
Ommaney		35	40	Kema Sue
Sitka		42	42	Kema Sue
Fairweather	3A	32	49	Kema Sue
Yakutat		51	51	Seymour
Prince William Sound		40	45	Bold Pursuit
Seward		44	48	Bold Pursuit
Gore Point		40	45	Bold Pursuit
Portlock		46	46	Clyde
Albatross		40	45	Clyde
Shelikof		24	45	St. Nicholas
Trinity	3B	40	47	Clyde
Semidi		42	47	Allstar
Chignik		44	45	Free to Wander
Shumagin		43	44	Polaris
Sanak		46	48	Polaris
Unalaska	4	64	66	Vanisle
4A Edge		51	57	Vanisle
4D Edge S		45	52	Sunward
4D Edge Central		48	53	Saint Peter
4D Edge N		44	47	Saint Peter
Adak		22	45	Norcoaster
Attu		43	44	Norcoaster
Total regions: 29		**1,206**	**1,366**	**Total vessels: 14**

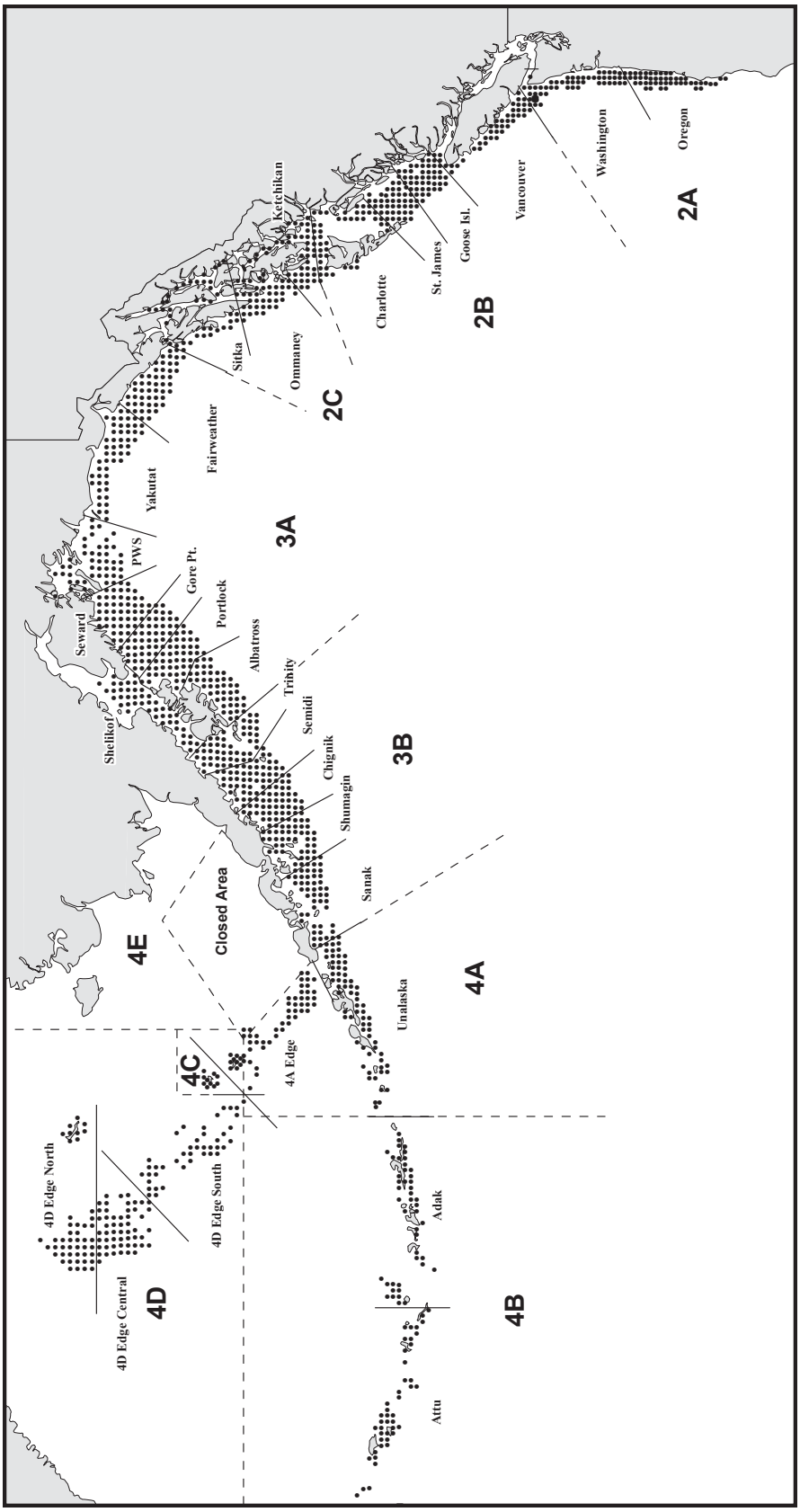

Figure 1. Stations surveyed and profiled during the 2016 IPHC fishery-independent setline survey (figure reproduced from Henry et al. 2017).

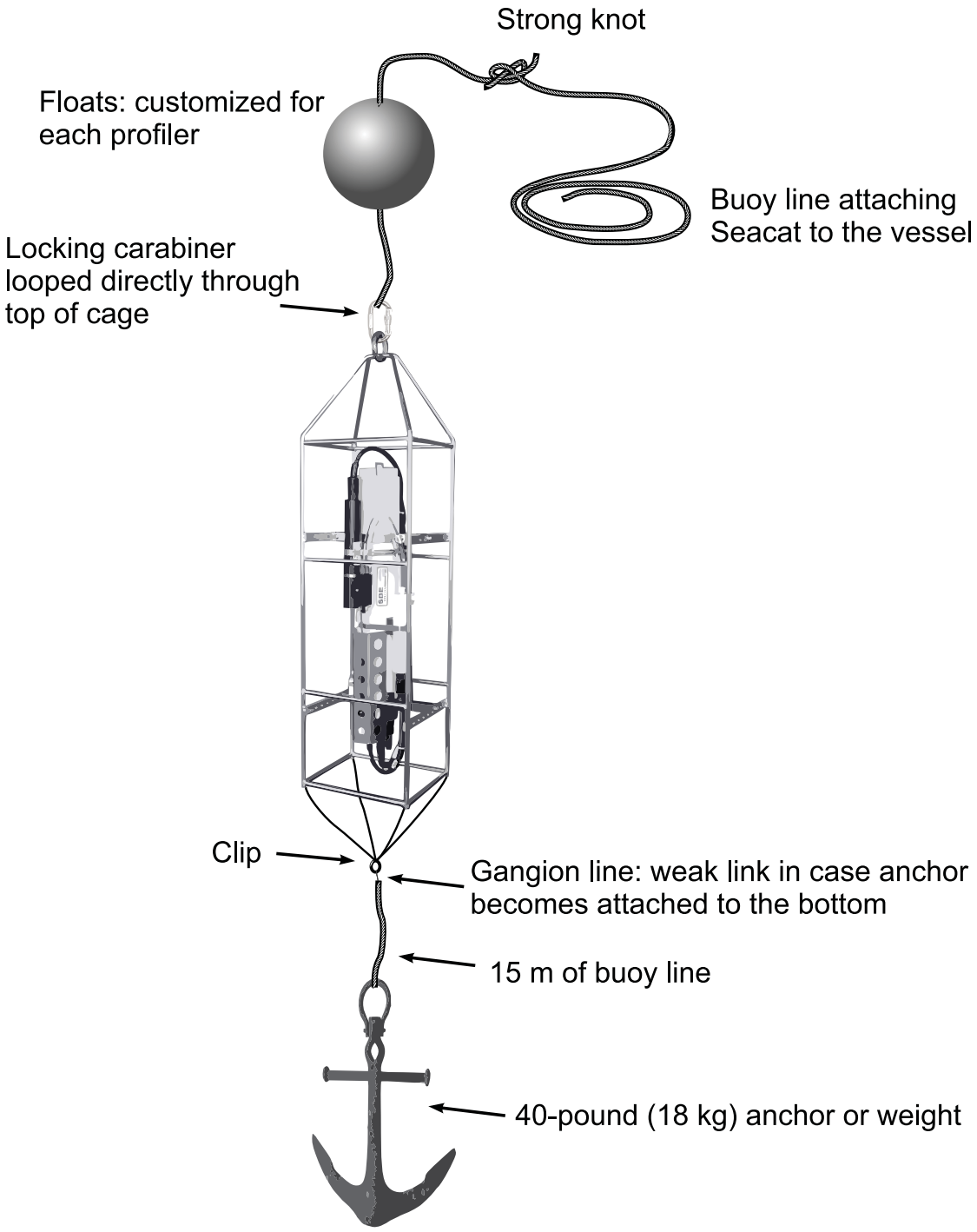

Figure 2. Schematic of the Seabird SBE19*plus* V2 water column profiler configuration used on the IPHC survey (reproduced from Sadorus et al. 2016).

Appendices (for website/full color viewing)

This section contains a series of plots produced using Ocean Data View (Schlitzer 2010) software illustrating oceanographic conditions in summer 2016 as measured by Sea-Bird profilers during the IPHC fishery-independent setline survey. Appendix 1 contains information for the U.S West Coast, Appendix 2 for the Gulf of Alaska, and Appendix 3 for the Bering Sea and Aleutian Islands. Temperature, salinity, dissolved oxygen, and pH are calculated using the deepest measurements at each station which is 5-15 m off-bottom. Chlorophyll *a* concentration is calculated using measurements at 25-m depth. The data are illustrated as iso-surface plots, which are continuous surfaces that use the observed point values to interpolate values at locations between those observations. Survey stations (i.e., where measurements were actually taken) are denoted as black dots. Note that these data have not yet been thoroughly analyzed and are considered preliminary.

Appendix 1: U.S. West Coast and British Columbia

Appendix 2: Gulf of Alaska

Appendix 3: Bering Sea and Aleutian Islands

To view the complete document online including the full color maps, please visit the IPHC website:
http://www.iphc.int/library/raras.html

Reference

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