

# Oceanographic monitoring during the IPHC setline survey in 2011

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## Abstract

This was the third year for the IPHC's comprehensive profiler project to collect oceanographic data from southern Oregon northward to British Columbia, into the Gulf of Alaska, Bering Sea, and Aleutian Islands. On an exploratory basis, this year stations were added in the Puget Sound and Strait of Juan de Fuca, as well as outside the traditional depth range of the survey in Oregon and Washington. The IPHC has been operating profilers since 2000 on a limited basis and coastwide starting in 2009. A total of 1,193 successful casts were made this year out of a possible 1,315.

## Introduction

Since the expansion of its survey operations in 1997, the International Pacific Halibut Commission (IPHC) has annually conducted fishing operations at more than 1,000 stations ranging geographically from Oregon to the Bering Sea. These stations are located on the continental shelf in depths between 35 and 500 meters, on an equidistant 10-nmi grid. As such, the IPHC operates the largest consistent sampling program of any research agency in the north Pacific. In the late 1990s, the IPHC sought proposals on how this sampling program could be used for other scientific investigations without affecting the core survey activities. One obvious project was the collection of oceanographic data. The IPHC already recorded bottom temperature at one-quarter to one-half of the survey stations; however, the potential existed to sample the entire water column.

To better understand the factors driving fluctuations in growth and recruitment of fish populations, researchers are paying increasing attention to climatic and oceanic conditions. Primary and secondary productivity are directly driven by variations in water temperature, salinity, dissolved oxygen, and other factors. Most of this productivity occurs in the mixed layer, between 20 and 100 meters depth. Acidification of the oceans and upwelling-induced hypoxia are just two of the phenomena linked to global climate change in recent years. How these fundamental changes in the physical and chemical makeup of the ocean waters affect the health and distributions of organisms living there is not well understood. Coupling oceanographic observations with catch estimates from the IPHC setline survey (White et al. 2012) is an obvious next step to increasing the understanding of what drives the abundance and distribution of our natural resources.

In 2000, a Sea-bird™ Seacat SBE-19 water column profiler was purchased by the IPHC and deployed aboard a commercial halibut longliner chartered for the annual stock assessment survey. In 2007, the IPHC received a grant from the Oregon Department of Fish and Wildlife Restoration and Enhancement Program to purchase a second Seabird™ Seacat SBE-19*plus* (an updated version of the SBE-19) dedicated to the IPHC survey stations off the Oregon coast. This new profiler was equipped with sensors to measure depth, temperature, salinity, dissolved oxygen (SBE-43), pH (SBE-18), and chlorophyll *a* concentration (WetLabs ECO-FLRTD).

The successful deployment of these two profilers aboard multiple vessels over multiple years and areas provided proof of concept that these oceanographic data could be collected with minimal

disruption to the survey operations. To that end, the IPHC received a grant from the National Oceanic and Atmospheric Administration (NOAA) in late 2008 to purchase 14 Seabird™ Seacat SBE19*plus* V2 water column profilers to be deployed on all survey vessels. This year was the third consecutive year of coastwide profiler deployment on the IPHC setline survey.

## **Methods**

The most recently purchased Seacat profilers are equipped with a titanium housing which is rated for depths to 7,000 meters. The sensors have maximum depth ratings ranging from 1,000 m to 7,000 meters, which is sufficient for all IPHC survey stations. The units weigh approximately 25 kg in air and 14 kg in water. The profiler is protected by a stainless steel cage, 96 cm tall and specially designed for the profiler. Software for downloading and displaying the data is provided by the manufacturer. Communication between the profiler and a laptop computer is accomplished via USB ports.

### **Profiler deployment**

To adapt the profiler for deployment from a 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, but also ensures that the unit will not crash into or become permanently attached to the ocean bottom. A sustained descent rate of 1-2 m/s is the target for this study. 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 using a section of gangion line as a weak link (in case the anchor cannot be freed from the bottom). A 40-pound longline anchor is attached to the end of the 15-meter line. To the top of the cage, two floats are attached that effectively offset the weight of the anchor in water. The floats are attached to standard halibut buoy line which is almost neutrally buoyant.

The unit is deployed at each station just prior to hauling the fishing gear at that station. To deploy the unit, the anchor is lowered into the water followed by the profiler and cage and then the buoys. After a minimum 90-second acclimation period at the surface, the line is released, and the full setup is allowed to free fall to the bottom. The profiler takes measurements from the surface to depth at a rate of four per second and a pump ensures consistent water flow past the sensors. Once the anchor hits the bottom, the remainder of the unit ceases descent shortly afterward due to the strong positive buoyancy of the unit and floats. During trials with this unit, recorded bottom depths were compared with profiler measured depth, and it appeared that the unit descended approximately five meters after the anchor hit bottom and therefore was never in danger of impacting the bottom. On board the vessel, it is usually obvious when the anchor hits bottom and the profiler unit stops descending because of a noticeable slackening of the line. After the anchor hits bottom, the vessel's gurdy is engaged and the profiler is immediately hauled back aboard. Once on deck, a series of protocols are executed to clean the sensors and store the unit until the next deployment as outlined in IPHC (2011).

### **Data capture**

Each profiler is equipped with a dedicated laptop computer that accompanies it into the field. Approximately once a day, the profiler is connected to the computer, data are uploaded, and the

profiler unit is then reset for the next day's casts. The data are sent remotely or via data cards back to the Seattle office after each trip. Because of problems in past years when the laptops were damaged in the field and resulted in the loss of any data stored on the computer hard drives, the computers were equipped with an additional USB backup in 2011 that automatically saved the day's data.

## Results

In 2011, a total of 11 fishing vessels were chartered to complete the IPHC setline survey (White et al. 2012) and each vessel was outfitted with a Seacat19*plus* V2 profiling unit, a laptop computer, and accessory gear. Out of a possible 1,315 stations coastwide, 1,193 (91%) of those were successfully profiled (Table 1).

In 2011, the setline survey included 15 stations in Puget Sound and the Strait of Juan de Fuca to be surveyed on an exploratory basis, as well as several stations off Oregon and Washington that were either deeper or more shallow than the standard depth range of the survey. The profiler was successfully deployed at these new sites with the exception of the deep stations which proved to be a bigger challenge. Although the profiler instruments have a working depth of 1000 m and were not in danger of damage, the floats currently used with the units are not rated for that depth. A cast to ~750 m caused the floats to be irreparably damaged and so only stations 500 m depth and less were profiled from that point forward.

The vessel captain and lead biologist decide whether it is prudent to launch the profiler. Poor weather and strong tides were the most common reasons given for unsuccessful profiles and aborted casts. When outfitted with the 40-pound anchor assembly, the profilers descend at a rate of about 1.0-1.5 m/s. On stations where tides were strong, the samplers were allowed to try incorporating an additional 10-20 pound weight to the bottom of the assembly to achieve a more vertical descent.

One profiler was lost this year off the south side of Adak Island in heavy currents. During the retrieval process, the line parted, sending the profiler to the ocean floor, but it likely remains suspended about 15 m off bottom since the entire assembly is thought to be intact. A \$1500 reward has been issued for the retrieval and return of this profiler as well as for a unit lost in 2009 off Kodiak Island.

A common problem in the past with profiler function has had to do with the pH sensors, but upon a preliminary review of profiles for this year, it appears this was not a problem. There were some problems with units shutting off during casts. On several units, this was caused by a loose switch, which was quickly corrected in the field. One profiler stopped logging all data properly mid-way through a trip and several attempts to troubleshoot both in the field and from the office were unsuccessful. The profiler was replaced as soon as possible and profiling resumed.

Backup measures put into place on the laptop computers this year proved successful and in many cases minimized the loss of data when a laptop was damaged or malfunctioned in the field. Most computer-related issues were successfully dealt with through the office. However, one unit was dropped in the field mid-season causing irreparable damage and needed replacing.

## Discussion

The first three years of data collection have gone relatively smoothly. Oceanographic conditions, like fish distributions, vary over time and space. But because the profiler casts are coincident in time and space to the survey stations, they provide an accurate environmental snapshot of conditions

experienced by the fish that are caught on the survey. The appendices are a series of maps looking at coastwide oceanographic conditions on the fishing grounds from 2009 – 2011, and are available on the IPHC website; visit [www.iphc.int/library/raras.html](http://www.iphc.int/library/raras.html).

Appendix I illustrates near bottom readings of temperature, salinity, dissolved oxygen, and pH, as well as chlorophyll *a* concentration at 25 m depth in Puget Sound and the Strait of Juan de Fuca. Appendix II encompasses the southern Oregon shelf to Queen Charlotte Sound. Appendix III is the Gulf of Alaska, and Appendix IV is the Bering Sea and Aleutian Islands. All 2011 data are preliminary.

### **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 it publically accessible. The complete set of 2009 and 2010 data is now available at: [http://www.ecofoci.noaa.gov/projects/IPHC/efoci\\_IPHCData.shtml](http://www.ecofoci.noaa.gov/projects/IPHC/efoci_IPHCData.shtml) Processing of the 2011 data is in progress and is expected to be available by spring of 2012.

### **Future plans**

Due to several mishaps with the laptop computers in the field, efforts are being made to make them more durable in the future. The IPHC plans to replace the current hard drives with solid state drives which will make the units more resistant to damage from impacts.

To date, bottom depth at each station has been recorded during the profiler cast by the captain using vessel instruments. This gives a very rough estimate of bottom depth independent of profiler data, but shipboard data vary widely from vessel to vessel and also in different weather conditions. In order to obtain a more reliable independent bottom depth measurement, IPHC is looking into placing a high resolution instrument on the anchor of the profiler assembly for 2012 and forward.

The IPHC plans to continue the setline survey and the coastwide deployment of profilers into the foreseeable future. The longer term goal is to build a time series of annual summer snapshots of oceanographic conditions along the continental shelf and be able to study patterns of halibut distribution in relation to these environmental variables.

### **Acknowledgments**

The success of the profiler project depends on the cooperation of many people. We would like to acknowledge the IPHC survey program staff for competently incorporating the profiler project into the survey protocols, Andy Vatter for making sure the gear is ready for the field, IPHC sea samplers for their hard work and attention to detail in collecting the data, the vessel captains

and crew for making sure the Seacats are safely retrieved after every cast, and Peggy Sullivan at NOAA/JISAO for her tireless work on the data and website.

## **References**

International Pacific Halibut Commission. Unpub. Getting to know your water column profiler 2011. Operation manual. International Pacific Halibut Commission. 53 p.

White, E., Dykstra, C. L., Geernaert, T. O., Soderlund, E., and Ranta, A. M. 2012. 2011 Standardized stock assessment survey. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2011. 491-528.

**Table 1. Number of casts, by survey region and vessel, completed during the 2011 SSA survey.**

IPHC survey region	Stations		Vessel name
	Profiled	Possible	
Oregon	53	60	Pacific Surveyor
Washington	57	62	Pacific Surveyor
Puget Sound <sup>1</sup>	14	15	Pacific Surveyor
Vancouver	37	41	Proud Venture
Goose Island	40	43	Proud Venture
St. James	37	42	Proud Venture
Charlotte	42	44	Star Wars II
Ketchikan	41	41	Star Wars II
Ommaney	37	40	Pender Isle
Sitka	42	42	Pender Isle
Fairweather	29	49	Bold Pursuit
Yakutat	48	51	Bold Pursuit
Prince William Sound	45	45	Bold Pursuit
Seward	46	48	Van Isle
Gore Point	44	45	Van Isle
Portlock	45	46	Van Isle
Shelikof	44	45	Predator
Albatross	44	45	Waterfall
Trinity	46	47	Free to Wander
Semidi	47	47	Waterfall
Chignik	40	45	Waterfall
Shumagin	35	44	Kema Sue
Sanak	48	48	Free to Wander
Unalaska	61	66	Free to Wander
4A Edge	42	57	Kema Sue
4D Edge	63	68	Kema Sue
Adak <sup>2</sup>	25	45	Pacific Sun
Attu	41	44	Pacific Sun
<b>Total</b>	<b>1,193</b>	<b>1,315</b>	

<sup>1</sup>Puget Sound and the Strait of Juan de Fuca were surveyed in 2011 for the first time on an exploratory basis. A final decision on whether to include this region in future surveys has not yet been made.

<sup>2</sup>A profiler was lost on the south side of Adak Island part way through the survey.

## **Appendices - for proper viewing, see IPHC website**

On the IPHC website (address below) is a series of full color plots produced using Ocean Data View (Schlitzer 2010) and ArcGIS software illustrating oceanographic conditions as measured by Seabird SBE19plusV2 profilers. Appendix I contains information from the Puget Sound and the Strait of Juan de Fuca which was surveyed for the first time in 2011, and Appendices II-IV include information from all three years of coastwide profiling (2009-2011) in the other areas as specified below. Temperature, salinity, dissolved oxygen, and pH are calculated using the deepest measurements at each station - typically 5-10 m off bottom. Chlorophyll *a* concentration is calculated using measurements at 25 m depth. The data in Appendix I are represented as point values due to the many small islands in the area which make interpolation difficult. The remaining areas are illustrated as isosurface plots which is a continuous surface created by using the point values and interpolating between points. Survey stations (i.e. where measurements were actually taken) are denoted as black dots. Note: 2011 data are preliminary.

Appendix I: Puget Sound and Strait of Juan de Fuca, Washington State

Appendix II: U. S. West Coast to Queen Charlotte Sound, B.C.

Appendix III: Gulf of Alaska

Appendix IV: Bering Sea and Aleutian Islands

To view the complete, full color document, visit the IPHC website:

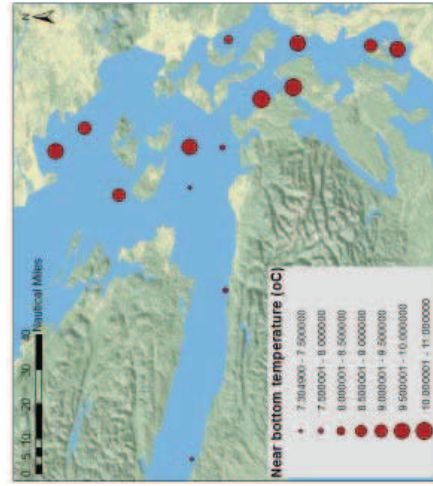
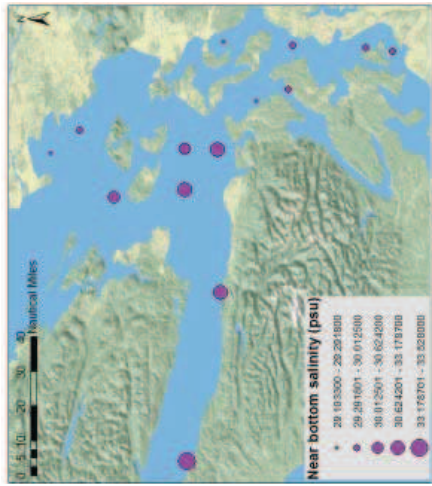
<http://www.iphc.int/library/raras.html> .

\*\* Note: For reference, an index of figures is provided on the following pages. For proper interpretation, the figures should be viewed in full size and color (available on the website).

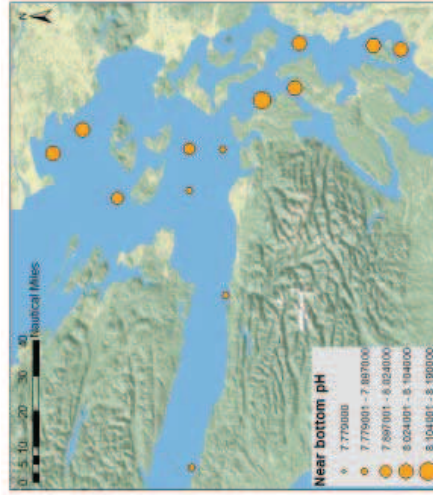
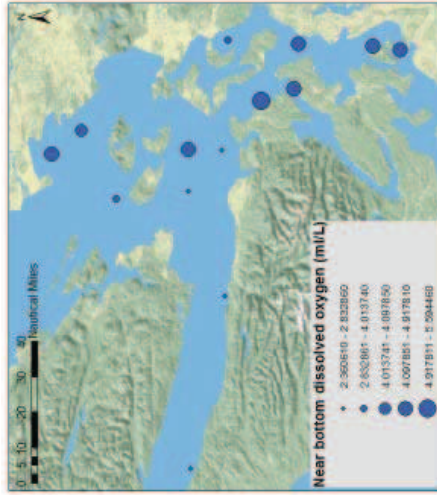
## **Reference**

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

# Index prints - Appendix I. Puget Sound and Strait of Juan de Fuca



Figures 1 and 2. Near bottom temperature and salinity in the Puget Sound and Strait of Juan de Fuca, Washington State, as measured during the IPHC setline survey in 2011.



Figures 3 and 4. Near bottom oxygen and pH in the Puget Sound and the Strait of Juan de Fuca, Washington State, as measured during the IPHC setline survey in 2011.

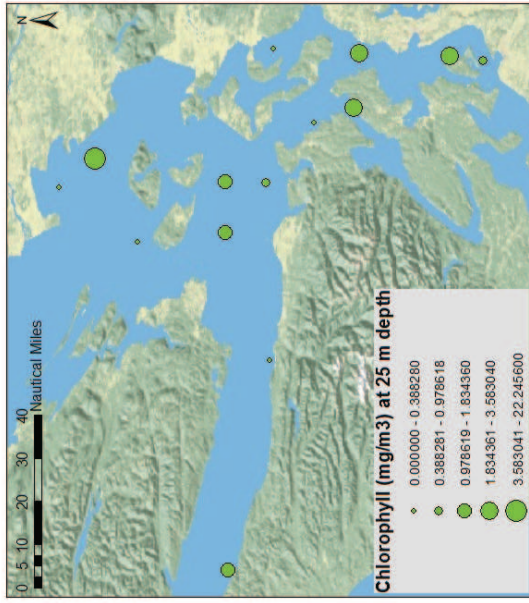


Figure 5. Chlorophyll a concentration at 25 m depth in the Puget Sound and Strait of Juan de Fuca, Washington State, as measured during the IPHC setline survey in 2011.

# Index prints - Appendix II. West Coast

## Temperature

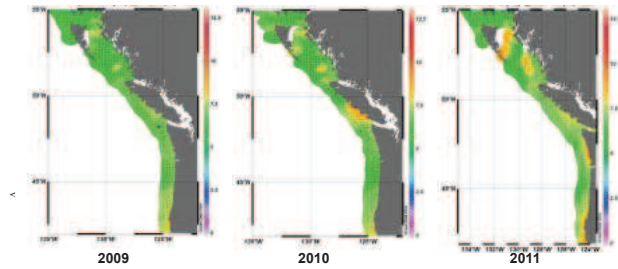


Figure 1. Near-bottom ocean temperature (°C) along the continental shelf of the U.S. West Coast north to Queen Charlotte Sound in summer 2009-2011, as measured during the IPHC setline survey.

## Salinity

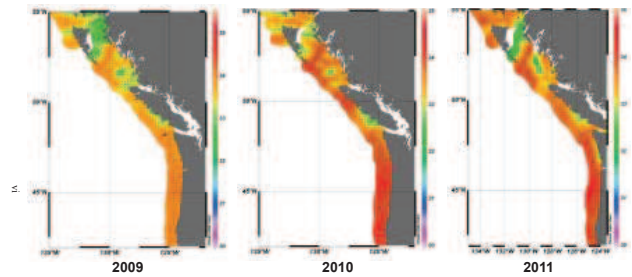


Figure 2. Near-bottom ocean salinity (psu) along the continental shelf of the U.S. West Coast north to Queen Charlotte Sound in summer 2009-2011, as measured during the IPHC setline survey.

## Dissolved oxygen

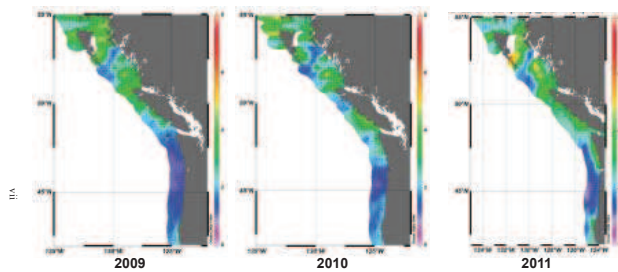


Figure 3. Near-bottom ocean dissolved oxygen (ml/L) along the continental shelf of the U.S. West Coast north to Queen Charlotte Sound in summer 2009-2011, as measured during the IPHC setline survey.

## pH

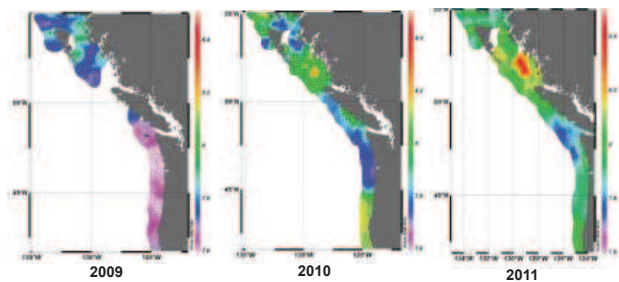


Figure 4. Near-bottom ocean pH along the continental shelf of the U.S. West Coast north to Queen Charlotte Sound in summer 2009-2011, as measured during the IPHC setline survey.

## Chlorophyll

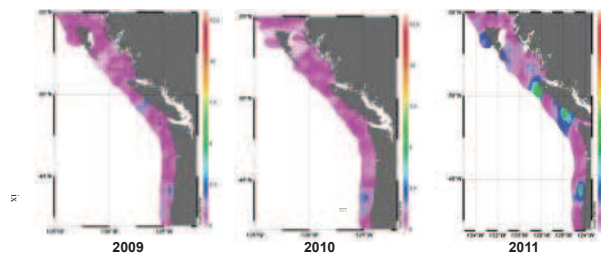


Figure 5. Chlorophyll *a* concentration (mg/m<sup>3</sup>) at 25 m depth along the continental shelf of the U.S. West Coast north to Queen Charlotte Sound in summer 2009-2011, as measured during the IPHC setline survey. Note that the scale for 2011 is different than the other two years, due to very strong plankton blooms this year.

# Index prints - Appendix III. Gulf of Alaska

## Temperature

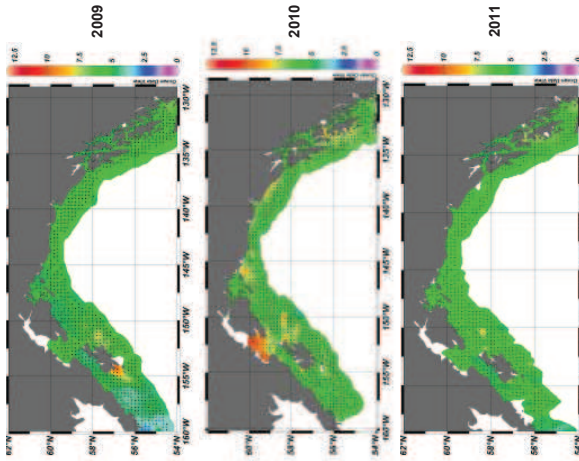


Figure 1. Near-bottom ocean temperature (°C) along the continental shelf of the Gulf of Alaska in summer 2009-2011, as measured during the IPHC setline survey.

x

## Salinity

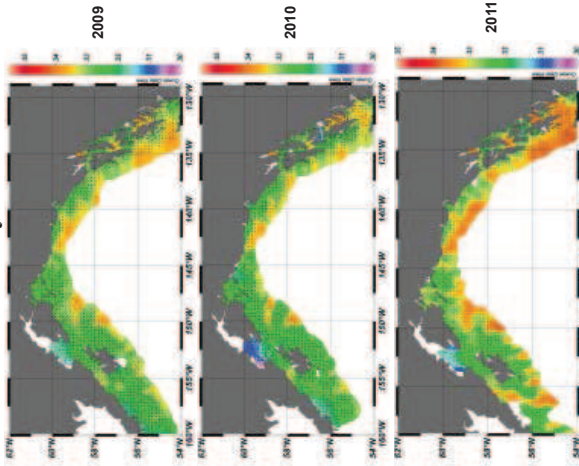


Figure 2. Near-bottom ocean salinity (psu) along the continental shelf of the Gulf of Alaska in summer 2009-2011, as measured during the IPHC setline survey.

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## Dissolved oxygen

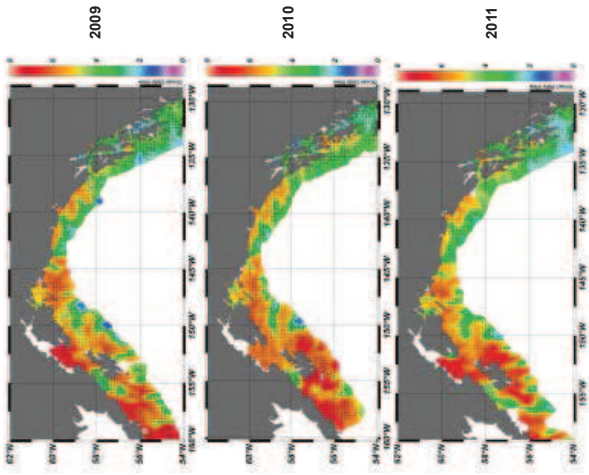


Figure 3. Near-bottom ocean dissolved oxygen (ml/L) along the continental shelf of the Gulf of Alaska in summer 2009-2011, as measured during the IPHC setline survey.

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## pH

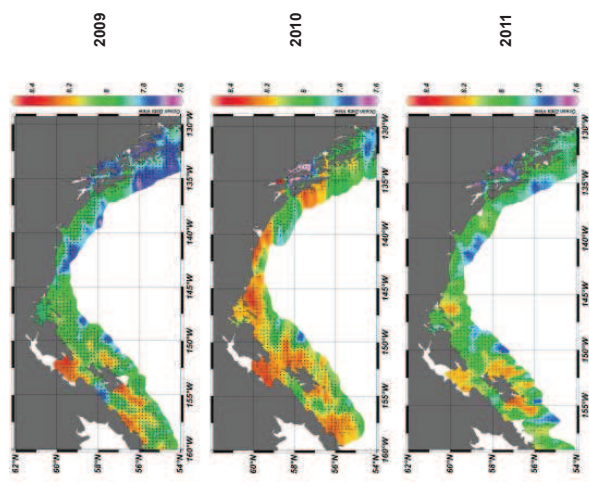


Figure 4. Near-bottom ocean pH along the continental shelf of the Gulf of Alaska in summer 2009-2011, as measured during the IPHC setline survey.

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## Chlorophyll

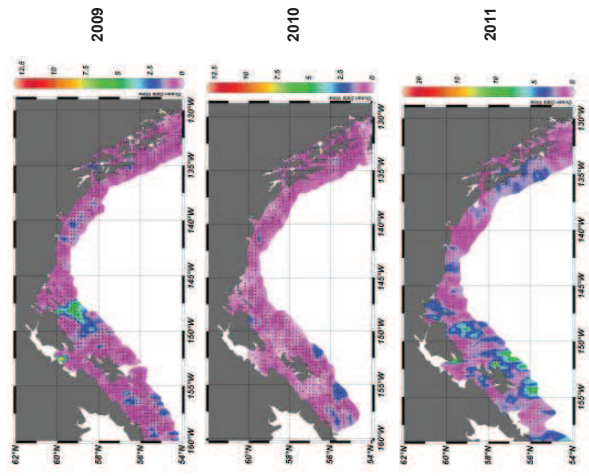


Figure 5. Chlorophyll concentration (mg/m³) at 25 m depth along the continental shelf of the Gulf of Alaska in summer 2009-2011, as measured during the IPHC setline survey. Note that the scale for 2011 is different than the other two years, due to very strong plankton blooms this year.

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# Index prints - Appendix IV. Bering Sea/Aleutian Islands

## Temperature

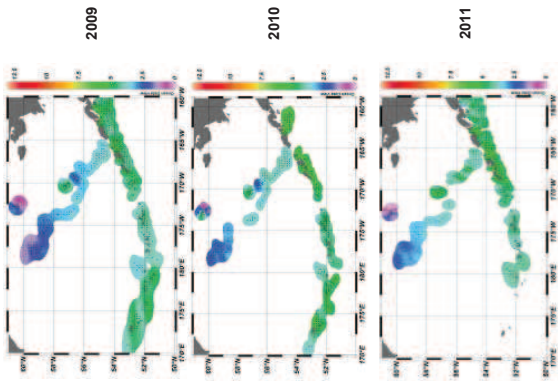


Figure 1. Near-bottom ocean temperature (°C) along the continental shelf of the Bering Sea and Aleutian Islands in summer 2009-2011, as measured during the IPHC setline survey.

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## Salinity

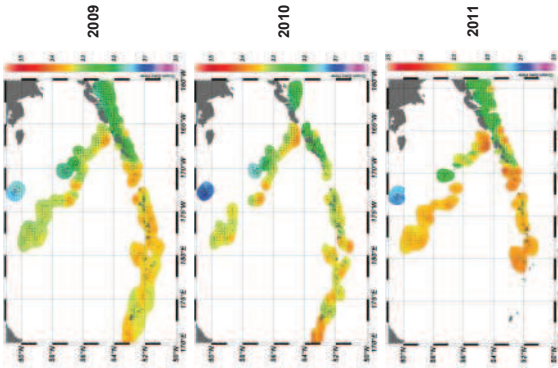


Figure 2. Near-bottom ocean salinity (psu) along the continental shelf of the Bering Sea and Aleutian Islands in summer 2009-2011, as measured during the IPHC setline survey.

XVI

## Dissolved oxygen

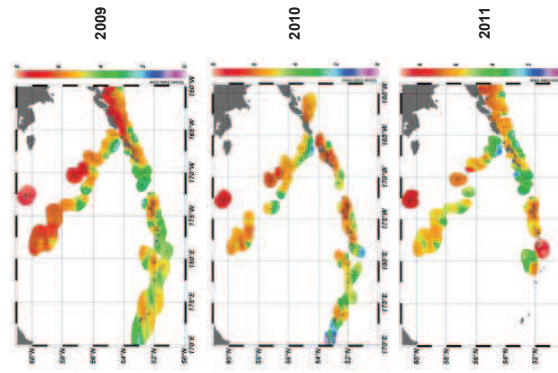


Figure 3. Near-bottom ocean dissolved oxygen (mL) along the continental shelf of the Bering Sea and Aleutian Islands in summer 2009-2011, as measured during the IPHC setline survey.

XVII

## Chlorophyll

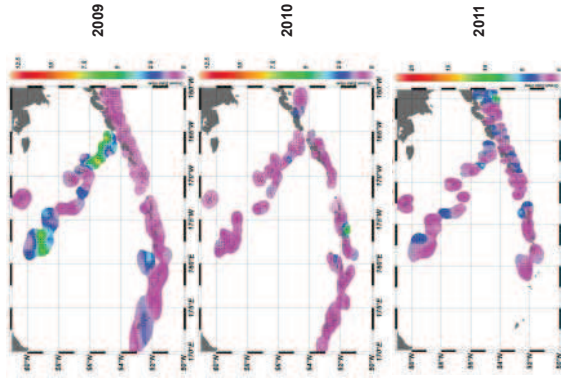


Figure 5. Chlorophyll *a* concentration (mg/m<sup>3</sup>) at 25 m depth along the continental shelf of the Bering Sea and Aleutian Islands in summer 2009-2011, as measured during the IPHC setline survey. Note that the scale for 2011 is different than the other two years, due to very strong plankton blooms this year.

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## pH

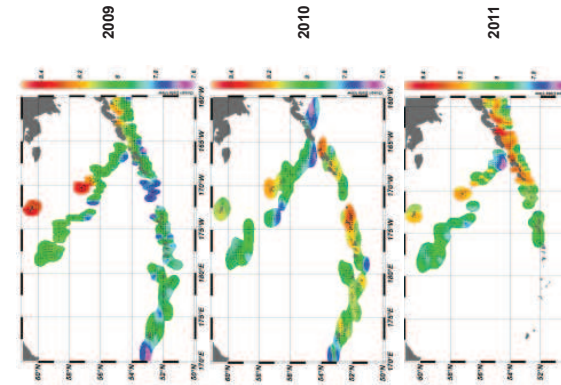


Figure 4. Near-bottom pH along the continental shelf of the Bering Sea and Aleutian Islands in summer 2009-2011, as measured during the IPHC setline survey.

