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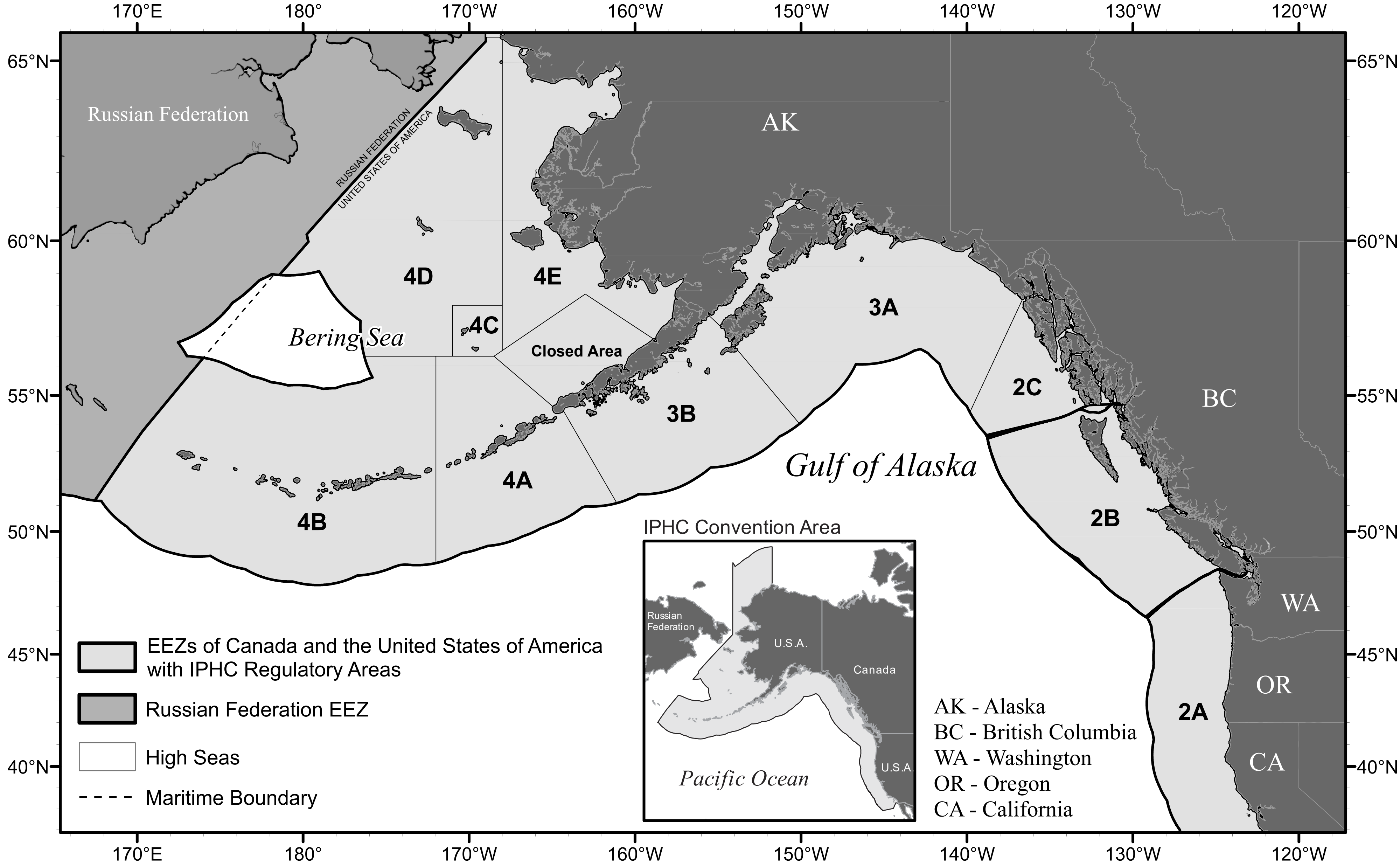
2021 ANNUAL REPORT

INTERNATIONAL PACIFIC HALIBUT COMMISSION



IPHC Regulatory Areas

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INTERNATIONAL PACIFIC HALIBUT COMMISSION

ANNUAL REPORT 2021

INTERNATIONAL PACIFIC

HALIBUT COMMISSION

Commissioners

Canada	United States of America
Paul Ryall	Glenn Merrill
Neil Davis	Robert Alverson
Peter DeGreef	Richard Yamada

Executive Director

David T. Wilson, Ph.D.

Bibliography entry

IPHC (2022) International Pacific Halibut Commission Annual Report 2021. *IPHC-2022-AR2021-R. 66 p.*

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Setline Survey Specialist Tyler Jack
Photographed by Guy Boxall

PREFACE

The International Pacific Halibut Commission (IPHC) was established in 1923 by a Convention between Canada and the United States of America. The Convention was the first international agreement providing for the joint management of a marine resource. The Commission's authority was expanded by several subsequent conventions, the most recent being signed in 1953 and amended by the Protocol of 1979.

The IPHC mission is "..... to develop the stocks of [Pacific] halibut in the Convention waters to those levels which will permit the optimum yield from the fishery and to maintain the stocks at those levels. ....." IPHC Convention, Article I, sub-article I, para. 2).

Three (3) IPHC Commissioners are appointed by the Governor General of Canada and three (3) by the President of the United States of America. The Commissioners appoint the Executive Director, who supervises the scientific, technical, field, and administrative personnel at the Secretariat. The scientific Secretariat collects and analyzes the statistical and biological data needed to inform the management of the Pacific halibut stock within Convention waters. The IPHC Secretariat headquarters is located in Seattle, Washington, U.S.A.

The Commission meets annually to review all regulatory proposals, including those made by the IPHC Secretariat, Contracting Parties, and by stakeholders. The measures adopted by the Commission are recommended to the two governments for approval and implementation. Upon approval the regulations are published in the Canada Gazette and U.S. Federal Register and are enforced by the appropriate agencies of both governments.

Our shared vision is to deliver positive economic, environmental, and social outcomes for the Pacific halibut resource for Canada and the U.S.A. through the application of rigorous science, innovation, and the implementation of international best practice.

Data in this report have been updated using all information received by the IPHC through 31 December 2020 and reported at the 97th Session of the IPHC Annual Meeting in 2021. Some data may have been subsequently updated and readers are encouraged to access the IPHC website for the latest information: https://www.iphc.int/. Unless otherwise indicated, all weights in this report are net weight (eviscerated, head-off, no ice and slime). Round (whole) weight may be calculated by dividing the net weight by 0.75.

About the Cover

The cover for this report has multiple photographs to showcase the people and types of work that contribute to the success of the International Pacific Halibut Commission.

Top row (L-R): F/V Pacific Surveyor photographed by John Turnea. Setline Survey Specialist Rachel Rillera, photographed by Kevin Coll. F/V Seymour Captain Pete Lopuszynski (facing camera) and crew member Kai Hansen photographed by Nancy Franco.

Bottom row (L-R): Pacific halibut photographed by Nancy Franco, Research Biologist Claude Dykstra and various Secretariat staff photographed by Tara Coluccio. Setline Survey Specialist Sarah Williamson photographed by Pam Tyhurst. Fisheries Data Specialist Kimberly Sawyer Van Vleck photographed by Caroline Prem.

Acronyms used in this report

ADEC - Alaska Department of Environmental Conservation
ADF&G - Alaska Department of Fish and Game
BBEDC - Bristol Bay Economic Development Corporation
BSAI - Bering Sea and Aleutian Islands
CDFW - California Department of Fish and Wildlife
CDQ - Community Development Quota
CGOARP - Central Gulf of Alaska Rockfish Program
COAC - Clean Otolith Archive Collection
C&S - Ceremonial and Subsistence
CSP - Catch Sharing Plan
CVRF - Coastal Villages Regional Fund
DFO - Fisheries and Oceans Canada
DMR - Discard Mortality Rate
DO - Dissolved Oxygen
EBS - Eastern Bering Sea
EC - Electronic Monitoring
FISS - Fishery-independent setline survey
GAF - Guided Angler Fish
HCR - Harvest Control Rule
HARM - Halibut Angler Release Mortality
IFMP - Integrated Fisheries Management Plan
IFQ - United States Individual Fishing Quota
IPHC - International Pacific Halibut Commission
IQ - Individual Quota
IVQ - Canadian Individual Vessel Quota
MP - Management Procedure
MPR - Mortality Per Recruit
MSAB - Management Strategy Advisory Board
MSE - Management Strategy Evaluation
NMFS - National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NPFMC - North Pacific Fishery Management Council
NPUE - Numbers-Per-Unit-Effort
NSEDC - Norton Sound Economic Development Corporation
ODFW - Oregon Department of Fish and Wildlife
PAT - Pop-up Archival Transmitting
PDO - Pacific Decadal Oscillation
PFMC - Pacific Fishery Management Council
PHI - Prior Hook Injury
PSC - Prohibited Species Catch
PSMFC - Pacific States Marine Fisheries Commission
QS - Quota Share
RDE - Remote Data Entry
RI - Rockfish Index
RSL - Reverse Slot Limit
SRB - Scientific Review Board
SPR - Spawning Potential Ratio
WDFW - Washington Department of Fish and Wildlife
WPUE - Weight-Per-Unit-Effort
XRQ - Experimental Recreational Halibut

Executive Director's Message

I would like to start by personally thanking all stakeholders for your time, contributions, and willingness to adapt through yet another year of navigating COVID-19 restrictions and impacts. While challenging, the past two years have displayed the true resilience and comradery of the Pacific halibut fishery and its stakeholders. After these two years of seeing one another through computer screens, I am eagerly awaiting the opportunity to return to in-person Commission activities as safety permits.

Throughout 2021, the IPHC Secretariat has continued to make progress in enhancing our scientific processes and the communication of scientific advice emanating from our core functions as a Secretariat serving the Commission. This has continued to occur in tandem with an evaluation of the supporting governance procedures of the organisation, including how stakeholder inputs are incorporated into the decision-making framework to ensure that all points of view are being adequately considered in a transparent manner.

Despite the ongoing difficulties and constraints of operating within a pandemic, we again successfully completed our Fishery-Independent Setline Survey (FISS) for 2021 without incident, effectively sampling 1,167 stations coastwide. This produced a precise and reliable index of the Pacific halibut stock and is the primary source of biomass trend information for the 2021 stock assessment, as well as the basis for the 2022 management decision making processes. Thus, the 2021 FISS was a great success, meeting both our scientific requirements and maintaining our economic goal of long-term revenue neutrality.

From a fishery perspective, the 2021 TCEY (39.0 million pounds; 17,690 t) represented a modest increase over that set for 2020 (36.6 million pounds; 16,602 t). This increase represents a slight increase in the scale of the biomass estimated in the 2021 stock assessment. Primary stock abundance indices increased at the coastwide level: the IPHC Fishery-Independent Setline Survey (FISS) numbers-per-unit-effort were up 17% from 2020, legal-sized weight-per-unit-effort (WPUE) was up 4%, and the directed longline fishery WPUE increased by 2% from 2020.

However, the 2021 stock assessment (consistent with all recent assessments) estimated that the spawning biomass has declined by ~17% since 2016, and that this decline will continue with a high probability at current fishing mortality levels. That said, the projections were more optimistic than those from recent assessments due to the increasing presence of the 2012 year-class in both the FISS and fishery. This translates to a lower probability of stock decline for 2022 than in recent assessments as well as a decrease in this probability through 2023-24.

We started the year with the female spawning biomass estimated to be at 33% (22-52%) of the level expected in the absence of fishing, and at the beginning of 2022 this estimate remained at the same level of 33% (22–54%). Such a level of relative biomass is widely considered to be close to a reasonable target level for sustaining optimal harvest rates of groundfish species, though species biology and ecology play a large role in determining species-specific levels. For Pacific halibut, simulations have indicated that SB30% is a reasonable proxy for SBMSY (the spawning biomass that produces the maximum fishery yield), and SB36% is likely near SBMEY (the biomass that produces the maximum economic yield).

Rest assured, the IPHC Secretariat staff and I will continue to develop and communicate the best possible scientific advice, to ensure that the Commission is equipped with the information it needs to make informed, timely, and scientifically-based management decisions; the overall aim of course, being to take a precautionary-based approach to fishery management, thereby ensuring a sustainable resource and its associated fisheries.

I again look forward to engaging with all of you over the coming year, either through the Commission's subsidiary bodies, or in person at our landing ports and communities that so heavily rely on Pacific halibut as a source of income, food, and cultural identity. Wishing you all a safe and healthy 2022.

David T. Wilson, Ph.D.
Executive Director

Activities of the Commission

The Commission is composed of six members (Commissioners) who are appointed by the Contracting Parties. They meet several times a year, in both formal and informal capacities, to consider matters relevant to the Pacific halibut stock, the fisheries, and governance. All meeting documents, presentations, and reports as well as more information on the structure of the Commission can be found on the IPHC website (https://www.iphc.int).

97th Session of the IPHC Annual Meeting (AM097; 2021)

The 97th Session of the IPHC Annual Meeting (AM097) was held electronically, from 25 to 29 January 2021. For AM097, Mr. Paul Ryall of Canada presided as Chairperson and Mr. Glenn Merrill of the United States of America presided as Vice-Chairperson. The Commission heard reports from the IPHC Secretariat about the status of the Pacific halibut (Hippoglossus stenolepis) population, reviewed finance and administration, discussed stakeholder concerns, considered the suggestions of its subsidiary bodies, and solicited public comment before adopting fishery regulations and making other decisions.

Mortality and fishery limits, and fishing periods for 2021

The Commission recommended to the governments of Canada and the United States of America a total mortality limit for 2021 of 17,690 tonnes (39.00 million pounds) net weight [1], and adopted the mortality limits for each IPHC Regulatory Area as described in Table 1.

The area and sector mortality and fishery limits resulting from the IPHC-adopted total mortality limits and the application of the existing Contracting Party catch sharing arrangements were as described in Table 2.

The total fishery limit (FCEY) for 2021 was set at 13,757 tonnes (30.33 million pounds),

[1] Note that all weight values in this section are expressed in terms of net weight, meaning the weight of Pacific halibut that is without gills and entrails, head-off, washed, and without ice and slime.

Table 1. Adopted mortality limits (net weight) from AM097.

IPHC Regulatory Area	Mortality limit (TCEY) (tonnes)	Mortality limit (TCEY) (Mlbs)
2A	748	1.65
2B	3,175	7.00
2C	2,631	5.80
3A	6,350	14.00
3B	1,415	3.12
4A	930	2.05
4B	635	1.40
4CDE	1,805	3.98
Total (IPHC Convention Area)	**17,690**	**39.00**

nearly a 10 percent increase from the fishery limits of 12,465 tonnes (27.48 million pounds) implemented by the Commission in 2020.

The Commission adopted fishing periods for 2021 as follows:

- All commercial fishing for Pacific halibut in all IPHC Regulatory Areas could begin no earlier than 6 March and must cease on 7 December.
- For the IPHC Regulatory Area 2A non-tribal directed commercial fishery, three-day (58-hour) fishing periods could take place beginning on 22 June, 6 July, and 20 July, with additional openings and fishing period limits (vessel quota) to be determined and communicated by the IPHC Secretariat.

Other decisions made at the meeting

The Commission made a range of other decisions at the 97th Session of the IPHC Annual Meeting (AM097), including recommendations concerning the following:

- The MSAB will have a continuing role in the MSE process and assisting the Commission with harvest policy decisions, in accordance with the IPHC Rules of Procedure (2021);
- IPHC Secretariat will develop a draft MSE Program of Work and the Commission will subsequently meet intersessionally to review the draft and provide direction.

IPHC Secretariat staff Colin Jones, Dr. Ian Stewart, Rachel Rillera, and Tyler Jack
Photographed by Tara Coluccio

Table 2. 2021 Mortality and Fishery limits and application of the existing Contracting Party catch sharing arrangements.

IPHC Regulatory Area	Fishery limits (net weight)	
	Tonnes (t)	Million Pounds (Mlb)
Area 2A (California, Oregon, and Washington)	**685**	**1.51**
Non-treaty directed commercial (south of Pt. Chehalis)	116	256,122*
Non-treaty incidental catch in salmon troll fishery	21	45,198*
Non-treaty incidental catch in sablefish fishery (north of Pt. Chehalis)	32	70,000*
Treaty Indian commercial	225	496,300*
Treaty Indian ceremonial and subsistence (year-round)	15	32,200*
Recreational – Washington	127	279,414*
Recreational – Oregon	132	291,506*
Recreational – California	18	39,260*
Area 2B (British Columbia) (includes recreational catch allocation)	**2,790**	**6.15**
Commercial fishery	2,372	5.23
Recreational fishery	417	0.92
Area 2C (southeastern Alaska) (combined commercial/ guided recreational)	**2,000**	**4.41**
Commercial fishery (3.41 Mlb retained catch and 0.07 Mlb discard mortality)	1,633	3.60
Guided recreational fishery (includes retained catch and discard mortality)	367	0.81
Area 3A (central Gulf of Alaska) (combined commercial/guided recreational)	**5,053**	**11.14**
Commercial fishery (7.05 Mlb retained catch and 0.29 Mlb discard mortality)	4,169	9.19
Guided recreational fishery (includes retained catch and discard mortality)	885	1.95
Area 3B (western Gulf of Alaska)	**1,161**	**2.56**
Area 4A (eastern Aleutians)	**753**	**1.66**
Area 4B (central/western Aleutians)	**558**	**1.23**
Areas 4CDE	**757**	**1.67**
Area 4C (Pribilof Islands)	335	0.738
Area 4D (northwestern Bering Sea)	335	0.738
Area 4E (Bering Sea flats)	88	0.194
Total	**13,757**	**30.33**

* Allocations resulting from the IPHC Regulatory Area 2A catch sharing arrangement are listed in pounds.

97th Session of the IPHC Interim Meeting (IM097; 2021)

The 97th Session of the IPHC Interim Meeting (IM097), held 30 November to 1 December 2021 via electronic means, was an occasion to prepare for the 98th Session of the IPHC Annual Meeting (AM098) scheduled for 24-28 January 2022. For IM097, Mr. Glenn Merrill of the United States of America presided as Chairperson and Mr. Paul Ryall of Canada presided as Vice-Chairperson.. The Commissioners and the public were able to hear IPHC Secretariat presentations and discuss a variety of topics, including a review of the 2021 fisheries statistics and preliminary stock assessment results, and the preliminary 2022 harvest decision table.

Administrative Specialist Ola Wietecha
Photographed by Tara Coluccio

Pacific Halibut Commercial Fishery

Commercial fishing is distinguished from other harvest types in that it is the activity of catching fish for commercial profit. The commercial Pacific halibut landings in 2021 totaled 10,833 tonnes or 23,888,156 pounds (Table 3). All values in this section are provided as net weight unless otherwise noted. Net weight is defined as the weight of Pacific halibut without gills, entrails, head, ice, and slime. Keep in mind that this chapter reflects data as of 1 February 2022. For updates on landings data, please refer to the IPHC website at: https://www.iphc.int.

Licensing and landings

Licensing

Licensing regulations for IPHC Regulatory Area 2A non-tribal fisheries were unchanged in 2021. All vessels fishing in that area had to follow these guidelines: procure an IPHC license, select one type of license (choices were directed longline, incidental in the troll salmon or sablefish fisheries, and recreational), and submit commercial fisheries applications by the deadline.

Landings

When Pacific halibut are delivered to a port for processing, they are considered to be "landed" for tracking purposes. The following sections review commercial landings, seasons, and trends for each area, with data from the IPHC, Fisheries and Oceans Canada (DFO), NOAA Fisheries, Metlakatla Indian Community, Washington Indian tribal fisheries management departments (including the Northwest Indian Fisheries Commission, Makah, Lummi, Jamestown S'Klallam, Swinomish, Port Gamble S'Klallam, Quileute, and Quinault Indian tribes), and state agencies including Alaska Department of Fish and Game, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, and California Department of Fish and Wildlife.

Landing patterns

In Canada (IPHC Regulatory Area 2B), two out of the 11 ports receiving commercial deliveries in 2021, received 95 percent of the landed catch: Port Hardy and Prince Rupert/Port Edward. Port Hardy (including Coal Harbour and Port McNeill) received 48 percent of the commercial landed catch (1,108 tonnes; 2,442,000 pounds), and Prince Rupert received 46 percent (1,066 tonnes; 2,351,000 pounds).

In the U.S.A. (Alaska), the landed catch was 8,139 tonnes (17,945,000 pounds). IPHC Regulatory Area 3A again had the highest fishery limit and landed catch. Homer received the largest portion of the Alaskan commercial catch, with 1,478 tonnes (3,258,000 pounds; 18%). Seward received the second and Kodiak the third largest landing volumes at 10 percent (912 tonnes; 2,008,000 pounds) as well as 10 percent (852 tonnes; 1,879,000 pounds) of the Alaskan commercial landings, respectively.

In Southeast Alaska (IPHC Regulatory Area 2C), Juneau and Sitka received the most in landed weight, together totaling 13% of total commercial Alaskan landings (Table 3).

Sampling of commercial landings

Sampling commercial landings is a key component to collecting data on Pacific halibut for the annual IPHC stock assessment. IPHC Secretariat collects otoliths (ear bones) that, when read under a microscope, give the animal's age in years; tissue samples for analysis and sex determination; associated fork lengths and fish weights; as well as logbook information, final landing weights, and any IPHC tags caught during fishing. Lengths and weights of sampled Pacific halibut allow the IPHC to calculate seasonal length-weight ratios by area and, in combination with age data, size-at-age information. Fin tissue samples are analyzed

Table 3. 2021 Pacific halibut landings (net weight) by IPHC Regulatory Area (as of 1 February 2022).

IPHC Regulatory Area	Fishery limits (net weight)		Landings (net weight)		Percent
	tonnes	pounds	tonnes	pounds	(%)
Area 2A (California, Oregon, Washington)	394	867,320	374	824,779	95
Non-treaty directed commercial	116	256,122	110	242,997	95
Non-treaty incidental to salmon troll fishery	21	45,198	8	18,562	41
Non-treaty incidental to sablefish fishery	32	70,000	31	69,081	99
Treaty Indian directed commercial	225	496,300	224	494,139	100
Area 2B (British Columbia)	2,372	5,230,000	2,321	5,118,017	98
Area 2C (southeastern Alaska)[1]	1,601	3,530,000	1,505	3,317,736	94
Area 3A (central Gulf of Alaska)	4,060	8,950,000	3,936	8,677,885	97
Area 3B (western Gulf of Alaska)	1,161	2,560,000	1,093	2,410,299	94
Area 4A (eastern Aleutian Is.)	753	1,660,000	649	1,430,595	86
Area 4B (central/western Aleutian Is.) IFQ	446	984,000	283	624,186	63
Areas 4CDE and Closed IFQ	402	885,600	372	819,798	93
Areas 4BCDE IFQ	467	1,030,400	314	692,252	67
Total	**10,474**	**23,092,125**	**9,822**	**21,652,933**	**94**

* Includes Metlakatla landings.

to provide the sex of individual fish and, in turn, estimate the sex composition of the commercial landings. Mean weights are combined with final landing weights to estimate landed catch in numbers. Logbook information provides weight-per-unit-effort data, fishing location for the landed weight, and data for research projects. Tags can provide information on migration, growth, exploitation rates, and natural and discard mortality. More information on the annual stock assessment and research activities can be found later in this report.

Sampling protocols are designed to ensure that the sampled Pacific halibut are representative of the population of landed Pacific halibut throughout the Convention Area; sampling days and places, and percentage of fish sampled are based on landing patterns and are reviewed annually. The protocols can vary slightly from port to port to achieve the appropriate sampling representation.

Considering that vessels travel to multiple IPHC Regulatory Areas and are not limited in where they may land their catch, IPHC Secretariat was stationed in ports coastwide in 2021. In Canada, IPHC Secretariat was stationed in Port Hardy and Prince Rupert. In the U.S.A., in IPHC Regulatory Area 2A, IPHC Secretariat was stationed in Newport and Charleston, Oregon and in Ilwaco and Bellingham, Washington. In addition, samples were taken in several ports in Washington by staff from the treaty Indian fishery management offices. In Alaska, IPHC Secretariat was stationed in the ports of Dutch Harbor, Kodiak, Homer, Seward, Sitka, and Petersburg.

Otoliths

The otolith collection targets included 1500 from each IPHC Regulatory Areas 2B-4B and 4CD (combined) for a total of 11,500 Pacific halibut otoliths The target for IPHC Regulatory Area 2A was set at 1,000; subdivided into a target of 650 for the treaty Indian fisheries and 350 for the IPHC Regulatory Area 2A non-tribal directed commercial fisheries. All collections resulted in 11,512 otoliths by sampling from 30 percent of the landed catch in 598 samples.

IPHC Secretariat also collected specimens for the Clean Otolith Archive Collection (COAC), which comprises samples gathered from all IPHC otolith collection programs and other research opportunities. These otoliths are not used for age determination, but are cleaned, dried, and stored whole in climate-controlled conditions for future analysis. COAC samples are collected from the fishery-independent setline survey (FISS) unless the sampling rate for the age determination collection is 100%. For this reason, COAC samples were to be collected from commercial landings from IPHC Regulatory Areas 4B in 2021. The annual COAC target is 100 otoliths from each IPHC Regulatory Area; this target was not attained in IPHC Regulatory Area 4B (0%) due to changes in landing patterns.

Logbooks

Alongside otolith samples, IPHC Secretariat in the ports collected logbook information from harvesters. In total, 2,877 logs were collected in 2021 (as of 31 January 2022). A total of 453 were collected from Canadian landings, and 2,424 were collected from U.S.A. landings.

Recovered tags

In 2021, a total of 52 tags of several types were recovered from tagged Pacific halibut. A total of 43 of these recoveries were from U32 wire tagging releases conducted between 2015 and 2021 in the Gulf of Alaska and Bering Sea which included subsets from discard mortality and tail pattern recognition studies, and eight were from the recreational discard mortality study conducted out of

Sitka and Seward, Alaska in 2021. Tag data collected dockside included fork lengths, individual fish weight(s), otoliths, fin clips, and capture location of the recovered tagged fish.

Electronic data collection

IPHC has digitized data collection to eliminate or reduce the need for post-collection data entry and increase the efficiency of data editing. IPHC Secretariat in Alaska used an electronic tablet to input data from paper logbooks into a remote data entry application. The goal was to enter data from as many of the logs collected as priorities and time allowed during the course of regular port duties. Modifications and enhancements to the application continue.

In British Columbia, Canada, the IPHC Secretariat was provided with a field version of the log entry program used at the IPHC Headquarters office. The goal was to enter as many Canadian logs as time permitted, though priority was given to other tasks such as biological sampling. In addition, Bluetooth-enabled tablets were provided for collection of electronic logs from vessels using Archipelago Marine Research's FLOAT - Fishing Log On A Tablet.

Photographed by Jen Paton

Setline Survey Specialist Guy Boxall
Photographed by Tyler Jack

Recreational Fishery

The recreational fishery is comprised of both guided (charter) and unguided (non-charter) sectors. In 2021 coastwide recreational harvest of Pacific halibut, including discard mortality, was estimated at approximately 3,460 tonnes (7,628,604 pounds) by the IPHC, using information provided by state and federal agencies from each of the Contracting Parties. The regulations governing recreational fishing of Pacific halibut were specifically geared to each IPHC Regulatory Area. Table 4 provides a brief summary of overall removals and more detailed tables providing a summary of seasons and retained catch can be found on the IPHC website: https://www.iphc.int.

IPHC Regulatory Area 2B – British Columbia (CANADA)

Size and/or annual limit requirements changed twice during the season in IPHC Regulatory Area 2B. Initially, the limit was a 126 cm (49.6 inch) maximum size limit and one Pacific halibut had to be between 90 – 126 cm (35.4 - 49.6 inches) or both under 90 cm (35.4 inch) when attaining the two fish possession limit with an annual limit of six per licence holder. On 1 April, the maximum size limit was increased to 133 cm (53.4 inch) and one Pacific halibut to be between 90 – 133 cm (35.4 – 53.4 inches) or both under 90 cm (35.4 inch) when attaining the two fish possession limit, with an annual limit of ten per licence holder. On 11 September, the daily and possession limit changed to either one (1) halibut measuring 90 cm to 133 cm in length (69 cm to 102 cm head-off), or three (3) halibut, each measuring under 90 cm in length (69 cm head-off).

British Columbia, Canada has a program that allows recreational harvesters to land fish that is leased from directed commercial fishery quota share holders for the current season. Approximately 7 tonnes (15,000 pounds) were landed under British Columbia's Experimental Recreational Quota program.

IPHC Regulatory Area 2A – California, Oregon and Washington (U.S.A.)

IPHC Regulatory Area 2A's recreational allocation was based on the Pacific Fishery

Management Council's Catch Sharing Plan formula, which divides the overall fishery limit among all sectors. The recreational allocation was further subdivided to seven subareas, after 32 tonnes or 70,000 pounds were allocated to the incidental Pacific halibut catch in the commercial sablefish fishery in Washington. This subdivision resulted in 127 tonnes or 279,414 pounds being allocated to Washington subareas and 132 tonnes or 291,506 pounds to Oregon subareas. In addition, California received an allocation of 18 tonnes or 39,260 pounds. Recreational fishery harvest seasons by subareas varied and were managed in-season in coordination with the Contracting Party agencies, with fisheries opening on 1 May. The IPHC Regulatory Area 2A recreational harvest totaled 184 tonnes (405,869 pounds), 33% under the recreational allocation (Table 4).

IPHC Regulatory Areas 2C, 3A, 3B, 4A, 4B, 4CDE – Alaska (U.S.A.)

The IPHC Regulatory Area 2C charter fishery continued to be managed using a reverse slot limit, allowing for the retention of one Pacific halibut that was ≤ 114 cm or 45 inches or ≥ 203 cm or 80 inches in total length. During the 7th Special Session of the IPHC (SS07) on 20 May, the reverse slot limit was changed to allow retention of one Pacific halibut that was ≤ 102 cm (40 inches) or ≥ 203 cm (80 inches) in total length. In IPHC Regulatory Area 3A, charter anglers were The IPHC Regulatory Area 2C charter fishery continued to be managed using a reverse slot limit, allowing for the retention of one Pacific halibut that was ≤ 127 cm or 50 inches or ≥ 182.9 cm or 72 inches in total length. In IPHC Regulatory Area 3A, charter anglers were allowed to retain two fish, but only one could exceed 81.3 cm (32 inches) in length, and a possession limit equaled to 2 daily bag limits with no annual limit. One trip per calendar day per charter permit was allowed, with no charter retention of Pacific halibut on Wednesdays.

Similar to British Columbia (Canada), Alaska (U.S.A.) has the Guided Angler Fish program that allows recreational harvesters to land fish that is leased from commercial fishery quota shareholders for the current season. In IPHC Regulatory Areas 2C and 3A, a total of 35 tonnes (76,529 pounds) and 2 tonnes (3,377 pounds), respectively, were leased from the directed commercial quota fisheries and landed as recreational harvest.

Table 4. Summary of 2021 recreational Pacific halibut allocations and landed catch by IPHC Regulatory Area.

	Allocation		Retained catch		Percent of
Area	tonnes	pounds	tonnes	pounds	allocation
2A	277	610,180	184	405,869	67
2B	417	920,000	366	806,000	88
2C (charter)[1,2]	367	810,000	523	1,153,862	142
3A (charter)[1,2]	885	1,950,000	1,113	2,454,045	126

[1] There is no allocation limit for the non-charter recreational fishery in these IPHC Regulatory Areas.
[2] Includes discard mortality

Discard mortality of Pacific halibut in the directed fishery

In the directed commercial Pacific halibut fishery, some Pacific halibut are captured that are not kept and, therefore, do not become part of the landed catch. Some of those released at sea survive, but some do not, and those that do not, must be accounted for. These removals are known as discard mortality or in this case, directed commercial discard mortality.

Estimates of directed commercial discard mortality in 2021 amounted to 464 tonnes (1,023,000 pounds; net weight) (Table 5). There are three main sources of directed commercial discard mortality accounted for by IPHC: (1) fish caught and never retrieved on lost or abandoned fishing gear; (2) the discard of fish that measure below the legal size limit of 32 inches (U32; 81.3 cm) and subsequently die; and (3) the discard of legal-sized Pacific halibut (O32; >32 inches or 81.3 cm) for regulatory compliance reasons, such as a vessel reaching its trip, catch, or quota share limit.

Directed commercial discard mortality from lost or abandoned gear

In the 1980s and early 1990s in Alaska and British Columbia, 'derby' fisheries with short fishing periods led to harvesters competing to catch as many Pacific halibut as quickly as possible. This resulted in a considerable quantity of lost fishing gear, which continued to catch fish. Estimates of the amount of missing gear were extrapolated to

Table 5. Directed commercial discard mortality of Pacific halibut (net weight) by IPHC Regulatory Area, 2021.

IPHC Regulatory Area	Discard Mortality	
	tonnes	pounds
2A	32	71,000
2B	82	181,000
2C[1]	61	135,000
3A	176	387,000
3B	63	139,000
4A	24	53,000
4B	15	32,000
4CDE	11	25,000
Total*	464	1,023,000

[1]Includes the Metlakatla fishery.

total catch values using available logbook catch and effort statistics. The advent of quota-share fishery management in these areas has greatly reduced the mortality from lost or abandoned gear.

The rate of O32 Pacific halibut discard mortality from gear loss is calculated by first figuring out the ratio of effective skates lost to effective skates hauled aboard the vessels for trips for which there was a log, then multiplying that number by the total landed catch. “Effective skates” refers to those that include all requisite data (such as skate length, hook spacing, and number of hooks per skate), and for which the gear type met the standardization criteria. The ratio includes both snap gear and fixed-hook gear in all IPHC Convention waters. U32 Pacific halibut discard mortality from lost gear was calculated in a similar manner incorporating the U32:O32 ratio calculations for discarded U32 Pacific halibut as described below.

Directed commercial discard mortality from discarded U32 Pacific halibut

The weight of discarded U32 Pacific halibut must be measured indirectly where direct observation and electronic monitoring are not available. Within the IPHC Convention Area, the Canadian fishery (IPHC Regulatory Area 2B; British Columbia) offers the most accurate accounting due to direct observation. Fishers there self-report their discards with the values being verified through video monitoring on the vessels. In all other IPHC Regulatory Areas, considering that the IPHC Fishery-Independent Setline Survey (FISS) uses similar fishing gear, FISS data have been used as a proxy for the expected encounter rates by area and year. Results are filtered to use FISS stations with a higher catch rate (by weight) of O32 Pacific halibut, similar to those observed in the directed commercial fishery.

A universal mortality rate of 16 percent has been applied to all Pacific halibut discards from the quota fisheries (Canada and U.S.A.). For derby fisheries in previous years in British Columbia and Alaska, and for the IPHC Regulatory Area 2A directed commercial fishery, a mortality rate of 25 percent is applied. Accordingly, the amount of discarded U32 Pacific halibut that subsequently die in the directed commercial fishery is estimated by multiplying the relative amount (percentage) of U32 to O32 Pacific halibut by the landed commercial catch and then by the mortality rate for the fishery.

Directed commercial discard mortality for regulatory compliance reasons

In IPHC Regulatory Area 2A, the directed commercial fishery is still managed by ‘derby’ fishing periods in which the quantity of fish that may be caught by each vessel is limited by a fishing period limit and the size of vessel. This may result in catches that exceed the vessel or trip limits, so that “excess” O32 Pacific halibut are discarded. Some vessel captains logged the amount of discards, which were then compared to the landed catch of Pacific halibut for those trips to arrive at a ratio of landed Pacific halibut to O32 discarded Pacific halibut. This ratio was then applied to all landed catch reported on fish tickets to determine the amount of discarded O32 Pacific halibut for all landings to which the mortality rate of 25 percent was applied. U32 Pacific halibut were accounted for in a similar manner incorporating the U32:O32 ratio calculations for discarded Pacific halibut. The amount of Pacific halibut retained by the IPHC Regulatory Area 2A salmon and sablefish directed commercial fisheries was not included in these calculations, however, as these removals were accounted for under non-directed commercial discard mortality estimates.

Subsistence Harvest

Pacific halibut that are caught by those who have traditionally relied on this fish as a critical food source or for customary purposes are classified as "subsistence," as opposed to recreational or commercial removals. Subsistence harvest is barred from resale, so by nature does not make up a part of the commercial landings. The IPHC defines subsistence harvest further as Pacific halibut taken in: 1) the sanctioned First Nations Food, Social, and Ceremonial (FSC) fishery in British Columbia, Canada; 2) the federal subsistence fishery in Alaska, U.S.A.; 3) tribal Indian Ceremonial and Subsistence (C&S) fisheries in Washington State, U.S.A.; and 4) U32 Pacific halibut (those under the legal size limit of 32 inches or 81.3 cm) retained by commercial fishers in IPHC Regulatory Areas 4D and 4E (U.S.A.) under IPHC Fishery Regulations (2021). In the latter case, IPHC permits U32 Pacific halibut to be retained because of its history of customary use in the area and because the remote location makes it unlikely that these fish will end up being commercially traded. State and federal regulations require that 'take-home' Pacific halibut caught during commercial fishing be recorded as part of the commercial catch on the landing records, so those fish caught within the commercial fisheries and not sold are accounted for as commercial landings and are not included in the estimates here. Table 6 provides a summary of subsistence removals followed by more detail by IPHC Regulatory Area.

Estimated harvests by IPHC Regulatory Area

Canada (IPHC Regulatory Area 2B; British Columbia)

The FSC fishery constituted British Columbia's subsistence harvest. Fisheries and Oceans Canada (DFO) has estimated the same level of harvest for this fishery since 2007.

U.S.A. (IPHC Regulatory Area 2A; California, Oregon, and Washington)

The subsistence allocation in IPHC Regulatory Area 2A consists of the C&S fishery that the tribes have subdivided from their directed commercial fishery limit.

U.S.A. (IPHC Regulatory Areas 2C, 3, 4A, 4B, 4CDE; Alaska)

After the Alaska subsistence program began in 2003, the Alaska subsistence catch declined until 2013, after which it rose until 2015. A new 2018 estimate was used for 2018 and 2019. The Alaska estimates for the subsistence Pacific halibut harvest are based on a biennial survey, the last of which was conducted in 2020; so the 2021 estimate was carried over from the previous year. The next survey is expected in 2022.

Regulations on the subsistence fishery in Alaska set by NOAA Fisheries include a registration program, and specifications on

Table 6. Subsistence Pacific halibut fishery removals (net weight) by IPHC Regulatory Area, 2021.

IPHC Regulatory Area	Subsistence Removals	
	tonnes	pounds
2A	15	32,200
2B	184	405,000
2C	132	290,137
3A	80	176,993
3B	6	13,861
4A	5	12,118
4B	<1	987
4CDE/Closed[1]	18	38,830
Total	**440**	**970,126**

[1] 2020 Alaska estimates were carried over for the 2021 estimates, with the exception of IPHC Regulatory Area 4D/4E subsistence harvest in the CDQ fishery, which were updated.

the type of gear, including the number of hooks and daily bag limits. The IPHC sets the fishing season dates.

According to Alaska Department of Fish and Game's voluntary annual survey, IPHC Regulatory Area 2C pulled in the most Pacific halibut as subsistence, followed by IPHC Regulatory Area 3A. The remaining IPHC Regulatory Areas accounted for a small fraction of the total.

Retention of U32 Pacific halibut in the CDQ fishery

The IPHC allows commercial Pacific halibut vessels fishing for certain Community Development Quota (CDQ) organizations in IPHC Regulatory Areas 4D and 4E (Bering Sea) to retain U32 (fork length < 32 inches or 81.3 cm) Pacific halibut under an exemption requested by the North Pacific Fishery Management Council. The CDQ harvest supplements the Alaskan subsistence catch. This removal is reported directly to the IPHC allowing for annual estimates, compared to the subsistence fishery elsewhere in Alaska which relies on a biennial survey. In 2021, retention of U32 Pacific halibut in the CDQ fishery was 1.0 tonne or 2,107 pounds, a decrease from the 1.3 tonnes of Pacific halibut retained in 2020. Changes in harvest each year tend to reflect the amount of effort by local fishing fleets and the availability of fish in their nearshore fisheries.

Bristol Bay Economic Development Corporation

The Bristol Bay Economic Development Corporation (BBEDC), the southernmost of the three CDQ organizations allowed to retain U32 Pacific halibut for subsistence purposes, comprises 17 member villages on the shores of Bristol Bay, AK: Port Heiden, Ugashik, Pilot Point, Aleknagik, Egegik, King Salmon, South Naknek, Naknek, Levelock, Ekwok, Portage Creek, Ekuk, Clark's Point, Dillingham, Manokotak, Twin Hills, and Togiak. The BBEDC aims to use sustainable fish harvesting to improve community life and livelihoods in its member communities. The BBEDC reported that in 2021, thirteen harvesters brought in a catch of 158 U32 Pacific halibut, weighing 0.7 tonnes or 1,641 pounds. Pacific halibut were landed by BBEDC vessels equally at Togiak and King Salmon.

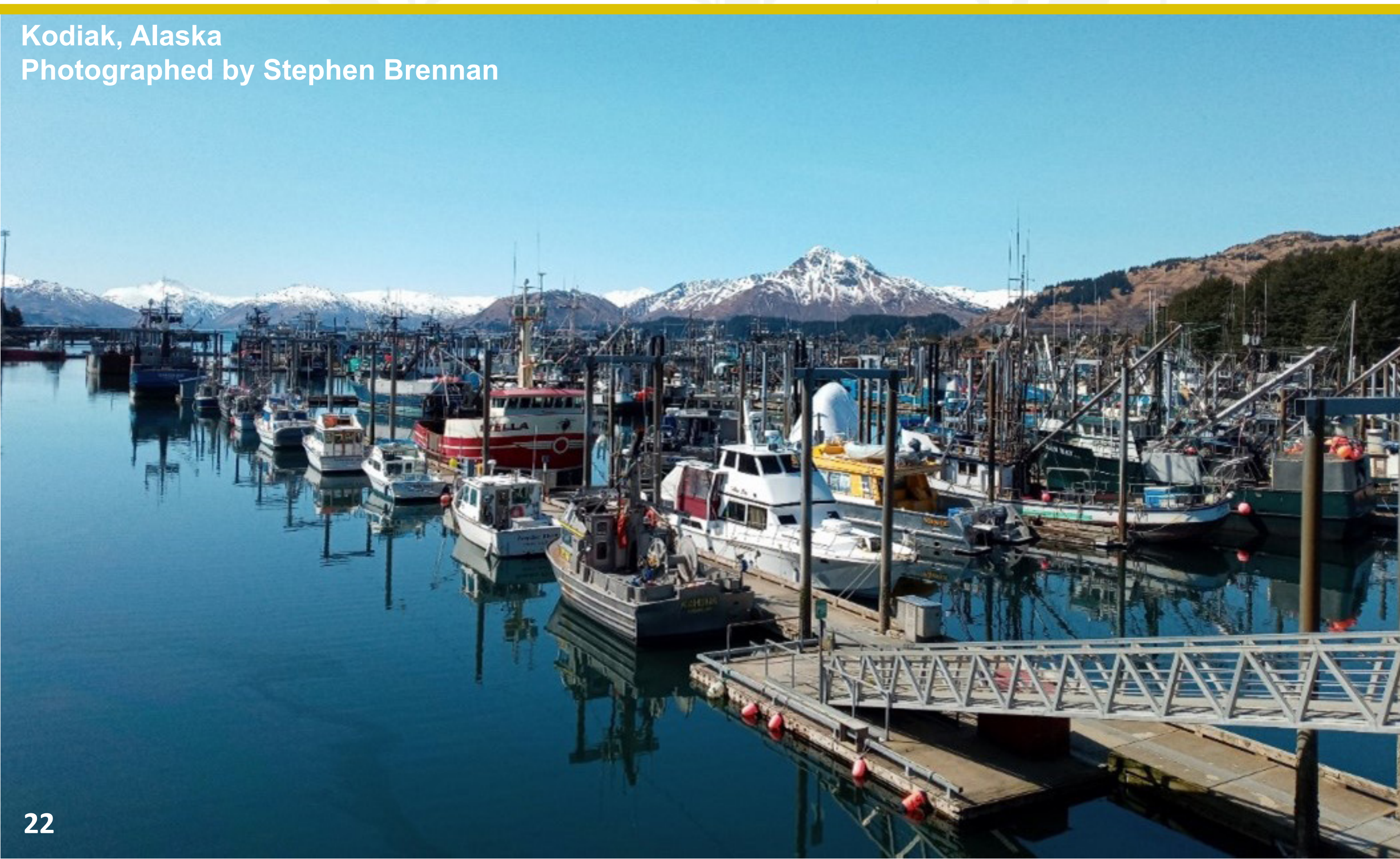
Coastal Villages Regional Fund

The Coastal Villages Regional Fund (CVRF) lies between the Norton Sound Economic Development Corporation (NSEDC) to the north, and the BBEDC to the south. It comprises 20 remote coastal villages: Platinum, Goodnews Bay, Quinhagak, Eek, Napaskiak, Oscarville, Napakiak, Tuntutuliak, Kongiganak, Kwigillingok, Kipnuk, Chefornak, Nightmute, Toksook Bay, Mekoryuk, Tununak, Newtok, Chevak, Hooper Bay, and Scammon Bay. In 2020, for the seventh year in a row, CVRF reported that their fishers landed zero Pacific halibut and no fish were received by their facilities.

Norton Sound Economic Development Corporation

The NSEDC is the northernmost of the three organizations, centered at Nome, AK. The NSEDC's purpose is to provide fishing opportunities for its 15 member communities, which are primarily on the coast of the Seward Peninsula, bounded by Kotzebue Sound on the north and Norton Sound on the south: Saint Michael, Stebbins, Unalakleet, Shaktoolik, Koyuk, Elim, Golovin, White Mountain, Nome, Teller, Brevig Mission, Wales, and the island communities of Little Diomede, Gambell, and Savoonga. In 2021, the area's only plant at Nome, received 54 U32 Pacific halibut, weighing 0.2 tonnes or 466 pounds.

Kodiak, Alaska
Photographed by Stephen Brennan



Discard Mortality of Pacific halibut in non-directed commercial fisheries

Described here is the removal of Pacific halibut caught incidentally by commercial fisheries targeting other species (a.k.a. bycatch) and that cannot legally be retained. This section focuses on the discard mortality of those fish, which comprises those that die as a result of their capture. In 2021, there was an estimated 1,720 tonnes or 3,793,000 pounds of Pacific halibut non-directed commercial fisheries discard mortality, representing a 30 percent decrease from the 2,079 tonnes or 4,584,000 pounds recorded in 2020. Estimates for 2021 are preliminary and subject to change as new information becomes available. Current values are available on the IPHC website: https://www.iphc.int

Sources of information for discard mortality in non-directed fisheries

The IPHC relies on observer and electronic monitoring programs run by government agencies from Canada and the U.S.A. for discard mortality in non-directed commercial fisheries estimates and information. In Canada, Fisheries and Oceans Canada (DFO) monitors fisheries off British Columbia (IPHC Regulatory Area 2B) where there is '100 percent' fishery monitoring for the groundfish trawl and hook-and-line fisheries. There are varying levels of monitoring for non-groundfish fleets in British Columbia. The COVID-19 pandemic affected the implementation of fishery monitoring in 2021.

In the U.S.A., the NOAA Fisheries monitors trawl fisheries off the coast of Alaska (IPHC Regulatory Areas 2C-4) and the west coast (IPHC Regulatory Area 2A). Off the west coast of the U.S.A., there is '100 percent' fishery monitoring for the commercial trawl groundfish fishery. There are varying levels of monitoring on non-trawl vessels and fisheries. Several fishery programs in Alaska have a mandatory '100 percent' monitoring requirement, including the Central Gulf of Alaska (GOA) Rockfish Program, the Bering Sea/Aleutian Islands (BSAI) Community Development Quota (CDQ) fisheries, the American Fisheries Act pollock cooperatives, and the BSAI Amendment 80 fishery cooperatives. In Alaska, an annual deployment plan (ADP) provides the scientific guidelines that determine how vessels not involved in these full coverage programs are chosen for monitoring, including vessels in the directed commercial Pacific halibut fishery. The COVID-19 pandemic affected implementation of the fishery monitoring and its level of coverage.

Discard mortality rates

The percentage of Pacific halibut that die as a result of being caught (called discard mortality rate or DMR) varies by both fishery and area. If observers are present, DMRs are calculated by judging the likelihood of survival for the Pacific halibut they see, using pre-set criteria. For fisheries without observers, assumed DMRs are used, which are based on similar fisheries in other areas where data are available.

Discard mortality in non-directed commercial fisheries by IPHC Regulatory Area

This section describes the estimated non-directed commercial fisheries discard mortality from each IPHC Regulatory Area (Table 7).

Canada (IPHC Regulatory Area 2B; British Columbia)

In Canada, Pacific halibut non-directed commercial discard mortality in trawl fisheries is capped at 454 tonnes round weight or 750,000 pounds net weight by DFO. Non-directed commercial discard mortality in non-trawl groundfish fisheries is largely handled under the quota system within the directed Pacific halibut fishery limit.

U.S.A. (IPHC Regulatory Area 2A; California, Oregon, and Washington)

As in prior years, the bottom trawl fishery and hook-and-line fishery for sablefish were responsible for the bulk of the non-directed commercial discard mortality in IPHC Regulatory Area 2A. Groundfish fisheries in IPHC Regulatory Area 2A are managed by NOAA Fisheries, following advice and recommendations developed by the Pacific Fishery Management Council (PFMC). Pacific halibut non-directed commercial discard mortality in the trawl IFQ fishery (also called trawl catch shares) in this area is capped at 45 tonnes or 100,000 pounds of O32 (> 32 inches fork length; 81.3 cm) Pacific halibut.

U.S.A. (IPHC Regulatory Area 2C; Southeast Alaska)

NOAA Fisheries reported non-directed commercial discard mortality by hook-and-line vessels fishing in the outside (federal) waters of IPHC Regulatory Area 2C. The vessels in this area were mostly targeting Pacific cod and rockfish in open access fisheries, and sablefish in the IFQ fishery. In state waters, fisheries that contribute to this removal include pot fisheries for red and golden king crab, and tanner crab. Information is provided periodically by Alaska Department of Fish and Game (ADFG), and the estimate was again rolled forward for 2020.

U.S.A. (IPHC Regulatory Areas 3A and 3B; Eastern, Central, and Western Gulf of Alaska)

Trawl fisheries are responsible for the majority of the non-directed commercial discard mortality in these IPHC Regulatory Areas, with hook-and-line fisheries a distant second. State-managed crab and scallop fisheries are also known to take Pacific halibut as non-directed commercial discard mortality, but at low levels. IPHC Regulatory Limited observer coverage, along with tendering, loopholes in trip scheduling, and safety considerations, likely result in observed trips not being representative of all trips and as a result Area 3 remains the area where non-directed commercial discard mortality is estimated most poorly.

U.S.A. (IPHC Regulatory Areas 4A, 4B, 4CDE; Bering Sea/Aleutian Islands)

The Pacific cod fishery is conducted in the late winter/early spring and late summer, and is the major fishery in this IPHC Regulatory Area contributing to the amount of Pacific halibut non-directed commercial

Table 7. Non-directed commercial fisheries discard mortality estimates of Pacific halibut (net weight) by year, IPHC Regulatory Area, and fishery, for 2021.[1]

IPHC Regulatory Area and Gear Type	Non-directed commercial fisheries discard mortality	
2A	tonnes	Pounds (in thousands)
Trawl (Groundfish)	0	0
Trawl (IFQ Bottom)	36	79
Trawl (Other Groundfish)	<1	1
Pot (Groundfish)	<1	1
Hook & Line	7	16
Trawl (Shrimp)	0	0
Total	44	97
2B		
Trawl (Groundfish Bottom)	112	247
Total	112	247
2C		
Pot (Groundfish)	1	3
Pot (Shellfish)	0	0
Trawl (Groundfish)	0	0
Hook & Line (non-IFQ)	<1	2
Hook & Line (IFQ)	10	23
Hook & Line (State Water)	15	33
Total	28	61
3A		
Dredge (Scallop & Sea Cucumber)	11	24
Trawl (Groundfish)	137	301
Hook & Line (non-IFQ)	33	73
Hook & Line (IFQ)	3	7
Pot (Groundfish)	4	8
Hook & Line (State Water)	5	11
Total	192	424
3B		
Pot (Shellfish)	0	0
Dredge (Scallop & Sea Cucumber)	6	13
Trawl (Groundfish)	126	278
Hook & Line (State Water)	n/a	n/a
Hook & Line (non-IFQ)	14	30
Hook & Line (IFQ)	3	7
Pot (Groundfish)	4	8
Total	152	336
4A		
Pot (Shellfish)	12	26
Dredge (Scallop & Sea Cucumber)	0	0
Trawl (Groundfish)	130	286
Hook & Line (State Water)	n/a	n/a
Hook & Line (non-IFQ)	5	10
Hook & Line (IFQ)	0	0
Pot (Groundfish)	5	10
Total	67	148

4B		
Pot (Shellfish)	<1	2
Trawl (Groundfish)	39	86
Hook & Line (State Water)	n/a	n/a
Hook & Line (non-IFQ)	23	51
Hook & Line (IFQ)	<1	2
Pot (Groundfish)	3	7
Total	67	148
4CDE/Closed		
Pot (Shellfish)	17	37
Dredge (Scallop & Sea Cucumber)	0	0
Trawl (Groundfish)	909	2,004
Hook & Line (State Water)	n/a	n/a
Hook & Line (non-IFQ)	43	94
Hook & Line (IFQ)	0	0
Pot (Groundfish)	6	13
Total	974	2,148
GRAND TOTAL	1,720	3,793

[1] Note that some totals may not sum precisely due to rounding.

discard mortality. In this IPHC Regulatory Area, almost all of the vessels are required to have ‘100 percent’ observer coverage because of the larger vessel size and the requirements of their fishery cooperative; very few small vessels fish Pacific cod or other flatfish in this IPHC Regulatory Area. Because of this level of observer coverage, non-directed commercial discard mortality estimates for IPHC Regulatory Area 4 fisheries are considered reliable. Pots are used to fish for Pacific cod and sablefish and fish very selectively. Non-directed commercial discard mortality rates are quite low for pots and survival is relatively high. Within the Bering Sea, the non-directed commercial discard mortality has typically been the highest in IPHC Regulatory Area 4CDE due to the groundfish fishery within that area.


Setline Survevy Specialist Tyler Jack
Photographed by Guy Boxall

Fishery Independent Survey Activities

Each year the International Pacific Halibut Commission (IPHC) conducts a Fishery-Independent Setline Survey (FISS), participates in NOAA (National Oceanic and Atmospheric Administration) Fisheries trawl surveys, and receives survey data from other organisations. Activities during these surveys include collection of biological and oceanographic data, tagging and release of fish, and other projects. IPHC Secretariat were not deployed aboard NOAA surveys in 2021 but Pacific halibut data collection did still occur through collaboration with NOAA Fisheries.

IPHC Fishery-Independent Setline Survey (FISS)

The IPHC Fishery-Independent Setline Survey (FISS) gathers catch rate information to monitor changes in biomass in the Pacific halibut population. The FISS uses standardised methods, including bait, gear, fishing locations, and time of year, to gain a balanced picture that can be compared over a large area and from year to year.

When other species are caught on the FISS, their presence provides data about bait competition, commonly known as 'hook competition'. Other species catch data also provide an indication of their abundance over time, making them valuable for population assessments, management, and potential avoidance strategies.

Design and procedures

The 2021 FISS covered both nearshore and offshore waters of British Columbia, Canada, and Alaska, Washington and Oregon, U.S.A., (Figure 1). The IPHC chartered 13 commercial longline vessels for FISS operations. During a combined 82 trips and 801 charter days, these vessels fished 18 charter regions. Each region required between 19 and 51 days to complete.

The FISS was conducted via stations arranged in a grid of 10x10 nautical miles with a depth range of 18 to 732 metres (10 to 400 fathoms). The 2021 FISS design was a selection of stations from the full FISS design of 1,890 stations. The 2021 FISS was

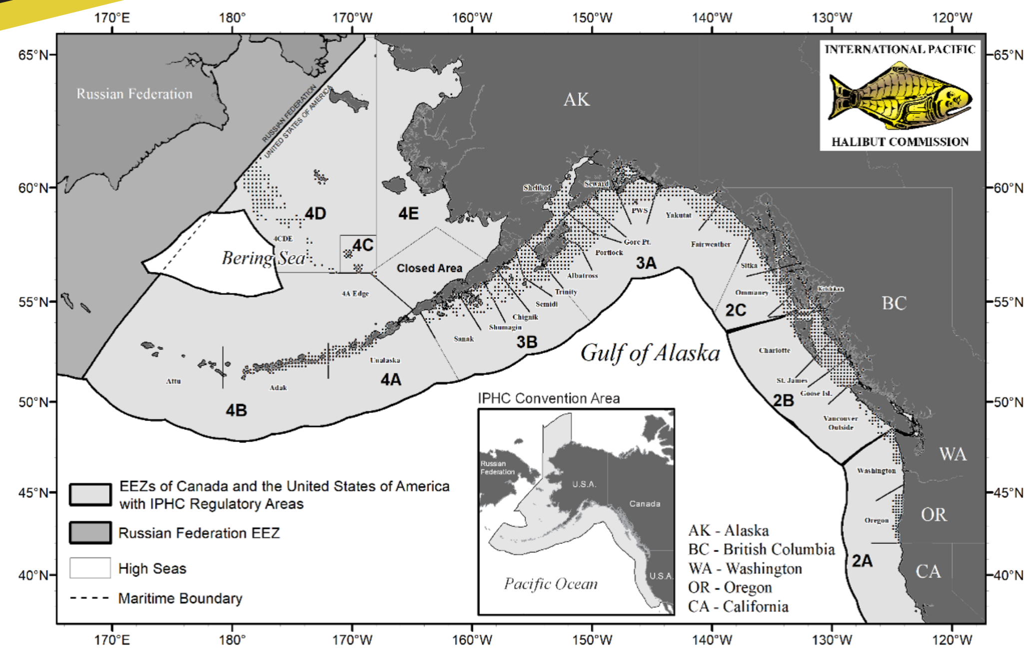


Figure 1. Stations fished during the 2021 IPHC Fishery-independendent setline survey.

to comprise a random subsample of 1,346 stations following decisions made at the 97th Session of the IPHC Annual Meeting (AM097). Each FISS station in the Seward charter region in IPHC Regulatory Area 3A was fished twice for a gear-comparison study (once with fixed gear and once with snap gear in random order). Of the 1,346 FISS stations planned for 2021, a total of 1,167 (87%) were deemed effective and incorporated into the stock assessment analysis. Four standard skates of gear were set at each station in IPHC Regulatory Areas 2A, 3B, and 4CDE, and eight standard skates in IPHC Regulatory Areas 2B, 2C, 3A, 4A, and 4B. Each vessel conducting FISS work set from one to four stations every day, with boats setting gear as early as 0500 hrs and allowing it to soak for at least five hours (but not overnight, if possible) before hauling. Data from gear soaked longer than 24 hours were discarded from the results, as were sets for which predetermined limits for lost gear, snarls, depredation, or displacement were exceeded. Other than the vessels using snap gear for the gear comparison work, FISS gear consisted of fixed-hook, 549 metre (1,800-foot) skates with 100 circle hooks of size 16/0 spaced 5.5 metres (18 feet) apart. The length of the gangions ranged from 61 to 122 centimetres (24 to 48 inches). Each hook was baited with 0.11 to 0.15 kilograms (1/4 to 1/3 pounds) of chum salmon.

Sampling protocols

Following protocols set out in the 2021 FISS Manual, shipboard Setline Survey Specialists assessed the functionality of bird avoidance devices during setting of the gear and recorded the number of hooks set and baits lost per skate. During gear retrieval, hook status (hook occupancy data to species or whether the hook was pulled up empty) for the first 20 consecutive hooks of each skate was recorded.

Setline Survey Specialists recorded lengths and weights of all Pacific halibut caught along with the corresponding skate numbers, and assessed the sex and maturity, prior hooking injury (PHI) incidence and severity, and evidence of depredation for each fish captured. Also collected was a randomized subsample of otoliths from every captured Pacific halibut for later age determination.

The male fish were assessed as either mature or immature, and the females were categorized as immature, ripening, spawning, or spent/resting. The sex and maturity level of U32 (fork length < 81.3 cm or 32 inches) Pacific halibut was recorded only if that fish was randomly selected for otolith removal or was already dead upon hauling. All U32 Pacific halibut not selected for otolith collection were measured and released alive.

Bait purchases

To ensure consistency from year to year, the bait used for the FISS has always been No. 2 semi-bright (Alaska Seafood Marketing Institute grades A through E), headed and gutted, and individually quick-frozen chum salmon. In August 2020, the IPHC Secretariat began arranging bait purchases for the 2021 FISS. Approximately 167 tonnes (370,000 pounds) of chum salmon were utilized from one supplier. Bait usage was based on 0.17 kilograms (0.37 pounds) per hook, resulting in approximately 136 kilograms (300 pounds) per eight-skate station. Bait quality was monitored and documented throughout the season and found to have met the standard as described above.

Fish sales

O32 (fork length > 81.3 cm or 32 inches) Pacific halibut caught during the FISS have historically been kept and sold to offset the cost of the FISS work with a goal of revenue neutrality. In 2021, U32 (fork length < 81.3 cm or 32 inches) Pacific halibut that were randomly selected for sampling were also kept and sold. All vessel contracts contained a lump sum payment along with a 10 percent share of the O32 Pacific halibut proceeds.

During the 2021 FISS, IPHC's chartered vessels delivered a total of 359 tonnes (792,157 pounds) of Pacific halibut to 19 different ports. The coastwide average price per kilogram was $15.13USD or $6.91 USD per pound, amounting to sales totaling $5,472,739.28 USD.

Field personnel

The 2021 FISS vessels were staffed by 22 Setline Survey Specialists, who worked a total of 1,685 person-days, including travel days, sea days, and debriefing days. Two setline survey specialists were aboard each FISS vessel. At a given time, one specialist handled fish, collected data, and sampled on deck, while the other specialist, in a portable shelter, recorded data and observations and stored samples collected by the specialist on deck. The IPHC did not deploy specialists on the NOAA Fisheries (AFSC) trawl survey in 2021 but did collaborate with NOAA Fisheries to have data collected aboard the trawl survey.

Oceanographic monitoring

This was the twelfth consecutive year of thThis was the thirteenth consecutive year of the IPHC oceanographic data collection program whereby water column

Table 8. The average total raw WPUE for each of the IPHC Regulatory Areas during the FISS 2021.

Regulatory Area	kg/skate	lb/skate	Station Count
2A	15	34	76
2B	46	102	225
2C	68	149	146
3A	64	140	418
3B	72	159	167
4A	52	114	36
4B	46	102	37
4C	34	76	20
4D	5	11	42

profiles were collected during the FISS. Oceanographic data were collected using instruments manufactured by Seabird Scientific that collected pressure (depth), conductivity (salinity), temperature, dissolved oxygen, pH, and fluorescence (chlorophyll a concentration) throughout the water column. Profiles were attempted at each FISS station, resulting in a total of 932 successful casts.

Additional research projects

In addition to core operations, the FISS provides a platform for a number of IPHC research projects as well as external special projects and data collections. Details of those projects are contained in the Biological and Ecosystem Research section of this report.

IPHC Fishery-Independent Setline Survey (FISS) results

As is typical, the IPHC targeted the summer months—May, June, July, and August—for FISS work. In 2021, this activity took place from 29 May through 14 September. On a coastwide basis, FISS vessel activity was highest in intensity at the beginning of the FISS season and declined early in August as boats finished their charter regions (Figure 1). All FISS activity was completed by mid-September.

Weight and number per unit effort (WPUE)

As a result of including both commercial and non-commercial fishing grounds in the FISS design, the FISS results showed an average weight per unit effort (WPUE) for all IPHC Regulatory Areas below that of the directed commercial Pacific halibut fleet (Table 8).

Non-Pacific halibut catch

Around 115 species of fish and invertebrates are captured each year as bycatch by the IPHC FISS (For more details on bycatch, visit https://www.iphc.int/data/fiss-bycatch). The predominant incidental catches in IPHC Regulatory Areas 2A, 2B, 2C, and 3A are sharks, primarily spiny dogfish (*Squalus suckleyi*). The most frequent incidental catch in IPHC Regulatory Areas 3B, 4A, and 4CDE/Closed are Pacific cod (*Gadus microcephalus*). In IPHC Regulatory Areas 4B and 4C, the "other species" category is most common and is comprised of yellow Irish lord sculpins (*Hemilepidotus jordani*), unidentified starfish, grenadiers (*Macrouridae*), and arrowtooth flounder (*Atheresthes stomias*).

Size and age observations

About 46 percent of Pacific halibut caught during the IPHC FISS were smaller than the current commercial legal-size limit (U32; < 81.3 cm or 32 inches) with a median fork length of 74 cm (29 inches). In 2021, median length decreased in all IPHC Regulatory Areas fished compared to 2020 (2B, 2C, 3A and 3B). IPHC Regulatory Area 3B and 4A had a median length below the legal-size limit. The largest median length was in IPHC Regulatory Area 2C (87 cm or 34.25 in).

The sex composition of FISS-caught O32 (> 81.3 cm or 32 inches) Pacific halibut varied widely among IPHC Regulatory Areas, ranging from 39 percent (4B) to 80 percent (2C) female. As in previous years, IPHC Regulatory Area 2C showed the highest concentration of females. Most female Pacific halibut caught during the FISS period (i.e. summer months) were in the mature stage and expected to spawn in the upcoming season.

NOAA Fisheries Trawl Surveys

The IPHC routinely collaborates with NOAA Fisheries to collect biological data from Pacific halibut caught during the groundfish trawl surveys conducted in Alaska. In 2021, survey personnel encountered and measured 4,532 Pacific halibut in the eastern Bering Sea survey, 466 in the northern Bering Sea survey, and 5,723 in the Gulf of Alaska survey. A subsample was selected for collection of weights and otoliths for aging which included 700 samples from the eastern Bering Sea, 264 from the northern Bering Sea, and 480 from the Gulf of Alaska.

POPULATION ASSESSMENT

Since 1923, one of the IPHC's primary tasks has been to assess the population (or stock) of Pacific halibut. In 2021, the IPHC conducted its annual coastwide stock assessment of Pacific halibut using updated data sources and new information from the 2021 fishing period. This section covers three main topics that have bearing on the population assessment process: (1) the data sources available for the Pacific halibut stock assessment and related analyses, (2) the results of the stock assessment, and (3) the outlook for the stock, scientific advice, and future research directions.

Data sources

The data for the stock assessment is based on both fishery-dependent and fishery-independent data, as well as auxiliary data. The data sources include historical information going as far back as the late 1800s, which allow scientists to better identify trends over time that may be of import to the understanding of the current population. Data collection has continuously improved and is now the best it has ever been; however, the historical data are incomplete and/or imperfect in some cases, limiting the conclusions that can be drawn for years past.

Historical data

Known Pacific halibut mortality consists of target/directed commercial fishery landings and discard mortality (including research), recreational fisheries, subsistence, and non-targeted/directed discard mortality ('bycatch') in fisheries targeting other species where Pacific halibut retention is prohibited. Over the period 1888-2021 mortality has totaled 7.3 billion pounds (~3.3 million metric tons, t). Since 1922, the fishery has ranged annually from 34 to 100 million pounds (16,000-45,000 t) with an annual average of 63 million pounds (~29,000 t). Annual mortality was above this long-term average from 1985 through 2010 and has averaged 38.5 million pounds (~17,500 t) from 2017-21.

2021 fishery-dependent and fishery-independent survey data

Fishery-dependent data includes information from directed commercial, recreational, subsistence, and non-directed commercial fisheries. Pacific halibut landings data from the commercial fishery since 1981 have been reported to IPHC by way of commercial fish tickets. Annual recreational mortality estimates are provided to the IPHC by state agencies (U.S.A. waters) and Fisheries and Oceans Canada (DFO). Since

1991, DFO and NOAA (National Oceanic and Atmospheric Administration) Fisheries have provided estimates of subsistence (or personal use) harvests; these estimates are not made every year in all cases, so in some instances they are simply repeated from previous years when no new data are available.

Fishery-dependent and fishery-independent data include: 1) weight-per-unit-effort (WPUE), numbers-per-unit-effort (NPUE), 2) age distributions, and 3) weight-at-age. The primary source of trend information is the IPHC fishery-independent setline survey (FISS); however, IPHC considers the commercial fishery WPUE to be another indicator for the stock, and so its estimates are also treated as an index of abundance, while accounting for possible changes in fishery practices and locations from year to year.

The 2021 modelled FISS results detailed a coastwide aggregate estimate of average NPUE which increased by 17% from 2020 to 2021, reversing the declines observed over the last four years (Figure 2). The modelled coastwide estimate of average WPUE of legal (O32: > 81.3 cm or 32 inches)) Pacific halibut, the most comparable metric to observed commercial fishery catch rates, increased by 4% from 2020 to 2021. This reduced trend relative to that for NPUE indicates that recruitment of younger fish is contributing more to current stock productivity than somatic growth of fish already over the legal minimum size limit. Individual IPHC Regulatory Areas varied from an estimated 57% increase (Regulatory Area 3B) to a 9% decrease (Regulatory Area 4CDE) in O32 WPUE. Due to the extensive survey conducted in 2021, uncertainty was near or below historical levels for most IPHC Regulatory Areas in 2021.

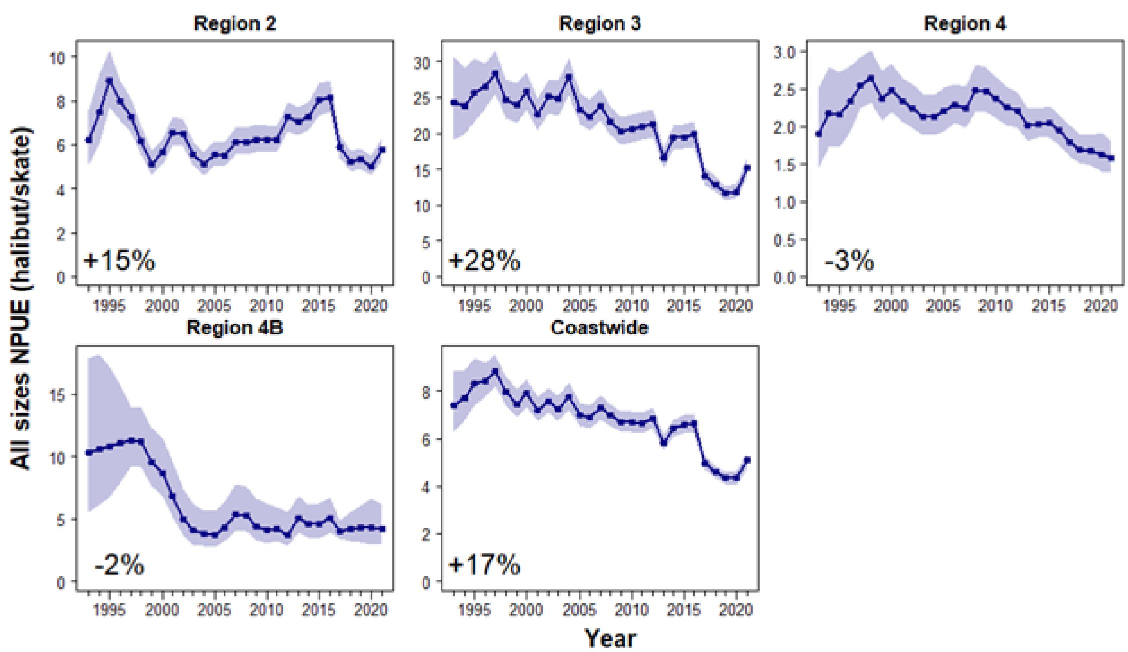


Figure 2. Trends in modelled FISS NPUE by Biological Region, 1993-2021. Percentages indicate the change from 2020 to 2021. Shaded zones indicate 95% credible intervals. Preliminary commercial fishery WPUE estimates from 2021 logbooks increased by 2% at the coastwide level. The bias correction to account for additional logbooks compiled after the fishing season resulted in an estimate of no change (+/- 0%) coastwide. Trends varied among IPHC Regulatory Areas and gears; however, Area-specific trends were mixed, and generally similar to those from the FISS, with the exception of IPHC Regulatory Area 4A which showed a sharp increase in the commercial data.

Fisheries Data Specialist Kimberly Sawyer Van Vleck
Photographed by Caroline Prem

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All information used in the 2021 stock assessment was finalized on 31 October 2021 in order to provide adequate time for analysis and modeling. As has been the case in all years, some data are incomplete, or include projections for the remainder of the year. These include commercial fishery WPUE, commercial fishery age composition data, and 2021 mortality estimates for all fisheries still operating. All preliminary data series in this analysis will be fully updated as part of the 2022 stock assessment.

Auxiliary inputs

The population assessment includes a number of additional information sources that are treated as data, even though they represent the products of analyses themselves. These are: 1) the weight-length relationship, 2) the maturity schedule, 3) estimates of ageing bias and imprecision, and 4) the regimes of the Pacific Decadal Oscillation (PDO). Details of these data sources are as follows.

- The headed and gutted weight (net pounds) of a Pacific halibut has historically been estimated via a simple equation of weight based on fork length. As length increases, weight corresponds at a rate slightly greater than cubic increase. Due to the direct sampling of individual Pacific halibut weights in the port sampling program (beginning in 2015) and the FISS (beginning in 2019), the weight-length relationship is used only for sources that do not directly sample individual fish weights (e.g., non-directed commercial discard mortality, recreational mortality). The IPHC will be providing IPHC Regulatory Area specific L-W relationships for future use based on the extensive sampling to date.

- Female Pacific halibut are estimated to become sexually mature on a set schedule that has been estimated to be stable through several historical investigations. Across all Regulatory Areas, half of all female Pacific halibut become sexually mature by 11.6 years, and nearly all fish are mature by age 17. This maturity schedule is the focus of planned research in 2022 and beyond.

- Age estimates are based on the counting of rings on an otolith, a method that is by nature subject to both bias and imprecision. However, it is relatively easy to estimate the age of Pacific halibut (compared to other groundfish), and analysis shows that the current aging method—referred to as "break-and-bake"—is remarkably precise.

- The PDO is a pattern of Pacific climate variability that changes about every 10-30 years. Research has shown that during the 20th century these environmental conditions have been correlated with the recruitment of Pacific halibut. In "positive" phases of the PDO (before 1947, and 1977-2006), the stock saw a higher average recruitment of younger fish. The PDO's longest "negative" phase since the late 1970s occurred from 2006 through 2013. Positive values were observed over 2014-19; however, it is unclear if this represents a change of phase or a different set of environmental conditions altogether.

Stock distribution

Estimates of the biological distribution of the stock are achieved using the modelled FISS WPUE index of Pacific halibut density, weighted by the geographical extent of each IPHC Regulatory Area. To account for factors that are known to affect FISS catch rates, two adjustments to the raw WPUE prior to modelling are made for FISS timing relative to the harvest and hook competition. The measure of "hook competition" accounts for competition from all species including other Pacific halibut. Adjusting for the presence of such competition reduces bias in the observed WPUE index of density and are applied at the station level.

Modelled survey WPUE (representing the density of all sizes of Pacific halibut captured by the FISS) is used to produce the best available estimates of the stock distribution by Biological Region (Figure 3). The current trend in estimated population distribution appears to be shifting back toward Biological Region 3 after more than a decade of decline. In both 2020 and 2021, Biological Regions 2 and 4 have decreased, while Region 4B has stayed relatively constant

Table 9. Recent stock distribution estimates by Biological Region based on modelling of all sizes of Pacific halibut captured by the FISS.

Year	Region 2 (2A, 2B, 2C)	Region 3 (3A, 3B)	Region 4 (4A, 4CDE)	Region 4B
2017	24.5%	48.3%	22.6%	4.6%
2018	24.1%	47.6%	22.9%	5.4%
2019	24.9%	46.3%	23.8%	5.0%
2020	23.0%	49.4%	22.6%	5.1%
2021	21.3%	54.8%	19.2%	4.7%

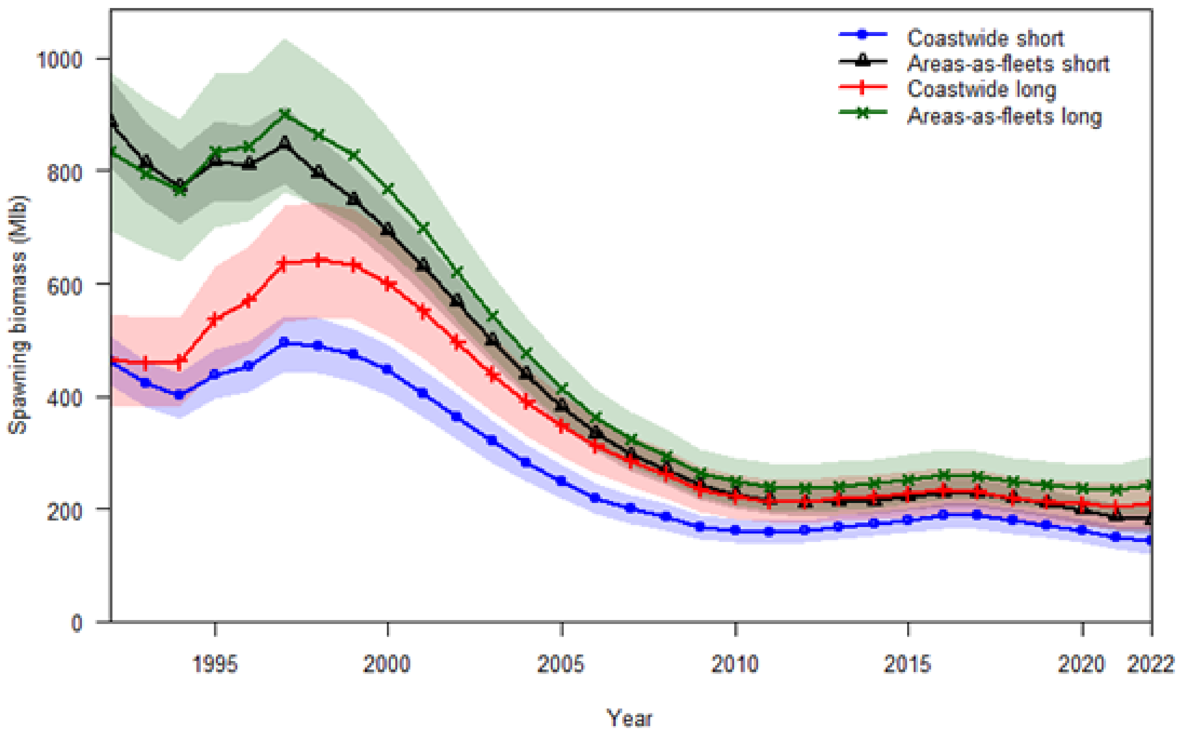


Figure 3. Retrospective comparison among recent IPHC stock assessments. Black lines indicate estimates of spawning biomass estimated by assessments conducted from 2012-2019 with the terminal estimate shown as a point, the shaded distribution denotes the 2020 ensemble: the dark blue line indicates the median (or "50:50 line") with an equal probability of the estimate falling above or below that level; colored bands moving away from the median indicate the intervals containing 50/100, 75/100, and 95/100 estimates; dashed lines indicate the 99/100 interval.

(Table 9). It is unknown to what degree current stock distribution corresponds to historical distributions from the mid-1900s or to the average distribution likely to occur in the absence of fishing mortality, as modelled survey estimates are only available beginning in 1993.

Population assessment at the end of 2021

Stock assessment

The methods for undertaking the population assessment for Pacific halibut have been improved many times over the last 30 years with the development of better model assumptions and analytical approaches. For the last nine years, a method called the “ensemble approach” has been used as a way to make the process both stronger and more flexible to future model changes. Originating from the field of weather and hurricane forecasting, it recognizes that there is no “true” assessment model, and risk assessment based on multiple models provides a basis for the estimation of management quantities (and the uncertainty about these quantities).

The 2021 stock assessment represents an update to the 2020 analysis, adding data sources where available, but retaining the same basic model structure for each of the four component models. Incremental changes made during 2021 were documented through a two-part review by the IPHC’s scientific review process. The 2021 assessment continues to make use of the extensive historical time series of data, as well as integrating both structural and estimation uncertainty via an ensemble of four equally weighted individual models. Within-model uncertainty from each model was propagated through to the risk analysis and decision table (Table 10). Therefore, key quantities such as reference points and stock size are reported as distributions, such that the entire plausible range can be evaluated. Point estimates reported in this stock assessment correspond to median values from the ensemble.

Spawning biomass and recruitment trends

The results of the 2021 stock assessment indicate that the Pacific halibut stock declined continuously from the late 1990s to around 2012. That trend is estimated to have been largely a result of decreasing size-at-age, as well as somewhat weaker recruitment strengths than those observed during the 1980s. The spawning biomass (SB) is estimated to have increased gradually to 2016, and then decreased to an estimated 191 million pounds (~86,600 t) at the beginning of 2022, with an approximate 95% credible interval ranging from 129 to 277 million pounds (~58,700-125,400 t; Figure 2). The recent spawning biomass estimates from the 2021 stock assessment are very consistent with previous analyses, back to 2012. Prior to that period, the current assessment indicates a high probability of larger biomass than estimated prior to the 2019 stock assessment; this is largely the result of the addition of sex-ratio information for the directed commercial landings. All assessments since 2015 have indicated a decreasing spawning biomass in the terminal year.

Average Pacific halibut recruitment is estimated to be higher (71 and 72% for the coastwide and Areas-as-Fleets (AAF) models, respectively) during favorable PDO regimes. Pacific halibut recruitment estimates show the large cohorts in 1999 and 2005. Cohorts from 2006 through 2011 are estimated to be much smaller than those from 1999-2005, which has resulted in a decline in both the stock and fishery yield as these low recruitments have moved into the spawning biomass. Based on age data through 2021, individual models in this assessment produced estimates of the 2012 year-classes that are comparable to the magnitude of the 2005 year-class. The 2012 year-class is estimated to be 19% mature in 2021, and the maturation of this cohort has a strong effect on the short-term projections.

Reference points

The IPHC's interim management procedure uses a relative spawning biomass of 30% as a trigger, below which the target fishing intensity is reduced. At a spawning biomass limit of 20%, directed fishing is halted due to the critically low biomass condition. This calculation is based on recent biological conditions: current weight-at-age and estimated recruitments still influencing the stock. Thus, the 'dynamic' calculation measures only the effect of fishing on the spawning biomass. The relative spawning biomass in 2022 was estimated to be 33% (credible interval: 22-54%) equal to the estimate for 2020, and greater than the values estimated for the previous decade. The probability that the stock is below the SB30% level is estimated to be 45% at the beginning of 2021, with less than a 1% chance that the stock is below SB20%. The IPHC's current interim management procedure specifies a target level of fishing intensity of a Spawning Potential Ratio (SPR) corresponding to an F43%; this equates to the level of fishing that would reduce the lifetime spawning output per recruit to 43% of the unfished level given current biology, fishery characteristics and demographics. Based on the 2021 assessment, the 2021 fishing intensity is estimated to correspond to an F46% (credible interval: 35-63%). Both 2020 and 2021 are estimated to be less than values estimated for the last 20+ years. This drop in fishing intensity corresponds both to reduced mortality limits (2020) and actual mortality below the limits (2020 and 2021).

Sources of uncertainty

This stock assessment includes uncertainty associated with estimation of model parameters, treatment of the data sources (e.g. short and long time-series), natural mortality (fixed vs. estimated), approach to spatial structure in the data, and other differences among the models included in the ensemble. Although this is an improvement over the use of a single assessment model, there are important sources of uncertainty that are not included.

The assessment utilized four years (2017-20) of sex-ratio information from the directed commercial fishery landings. However, uncertainty in historical ratios, and the degree of variability likely present in those and future fisheries remains unknown. Additional years of data are likely to further inform selectivity parameters and cumulatively reduce uncertainty in stock size in the future. The treatment of spatial dynamics and movement rates among Biological Regions, which are represented via the coastwide and AAF approaches, has large implications for the current stock trend, as evidenced by the different results among the four models comprising the stock assessment ensemble. This assessment also does not include mortality trends or explicit demographic linkages with Russian waters, although such linkages may be increasingly important as warming waters in the Bering Sea allow for potentially important exchange across the international border.

Additional important contributors to assessment uncertainty (and potential bias) include the lag in estimation of incoming recruitment between birth year and direct observation in the fishery and survey data (6-10 years). Like most stock assessments, there is no direct information on natural mortality, and increased uncertainty for some estimated components of the fishery mortality. Fishery mortality estimates are assumed to be accurate; therefore, uncertainty due to discard mortality estimation (observer sampling and representativeness), discard

Photographed by Caroline Prem

mortality rates, and any other documented mortality in either directed or non-directed fisheries (e.g., whale depredation) could create bias in this assessment. Maturation schedules and fecundity are currently under renewed investigation by the IPHC. Currently used historical values are based on visual field assessments, and the simple assumption that fecundity is proportional to spawning biomass and that Pacific halibut do not experience appreciable skip-spawning (physiologically mature fish which do not actually spawn due to environmental or other conditions). To the degree that maturity, fecundity or skip spawning may be temporally variable, the current approach could result in bias in the stock assessment trends and reference points. New information will be incorporated as it becomes available; however, it may take years to better understand trends in these biological processes at the scale of the entire population. Projections beyond three years are avoided due to the lack of mechanistic understanding of the factors influencing size-at-age and relative recruitment strength, the two most important factors in historical population trends.

Due to the many remaining uncertainties in Pacific halibut biology and population dynamics, a high degree of uncertainty in both stock scale and trend will continue to be an integral part of an annual management process. Results of the IPHC's ongoing Management Strategy Evaluation (MSE) process can inform the development of management procedures that are robust to estimation uncertainty via the stock assessment, and to a wide range of hypotheses describing population dynamics.

Outlook

Stock projections were conducted using the integrated results from the stock assessment ensemble in tandem with summaries of the 2021 directed and non-directed fisheries. The harvest decision


Copper River Seafoods crew (L-R)
Robert Allain, Amanda Eben, Sophie Gustafson, Birch Biessel, Aurora Shadle, and Angela Stauss.
Photographed by Jessica Marx

table (Table 10) provides a comparison of the relative risk (in times out of 100), using stock and fishery metrics (rows), against a range of alternative harvest levels for 2022 (columns). A grid of alternative TCEY values corresponding to SPR values from 40% to 46% is also provided to allow for finer detail across the range of estimated SPR values identified by the MSE process as performing well with regard to stock and fishery objectives. For each column of the decision table, the mortality (including all sizes and sources), the coastwide TCEY and the associated level of fishing intensity projected for 2022 (median value with the 95% credible interval below) are reported.

The projections for this assessment are more optimistic than those from the 2019 and 2020 assessments due to the increasing projected maturity of the 2012 year-class. This translates to a lower probability of stock decline for 2022 than in recent assessments as well as a decrease in this probability through 2023-24. There is greater than a 50% probability of stock decline in 2023 (55-64/100) for the entire range of SPR values from 40-46%, which include the status quo TCEY and the F43% reference level. The 2022 "3-year surplus" alternative, corresponds to a TCEY of 38.0 million pounds (~17,240 t), and a projected SPR of 48% (credible interval 32-63%). At the reference level (a projected SPR of 43%) the probability of spawning biomass decline from 2022 to 2023 is 59%, decreasing to 55% in three years, as the 2012 cohort matures. The one-year risk of the stock dropping below SB30% ranges from 43% at the F46% level to 45% at the F40% level of fishing intensity.

Scientific advice

Sources of mortality

In 2021, total Pacific mortality due to fishing increased to 37.66 million pounds (17,084 t) but remained below the 5-year average of 38.48 million pounds (17,456 t). Of that total, 88% comprised the retained catch, up from 84% in 2020.

Stock status (spawning biomass)

Current (beginning of 2022) female spawning biomass is estimated to be 191 million pounds (86,600 t), which corresponds to a 45% chance of being below the IPHC trigger reference point of SB30%, and less than a 1% chance of being below the IPHC limit reference point of SB20%. The stock is estimated to have declined by 17% since 2016 but is currently at 33% of the unfished state. Therefore, the stock is considered to be 'not overfished'. Projections indicate that mortality consistent with the interim management procedure reference fishing intensity (F43%) is likely to result in further declining biomass levels in the near future.

Fishing intensity

The 2021 fishing mortality corresponded to a point estimate of SPR = 46%; there is a 47% chance that fishing intensity exceeded the IPHC's current reference level of F43% (Figure 4). The Commission does not currently have a coastwide fishing intensity limit reference point.

Stock distribution

The proportion of the coastwide stock represented by Biological Region 3 has increased sharply over 2020-21, reversing over a decade of steady decline. This trend occurs in tandem with declines in Biological Regions 2 and 4; however, all regions remain within the historical range observed from 1993-2021. These estimates have been updated and strongly informed by the comprehensive FISS design implemented in 2021.

Table 10. Harvest decision table for the 2022 mortality limits. Columns correspond to yield alternatives and rows to risk metrics. Values in the table represent the probablity, in "times out of 100" (or percent chance) of a particular risk.

		2022 Alternative				3-Year Surplus		Status quo		Reference $F_{43\%}$					
		Total mortality M lb	0.0	31.2	38.7	39.2	39.9	40.2	41.1	42.4	43.8	45.2	46.6	61.2	
		TCEY (M lb	0.0	30.0	37.5	38.0	38.7	39.0	39.9	41.2	42.6	44.0	45.4	60.0	
		2022 fishing intensity	$F_{100\%}$	$F_{53\%}$	$F_{46\%}$	$F_{46\%}$	$F_{45\%}$	$F_{45\%}$	$F_{44\%}$	$F_{43\%}$	$F_{42\%}$	$F_{41\%}$	$F_{40\%}$	$F_{32\%}$	
		Fishing ntensity nterval	--	38-69%	32-64%	32-63%	32-63%	31-63%	31-62%	30-61%	29-60%	28-59%	28-59%	21-51%	
Stock Trend (spawning biomass)	in 2023	is less than 2022	<1	39	55	55	56	57	58	59	61	63	64	84	a
		is 5% less than 2022	<1	3	14	16	18	19	21	25	30	34	37	58	b
	in 2024	is less than 2022	<1	39	53	54	55	55	56	58	59	61	62	80	c
		is 5% less than 2022	<1	16	37	39	40	41	43	46	48	50	52	66	d
	in 2025	is less than 2022	<1	33	49	50	51	52	53	55	56	58	60	77	e
		is 5% less than 2022	<1	18	38	39	41	42	43	46	48	50	52	67	f
Stock Status (Spawning biomass)	in 2023	is less than 30%	31	40	43	43	43	43	44	44	44	45	45	48	g
		is less than 20%	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	h
	in 2024	is less than 30%	16	34	39	39	40	40	41	41	42	43	44	49	
		is less than 20%	<1	<1	<1	<1	<1	1	1	1	1	1	1	6	
	in 2025	is less than 30%	4	29	36	37	37	37	38	40	41	42	43	49	k
		is less than 20%	<1	<1	1	1	1	1	1	1	2	2	3	12	
Fishery Trend (TCEY)	in 2023	is less than 2022	0	21	48	49	49	49	50	50	50	50	51	70	m
		is 10% less than 2022	0	7	41	42	44	45	47	48	49	50	50	58	n
	in 2024	is less than 2022	0	22	48	48	49	49	50	50	50	50	50	69	o
		is 10% less than 2022	0	9	41	42	44	45	46	48	49	50	50	58	p
	in 2025	is less than 2022	0	22	47	48	48	49	49	50	50	50	50	68	q
		is 10% less than 2022	0	10	40	42	43	44	46	48	49	49	50	58	r
Fishery Status (Fishing intensity)	in 2022	is above $F_{43\%}$	0	20	48	49	49	50	50	50	50	50	51	70	s

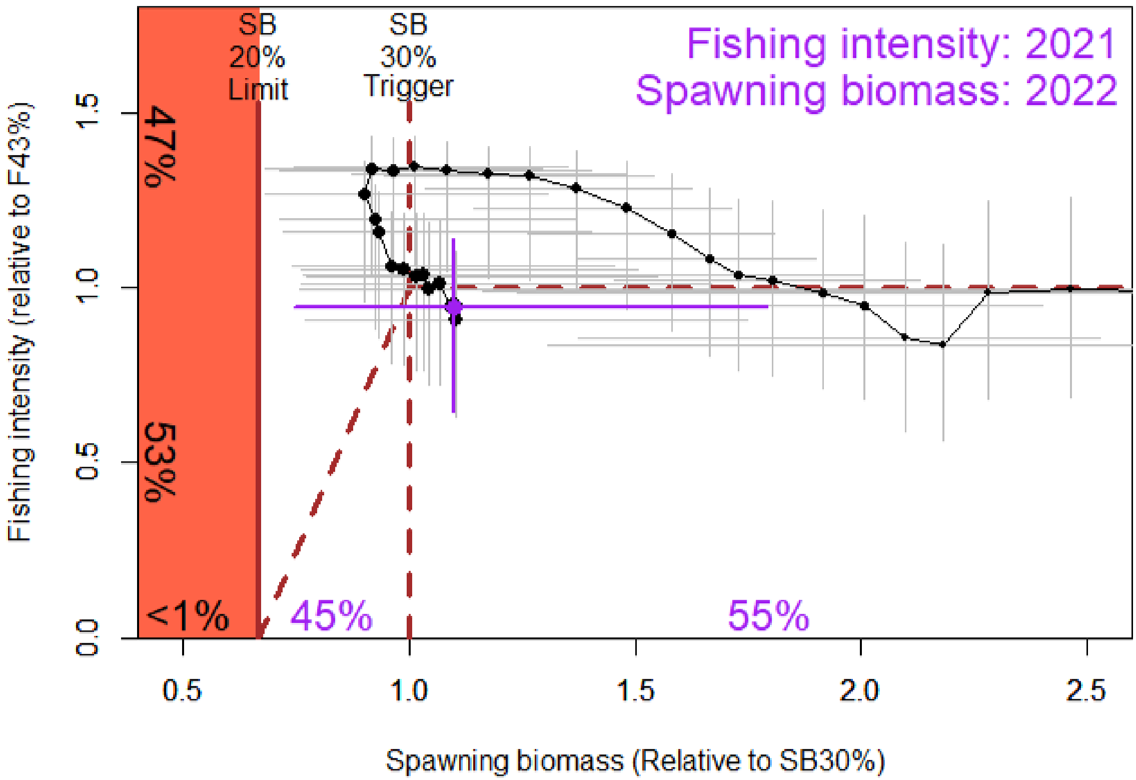


Figure 4. Phase plot showing the time-series (1992-2021) of estimated spawning biomass and fishing intensity relative to the reference points specified in the IPHC's interim management procedure. Dashed lines indicate the current $F_{43\%}$ (horizontal) reference fishing intensity, with linear reduction below the $SB_{30\%}$ (vertical) trigger, the red area indicates relative spawning biomass levels below the $SB_{20\%}$ limit. Each year of the time series is denoted by a solid point (credible intervals by horizontal and vertical whiskers), with the relative fishing intensity in 2020 and spawning biomass at the beginning of 2021 shown as the largest point (purple). Percentages along the y-axis indicate the probability of being above and below $F_{43\%}$ in 2020; percentages on the x-axis the the probabilities of being below $SB_{20\%}$, between $SB_{20\%}$ and $SB_{30\%}$ and above $SB_{30\%}$ at the beginning of 2021.

Future research in support of the stock assessment

Research priorities for the stock assessment and related analyses have been consolidated with those for the IPHC's MSE and the Biological Research program and are included in the IPHC's 5-year research plan five-year research plan.

HARVEST STRATEGY POLICY

Harvest strategy policy at the IPHC is a strategic approach to setting harvest limits that is informed by many analyses and simulation studies. The IPHC Harvest Strategy Policy provides a framework for applying a science-based approach to setting mortality limits for Pacific halibut throughout the IPHC Convention Area. The framework uses a management procedure that incorporates science and policy to determine the coastwide Total Constant Exploitation Yield (TCEY) and then distribute it across all IPHC Regulatory Areas.

In 2017 the Commission agreed to modify the policy by separating the scale (coastwide fishing intensity) and the distribution of fishing mortality. In 2018, the Management Strategy Evaluation (MSE) process provided recommendations on the scale portion of the policy. The first step in the modified harvest strategy policy is to determine the TCEY from the coastwide fishing intensity (scale) on the coastwide stock based on Spawning Potential Ratio (SPR). Once the coastwide TCEY is determined it is split into a TCEY for each IPHC Regulatory Area. This separation of scale and distribution accounts for all mortality from all sources and allows the Commission to separate the decision of coastwide fishing intensity from distributing the TCEY.

The scale part of the harvest strategy is currently based on a fishing mortality rate that corresponds to a SPR of 43% (a 57% reduction in the spawning potential). This SPR was based on the range of values identified through the MSE process, considering the trade-off between yield and variability in the stock and fishery dynamics while ensuring that conservation objectives are met. The SPR can be thought of as the percentage of spawning potential for a fish over its lifetime given a constant level of fishing. For example, a fish may have many chances to spawn without fishing, but that potential will be reduced with fishing.

The distribution of the coastwide TCEY uses estimates from the Fishery-Independent Setline Survey (FISS), relative harvest rates, and agreements for IPHC Regulatory Areas 2A and 2B which are set to expire at the end of 2022. Estimates of biomass from the FISS is a science-based method to distribute the mortality similar to how the stock is distributed. Relative harvest rates, based on science and policy, are used to reduce the fishing mortality in western areas from which Pacific halibut typically migrate to eastern areas and are typically less productive. The policy-based agreements for IPHC Regulatory Areas 2A and 2B are based on socio-economic and historic justifications.

Management Strategy Evaluation

Management Strategy Evaluation (MSE) is a formal process in which to evaluate the performance of alternative management procedures for the Pacific halibut fishery against defined goals and objectives. Incorporating uncertainty about stock parameters and dynamics into the MSE can identify management procedures that are robust to those uncertainties. At the IPHC, the MSE process has been interactive, with a Management Strategy Advisory Board (MSAB) made up of stakeholders and managers involved in the resource. The MSAB provides suggestions that are evaluated against objectives defined by all of the parties involved.

The MSE analysis was completed in 2020 with an evaluation and comparison of many candidate management procedures to be presented to the Commission for potential adoption and implementation in 2021. These management procedures were made up of many different elements to determine the coastwide Total Constant Exploitation Yield (TCEY) and distribute it to IPHC Regulatory Areas. Conservation and fishery objectives were used for the evaluations and trade-offs between those objectives. It was found that SPR values in the range of 40% to 46% met the currently defined objectives and averaging recent estimates of the stock distribution improved stability of the TCEY for IPHC Regulatory Areas. Potentially increasing the fishing intensity to accommodate some IPHC Regulatory Areas may also meet short-term objectives but could perform worse in the long-term. The various elements investigated could be combined to create new management procedures and subsequently evaluated to determine if the new combination would show improved outcomes.

The MSE program of work was updated in 2021 for completion in 2023 and included items related to improving the MSE framework, investigating management procedures, and evaluation of the results. Improving the MSE framework elements will result in updated operating models to simulate the Pacific halibut population, incorporation of decision-making variability, and improved simulation of the stock assessment. The Commission is currently focused on investigating size limits and multi-year assessments. Multi-year assessments is the concept of not conducting the stock assessment annually, but incorporating a procedure in years without an assessment that may use data that are collected annually, such as the IPHC Fishery-Independent Setline Survey (FISS). Finally, the clear communication of results is important so that stakeholders and Commissioners can provide advice and make informed decisions.

Management Strategy Advisory Board (MSAB)

The central role of the MSAB is to provide advice to the Commission on options for fishery objectives, performance metrics, candidate management procedures, and to measure the performance of various management strategies against the defined objectives. An MSAB meeting is scheduled to occur in late 2022 to review MSE results related to the current program of work.

Fin clips
Photographed by Joan Forsberg

Research

Since its inception, the IPHC has had a long history of research activities devoted to describing and understanding the biology and ecology of the Pacific halibut. The main objectives of the IPHC's 5-year Biological and Ecosystem Sciences Research Plan at IPHC are to:

1) identify and assess critical knowledge gaps in the biology of the Pacific halibut;
2) understand the influence of environmental conditions; and
3) apply the resulting knowledge to reduce uncertainty in current stock assessment models.

The IPHC Secretariat develops new projects that are designed to address key biological and ecological topics as well as the continuation of certain projects initiated in previous years. Projects are based on input from the Commissioners, stakeholders, and specific subsidiary bodies to the IPHC such as the Scientific Review Board (SRB) and the Research Advisory Board (RAB). Importantly, biological and ecological research activities at IPHC are guided by a 5-year plan that identifies key research areas that follow Commission objectives (Table 11).

The IPHC conducts data collection activities from fishery-independent and fishery-dependent sources such as the IPHC fishery-independent setline survey and commercial fishery landings, respectively, which are described in other chapters of this report.

Migration and distribution

Wire tagging to study migration of young Pacific halibut

In 2015, the IPHC began a long-term effort to wire-tag young Pacific halibut with the goal of providing data on juvenile Pacific halibut movement and growth. Migration information on adult Pacific halibut has been well documented in recent tagging studies, but less is known about juvenile Pacific

Table 11. A summary of the key research areas as described in the Five-Year Research Plan for the period 2017-21.

Key research areas	Description
Migration and Distribution	Improve our knowledge of Pacific halibut migration throughout all life stages in order to achieve a complete understanding of stock distribution and the factors that influence it
Reproduction	Provide information on the sex ratio of the commercial landings and improve current estimates of maturity
Growth and Physiological Condition	Describe the role of some of the factors responsible for the observed changes in size-at-age over the past several decades and provide tools for measuring growth and physiological condition in Pacific halibut
Discard Mortality and Survival	Provide updated estimates of discard mortality rates (DMRs) in both the directed longline, recreational and trawl fisheries

halibut movement. This tagging effort began with a pilot study on the National Oceanic and Atmospheric Administration's (NOAA) Fisheries groundfish trawl surveys in 2015. Tagging has continued on the trawl surveys and was expanded to the IPHC fishery-independent setline survey (FISS) in 2016.

In 2021, 2,534 Pacific halibut were tagged and released on the IPHC FISS but no tagging was conducted in the NOAA groundfish trawl surveys. Therefore, a total of 6,111 U32 (< 81.3 cm or 32 inches) Pacific halibut have been wire tagged and released on the IPHC FISS and 126 of those have been recovered to date. In the NOAA groundfish trawl surveys through 2019, a total of 6,536 tags have been released and, to date, 76 tags have been recovered.

Evaluating Pacific halibut larval connectivity between the Gulf of Alaska and Bering Sea

Knowledge of the dispersal of Pacific halibut larvae and subsequent migration of young juveniles has remained elusive because traditional tagging methods are not effective on these life stages due to the small size of the fish. This larval connectivity project, in cooperation with NOAA EcoFOCI, used two recently developed modeling approaches to estimate dispersal and migration pathways in order to better understand the connectivity of populations both within and between the Gulf of Alaska (GOA) and Bering Sea (BS) (Sadorus et al. 2021[1]). In brief, to improve current understanding of larval dispersal pathways and migrations of young fish within and between GOA and BS, investigations were conducted to (1) examine pelagic larval dispersal and connectivity between the two ins using an individual-based biophysical model (IBM), and (2) track movement of fish up to age-6 years using annual age-based distributions and a spatio-temporal modeling approach. IBM results indicate that the Aleutian Islands constrain connectivity between GOA and BS, but that large island passes serve as pathways between these ecosystems. The

[1] Sadorus LL, Goldstein ED, Webster RA, Stockhausen WT, Planas JV, Duffy-Anderson JT (2021) Multiple life-stage connectivity of Pacific halibut (Hippoglossus stenolepis) across the Bering Sea and Gulf of Alaska. Fish. Oceanogr. 30(2):174-193. https://doi.org/10.1111/fog.12512

degree of connectivity between GOA and BS is influenced by spawning location such that up to 50-60% of simulated larvae from the westernmost GOA spawning location arrive in the BS with progressively fewer larvae arriving proportional to distance from spawning grounds further east. There is also a large degree of connectivity between eastern and western GOA and between eastern and western BS. Spatial modeling of 2-6 year old fish shows ontogenetic migration from the inshore settlement areas of eastern BS towards Unimak Pass and GOA by age 4 years. The pattern of larval dispersal from GOA to BS, and subsequent post-settlement migrations back from BS toward GOA, provides evidence of circular, multiple life-stage, connectivity between these ecosystems, regardless of temperature stanza or year class strength. The results of these studies will improve estimates of productivity by contributing to the generation of potential recruitment covariates and by informing minimum spawning biomass targets by Biological Region. In addition, these results will assist in the biological parameterization and validation of movement estimates in the Management Strategy Evaluation (MSE) Operating Model.

Reproduction

Efforts at IPHC are currently underway to address two critical issues in stock assessment based on estimates of female spawning biomass: the sex ratio of the commercial catch and maturity estimations.

Sex ratio of the commercial landings

Throughout the fishery's history, the sex ratio of commercially-caught Pacific halibut has remained unknown as landed individuals are eviscerated at sea and otherwise sexually indistinguishable. Historically, the sex ratio from the IPHC's fishery independent setline survey (FISS) has been the only direct source of sex-ratio information, but differences in size between individuals landed commercially and on the FISS suggested a greater proportion of females in the fishery.

The IPHC has generated sex information of the entire set of aged commercial fishery samples collected from 2017 until 2020 (>10,000 fin clips per year) using genetic techniques based on the identification of sex-specific single nucleotide polymorphisms (SNPs) (Drinan et al., 2018 [2]) using TaqMan qPCR assays conducted at the IPHC's Biological Laboratory. The IPHC Secretariat is currently processing genetic samples from the 2021 commercial landings, as additional years of sex-ratio information of the commercial catch are likely to further inform selectivity parameters and cumulatively reduce uncertainty in future estimates of stock size, in addition to improving simulation of spawning biomass in the MSE Operating Model.

Reproductive assessment of female and male Pacific halibut

Each year, the FISS collects biological data on the maturity of female Pacific halibut that are used in the stock assessment. In particular, a female maturity schedule based on characteristics that can be identified through direct examination is used to estimate spawning stock biomass. Currently used estimates of maturity-at-age indicate that the age at which 50 percent of female Pacific halibut are sexually mature is 11.6 years on average. However, the current method using macroscopic visual criteria of the ovaries collected in the field to estimate maturity may introduce an unknown level of uncertainty. Furthermore, estimates of

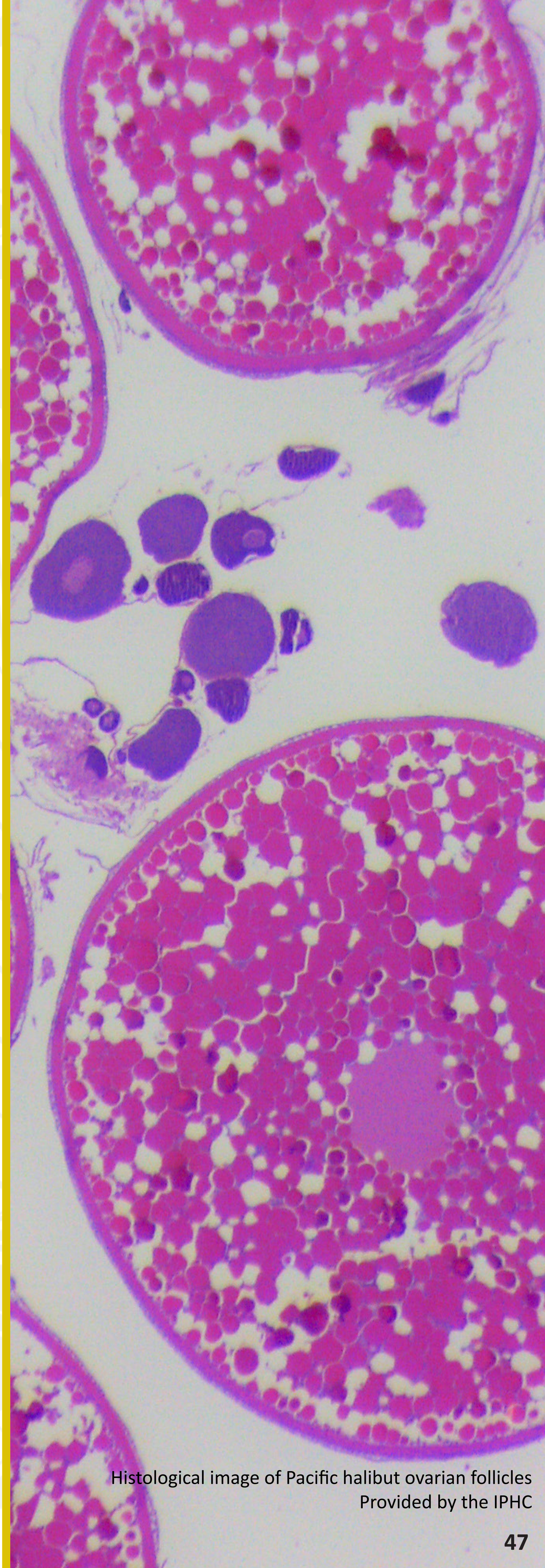
[2] Drinan DP, Loher T, and Hauser L (2018) Identification of Genomic Regions Associated With Sex in Pacific Halibut. J Hered 109: 326-332.

maturity-at-age have not been revised in recent years and may be outdated. For this reason, current research efforts are devoted to describing reproductive development and maturity in female Pacific halibut.

Described for the first time by the IPHC Secretariat are the different oocyte stages that are present in the ovary of female Pacific halibut and how these are used to classify female histologically to specific maturity stages (Fish et al. 2020 [3]). In brief, eight different oocyte developmental stages have been described, from early primary growth oocytes until preovulatory oocytes, and their size and morphological characteristics established. Maturity classification was determined by assigning maturity status to the most advanced oocyte developmental stage present in ovarian tissue sections and seven different microscopic maturity stages were established. Analysis of oocyte size frequency distribution among the seven different maturity stages provided evidence for the group-synchronous pattern of oocyte development and for the determinate fecundity reproductive strategy in female Pacific halibut. The results of this study will allow us to establish a comparison of the microscopic/histological and macroscopic/field classification criteria that are currently used to assign the maturity status of females that is used in stock assessment. The results of this study set the stage for and in-depth study on temporal changes in maturity, as assessed by microscopic observations of ovarian samples collected throughout an entire annual reproductive cycle, that is now completed (Fish et al. 2022 [4]). The results obtained confirm that the peak period of spawning for Pacific halibut in the central Gulf

[3] Fish T, Wolf N, Harris BP, Planas JV (2020) A comprehensive description of oocyte developmental stages in Pacific halibut, Hippoglossus stenolepis. J Fish Biol. 97: 1880–1885. https://doi.org/10.1111/jfb.14551.

[4] Fish T, Wolf N, Smeltz TS, Harris BP, Planas JV (2022) Reproductive biology of female Pacific halibut (Hippoglossus stenolepis) in the Gulf of Alaska. (In Review).



Histological image of Pacific halibut ovarian follicles
Provided by the IPHC

of Alaska takes place in January and February and that Pacific halibut females spawn following an annual reproductive cycle. Analysis of the temporal changes in female reproductive phase shows that spawning capable females are detected as early as August, therefore marking the beginning of the spawning capable reproductive phase. For stock assessment purposes, the spawning capable reproductive phase comprises females that are considered mature. Importantly, the detection of spawning capable females in July-August is conducive to conducting routine histological assessments of female maturity during the IPHC's FISS sample collection period (i.e. June to late August). As a result of this information, the IPHC Secretariat will collect ovarian samples in each of the four Biological Regions in order to conduct histologically-based maturity curves to revise the current maturity schedule and to investigate potential spatial differences in maturity schedules.

Furthermore, the IPHC Secretariat is also establishing a comparison of the microscopic (e.g. histological) and macroscopic (e.g. visual) maturity classification criteria to determine whether field classification criteria that are currently used to assign the maturity status of females that is used in stock assessment needs to be revised in light of the improved knowledge on ovarian development.

Growth and physiological condition

Current studies in this research area are aimed at understanding the possible role of body growth variation in the observed changes in size-at-age (SAA), and at developing tools for measuring growth and physiological condition in Pacific halibut. In view of our limited knowledge on the underlying physiological basis of body growth and, importantly, on the possible contribution of growth alterations in driving changes in SAA, the IPHC is conducting studies to develop and apply tools to evaluate age-specific growth patterns and their response to environmental influences in Pacific halibut over space and time. The specific objectives of these studies are to investigate the effects of temperature, population density, social structure, and stress on biochemical and molecular indicators of body growth. In addition to significantly improving our understanding of the physiological mechanisms regulating growth, this aims at identifying key molecular and biochemical growth signatures that could be used to monitor growth patterns in the Pacific halibut population. At the present time, transcriptomic and proteomic analyses of skeletal muscle from fish subjected to different temperature-induced growth manipulations have resulted in the identification of a number of genes and proteins that could represent potential growth markers for Pacific halibut.

In summary, temperature acclimation laboratory studies were conducted at the Hatfield Marine Science Center in Newport, Oregon in collaboration with scientists from the Alaska Fisheries Science Center under the framework of a research grant funded by the North Pacific Research Board to the IPHC (NPRB 1704; 2017-2020). These studies resulted in the successful manipulation of growth patterns: 1) growth suppression by acclimation to low water temperature and 2) growth stimulation by temperature-induced growth compensation in juvenile Pacific halibut. White skeletal muscle samples from the control and treatment groups resulting from the two types of growth manipulations were collected and processed for transcriptomic (i.e. RNAseq) and proteomic analyses.

Temperature induced growth suppression resulted in a significant decrease in the mRNA expression levels of 676 annotated genes and in a significant decrease in the abundance of 150 annotated proteins. In contrast, temperature-induced growth stimulation resulted in a significant increase in the mRNA expression levels of 202 annotated genes and a significant increase in the abundance of 149 annotated proteins. Based on the transcriptomic results, a set of potential growth marker genes has been selected for validation by qPCR as well as a set of potential housekeeping genes for normalization of expression levels. The identified growth marker genes will be tested using muscle samples from wild-caught Pacific halibut in order to validate the use of these markers to monitor growth patterns in the wild.

Other studies that the Secretariat is conducting with regards to factors that may result in growth alterations involve investigating the effects of density and handling stress on somatic growth. In particular, additional laboratory experiments were conducted in which juvenile Pacific halibut were held in groups of 8 fish per tank (with 4 replicate tanks), 4 fish per tank (with 4 replicate tanks) and also individually (with 10 replicate tanks) under restricted feeding (at 50% of maximal feeding rate) for a period of 6 weeks. White skeletal muscle samples and liver samples were collected from fish at different densities and differential gene expression was conducted by RNAseq analysis. Our studies evaluating the effects of handling stress on somatic growth involved air exposure of juvenile Pacific halibut and white muscle samples from fish exposed or not to air were collected for analysis of growth marker gene expression. These studies will allow (1) the identification of genes whose expression is indicative of growth changes and (2) the identification of common or unique responses to the different growth manipulations (i.e. temperature- versus density- or stress-induced).

Discard mortality and survival

Information on all Pacific halibut removals is integrated by the IPHC Secretariat, providing annual estimates of total mortality from all sources for the stock assessment. Discarding of Pacific halibut via the incidental catch of fish in non-target fisheries and the mortality that occurs in the directed fishery (i.e. fish discarded for sublegal size or for regulatory reasons), respectively, represent important sources of mortality that can result in significant reductions in exploitable yield in the directed fishery. Given that the incidental mortality from the commercial Pacific halibut fisheries and bycatch fisheries is included as part of the total removals that are accounted for in stock assessment, changes in the estimates of incidental mortality will influence the output of the stock assessment and, consequently, the catch levels of the directed fishery. For this reason, the IPHC Secretariat is conducting investigations on the effects of capture and release on survival, and on providing experimentally-derived estimates of DMRs in the directed longline and guided recreational Pacific halibut fisheries that will improve trends in unobserved mortality in stock assessment and that will be important for fishery parameterisation.

Discard mortality rates in the directed Pacific halibut fishery

The IPHC Secretariat, with funding by a grant from the Saltonstall-Kennedy Grant Program NOAA (NA17NMF4270240; 2017-2020), has conducted studies to evaluate the effects of hook release techniques on injury levels, their association with the physiological condition of captured Pacific halibut and, importantly, has generated experimentally-derived estimates of discard mortality rate (DMR) in the directed longline fishery. The initial results on individual survival outcomes for Pacific halibut released in excellent condition as the viability category assigned to the fish following capture indicate a range of DMRs between 4.2% (minimum) and 8.4% (maximum), that is consistent with the currently-applied DMR value of 3.5%. A manuscript describing these results has been

Undergraduate interns Maya Stock and Eva Sukphon-Devita
Photographed by Lauri Sadorus

published in the Journal of North American Fishery Management (Loher et al., 2021 [5]).

The IPHC Secretariat is currently conducting modeling analyses of potential relationships between individual physiological characteristics of discarded Pacific halibut, environmental conditions and handling practices, as well as on the ability of electronic monitoring systems to capture release methods and individual lengths of captured fish.

Discard mortality rates of Pacific halibut in the recreational fishery

The IPHC Secretariat is conducting a research project to better characterize the nature of charter recreational fisheries with the ultimate goal of better understanding discard practices relative to that which is employed in the directed longline fishery. This project has received funding from the National Fish and Wildlife Foundation (NFWF Project No. 61484) and the North Pacific Research Board (NPRB Project No. 2009). The experimental field components of this research project took place in Sitka, Alaska (IPHC Regulatory Area 2C) from 21-27 May 2021, and in Seward, Alaska (IPHC Regulatory Area 3A) from 11-16 June 2021. In brief, Pacific halibut were captured with the use of 12/0 and 16/0 circle hooks that best reflect the gear currently used and fish sizes were targeted to cover the Pacific halibut size distribution recorded by Alaska Department of fish and Game (ADFG) on an annual basis. All injuries were documented, along with length, weight, somatic fat measurements (using the Distell Fatmeter), and a blood sample (for measuring the levels of physiological stress indicators in plasma) was collected for each fish, before they were tagged and released. Environmental information on temperature (bottom/surface) and time (fight time, time on deck) was also tracked. Eighty (80) Pacific halibut assigned to the "Excellent" release viability category were fitted with accelerometer satellite pop-up archival tags (sPAT) for near term survival estimation in IPHC Regulatory Area 3A. Analyses of survival data and levels of blood stress indicators are currently underway.

5 Loher T, Dykstra CL, Hicks A, Stewart, IJ, Wolf N, Harris BP, Planas JV (2021). Estimation of post-release longline mortality in Pacific halibut (Hippoglossus stenolepis) using acceleration-logging tags. North American Journal of Fisheries Management (In Press). https://doi.org/10.1002/nafm.10711

Genetics and genomics

Novel technical advances in genetic analyses of wild fish populations through the application of whole genome sequencing allow for an unprecedented level of resolution of genetic diversity. The IPHC Secretariat is currently conducting genomic analyses of population structure and genetic diversity of Pacific halibut with the use of whole genome resequencing technologies that are now possible with the completed draft sequence of the Pacific halibut genome.

Genomic analyses of stock structure and genetic diversity

Understanding population structure is imperative for sound management and conservation of natural resources (Hauser, 2008 [6]). Pacific halibut in Canadian and U.S.A. waters have been managed by the IPHC as a single coastwide unit stock since 2006. The rationale behind this management approach is based on our current knowledge of the highly migratory nature of Pacific halibut as assessed by tagging studies (Webster et al., 2013 [7]) and of past analyses of genetic population structure that failed to demonstrate significant differentiation in the North-eastern Pacific Ocean population of Pacific halibut by allozyme (Grant, 1984 [8]) and small-scale microsatellite analyses (Bentzen, 1998 [9]; Nielsen et al., 2010 [10]). However, more recent studies have reported slight genetic population structure on the basis of genetic analysis conducted with larger sets of microsatellites suggesting that Pacific halibut captured in the Aleutian Islands may be genetically distinct from other areas (Drinan et al., 2016 [11]). These findings of subtle genetic structure in the Aleutian Island chain area are attributed to limited movement of adults and exchange of larvae between this area and the rest of the stock due to the presence of oceanographic barriers to larval and adult dispersal (i.e. Amchitka Pass) that could represent barriers to gene flow. Unfortunately, genetic studies suggesting subtle genetic structure (Drinan et al., 2016 [11]) were conducted based on a relatively limited set of microsatellite markers and, importantly, using genetic samples collected in the summer (i.e. non-spawning season) that may not be representative of the local spawning population. With the collection of winter (i.e. spawning season) genetic samples in the Aleutian Islands by the IPHC in early 2020, a collection of winter samples from five different geographic areas across the North-eastern Pacific Ocean (i.e. British Columbia, Central Gulf of Alaska, Bering Sea, Central and Western Aleutian Islands) is now available to re-examine the genetic structure of the Pacific halibut population. Importantly, novel, high-throughput and high-resolution genomics approaches are now available for use, such as low-coverage whole genome resequencing, in order to describe with unprecedented detail the genetic structure of the Pacific halibut population. The recently

[6] Hauser L, and Carvalho GR (2008). Paradigm shifts in marine fisheries genetics: ugly hypotheses slain by beautiful facts. Fish and Fisheries 9, 333-362.

[7] Webster RA, Clark WG, Leaman BM, and Forsberg JE (2013) Pacific halibut on the move: a renewed understanding of adult migration from a coastwide tagging study. Can. J. Fish. Aquat. Sci., 70:642-653.

[8] Grant WS, Teel DJ, and Kobayashi T (1984) Biochemical Population Genetics of Pacific Halibut (*Hippoglossus stenolepis*) and Comparison with Atlantic Halibut (*Hippoglossus hippoglossus*). Can. J. Fish. Aquat. Sci.41, 1083-1088.

[9] Bentzen P, Britt J, and Kwon J (1998) Genetic variation in Pacific halibut (*Hippoglossus stenolepis*) detected with novel microsatellite markers. Report of Assessment and Research Activities.1998.

[10] Nielsen JL, Graziano SL, Seitz AC (2010) Fine-scale population genetic structure in Alaskan Pacific halibut (*Hippoglossus stenolepis*). Conservation Genetics 11: 999-1012.

[11] Drinan DP, Galindo HM, Loher T, and Hauser L (2016) Subtle genetic population structure in Pacific halibut *Hippoglossus stenolepis*. J Fish Biol 89: 2571-2594.

sequenced Pacific halibut genome represents an essential resource for the success of the whole genome resequencing approach. The results from the proposed genomic studies will provide important information on spawning structure and, consequently, on the genetic baselines of source populations. Importantly, the results from these studies will provide management advice regarding the relative justifiability for considering the western Aleutians as a genetically-distinct substock. These research outcomes will represent important avenues for improving estimates of productivity and parametrization of the Management Strategy Evaluation (MSE) Operating Model.

A second genetic objective is to evaluate the genetic variability or genetic diversity among juvenile Pacific halibut in a given ocean basin in order to infer information on the potential contribution from fish spawned in different areas to that particular ocean basin. We hypothesize that genetic variability among juvenile Pacific halibut captured in one particular ocean basin (e.g. eastern Bering Sea) may be indicative of mixing of individuals originating in different spawning grounds and, therefore, of movement. By comparing the genetic variability of fish between two ocean basins (i.e. eastern Bering Sea and Gulf of Alaska) with the application of low-coverage whole genome resequencing approaches, we will be able to evaluate the extent of the potential contribution from different sources (e.g. spawning groups) in each of the ocean basins and provide indications of relative movement of fish to these two different ocean basins. The use of genetic samples from juvenile Pacific halibut collected in the National Oceanic and Atmospheric Administration (NOAA) Fisheries trawl survey in the eastern Bering Sea and in the Gulf of Alaska, aged directly by otolith reading or indirectly through a length-age key, will allow us to provide information on genetic variability among fish that are at or near their settlement or nursery grounds. These studies will provide the ability to assign individual juvenile Pacific halibut to source populations (as established by investigating population structure) and genetic information on movement and distribution of juvenile Pacific halibut.

Sequencing of the Pacific halibut genome

One of the most important biological resources for a fish species with high socio-economic importance and a fascinating life history such as the Pacific halibut is the sequenced genome. Through the genome comes an understanding of the genetic basis of biological processes such as growth or reproduction as well as the genetic and evolutionary changes in Pacific halibut that occur in response to environmental and fisheries-related influences. The IPHC Secretariat has recently completed the generation of a first draft sequence of the Pacific halibut genome (Jasonowicz et al., 2021 [12]), the blueprint for all the genetic characteristics of the species. Briefly, the Pacific halibut genome has a size of 586 Mb and contains 24 chromosomes- covering 98.6% of the complete assembly with a N50 scaffold length of 25 Mb at a coverage of 91x. The Pacific halibut genome sequence has been submitted to the National Center for Biological Information (NCBI) with submission number SUB7094550 and with accession number JABBIT000000000. Furthermore, the Pacific halibut genome has been annotated and is available in NCBI as NCBI Hippoglossus stenolepis Annotation Release 100. The generated genomic resources will greatly assist current studies on the genetic structure of the Pacific halibut population, on the application of genetic signatures for assigning individuals to spawning populations and for a thorough characterization of regions of the genome or genes responsible for important traits of the species.

[12] Jasonowicz AC, Simeon A, Zahm M, Cabau C, Klopp C, Roques C, Iampietro C, Lluch J, Donnadieu C, Parrinello H, Drinan DP, Hauser L, Guiguen Y, Planas JV (2022). Generation of a chromosome-level genome assembly for Pacific halibut (Hippoglossus stenolepis) and characterization of its sex-determining genomic region. (In Review).

Economic Research

The economic effects of changes to harvest levels can be far-reaching. Fisheries management policies that alter catch limits have a direct impact on commercial harvesters, but at the same time, there is a ripple effect through the economy. Fisheries operations create demand for inputs from other sectors, while at the same time support industries further along the value chain that rely on the supply of fish, such as seafood processors. Recreational fishing is key to the prosperity of a broad set of local businesses and creates employment opportunities supporting households in coastal communities. Policies or any other exogenous changes may also have an economic impact not only on the region subjected to the change.

The goal of the IPHC economic research is to provide stakeholders with an accurate and all-sectors-ecnompassing assessment of the socioeconomic impact of the Pacific halibut resource that includes the full scope of Pacific halibut's contribution to regional economies of Canada and the United States of America (U.S.A.). This research contributes to a wholesome approach to Pacific halibut management that is optimal from both biological and socioeconomic perspective, as mandated by the Convention.

Pacific Halibut Multiregional Economic Impact Assessment (PHMEIA) is a core product of the IPHC economic research. PHMEIA model describes economic interdependencies between sectors and regions to bring a better understanding of the role and importance of Pacific halibut resource in a regions' economies. The model details the within-region production structure of the Pacific halibut sectors (fishing, processing, charter) and accounts for economic activity generated through sectors that supply fishing vessels, processing plants, and charter businesses with inputs to production, by embedding Pacific halibut sectors into the model of the entire economy of Canada and the U.S.A.

The PHMEIA results suggest that the revenue generated by Pacific halibut at the harvest stage accounts for only a fraction of economic activity that would be forgone if the resource was not available to fishers in the Pacific Northwest. In a typical year, (based on 2019 data), one USD/CAD of Pacific halibut commercial landings was found to be linked to our four USD/CAD-worth economic activity in Canada and the United States and contributed USD/CAD 1.3 to households. In the recreational sector, one USD/CAD spent by recreational anglers was linked to USD/CAD 4.9 circulating in the economy and USD/CAD 0.7 impact on households. The total economic activity linked to assessed Pacific halibut sectors is estimated at about USD 1,010 million (CAD 1,350 million), and contribution to households at over USD 300 million (CAD 400 million), highlighting how important Pacific halibut is to regional economies. However, the 2020 results suggest that Pacific halibut contribution to households' income dropped by a quarter throughout the pandemic, demonstrating Pacific halibut sectors' exposure to external factors beyond stock condition.

Looking Forward

This section summarises the major decisions made at the 98th Session of the IPHC Annual Meeting (AM098), held 24-28 January 2022 via an electronic platform due to the ongoing COVID-19 pandemic. For a full accounting of documents and presentations provided to the Commission for the meeting, and the final report of the meeting, visit the IPHC webpage:

https://www.iphc.int/venues/details/98th-session-of-the-iphc-annual-meeting-am098

Mortality limits

The Commission adopted mortality limits (described as Total Constant Exploitation Yield, TCEY limits) for 2022 as provided in Table 12. These mortality limits include a variety of estimated sources of mortality which are detailed in Table 13a and 13b.

Fishing periods (season dates)

The Commission recommended a fishing period 6 March to 7 December for all commercial Pacific halibut fisheries in Canada and the United States of America. All commercial fishing for Pacific halibut in all IPHC Regulatory Areas may begin no earlier than noon local time on 6 March and must cease by noon local time on 7 December.

Recommendations

Recreational Fisheries

The Commission adopted two regulations governing the recreational fishery. The first was to establish recordkeeping requirements needed to enforce Pacific halibut annual limits for recreational fishing for Pacific halibut in IPHC Regulatory Areas 2C and 3A.

The second was IPHC Regulation changes for charter recreational Pacific halibut fisheries in IPHC Regulatory Areas 2C and 3A, in order to achieve the charter Pacific halibut allocation under the North Pacific Fisheries Management Council's (NPFMC) Pacific halibut Catch Sharing Plan:

a) IPHC Regulatory Area 2C – one-fish bag limit with size limit of less than or equal to 40 inches or greater than or equal to 80 inches;

b) IPHC Regulatory Area 3A – two-fish bag limit with one fish of any size and a second fish less than or equal to 28 inches, Wednesdays and two Tuesdays (26 July and 2 August) closed to retention of Pacific halibut, one trip per vessel and one trip per permit per day.

Fishing gear

The Commission adopted changes to the IPHC Regulations allowing trap gear use on directed commercial trips in IPHC Regulatory Area 2B. The Commission also expressed interest in sharing experience between Contracting Parties on the effectiveness of the use of traps/pots in preventing whale depredation.

Length-weight table

The Commission recommended the adoption of the updated length-weight relationship as presented by IPHC Secretariat during the meeting and its dissemination to the appropriate domestic management agencies.

Commission officers

The Commission elected Mr. Paul Ryall (Canada)as Chairperson of the IPHC, and Mr. Glenn Merrill (U.S.A.) as Vice-Chairperson of the IPHC.

IPHC Rules of Procedure (2021)

The Commission adopted the IPHC Rules of Procedure (2022), and requested that the IPHC Secretariat finalise and publish them accordingly with the following amendments:

a. amend para. 1.a of the Research Advisory Board Terms of Reference to read as follows:

"I.1.a *Suggest research topics to be considered for incorporation in the IPHC integrated research and monitoring activities, as well as to comment upon operational and implementation considerations of those research and monitoring activities.*"

b. retain para. 14 of the Processor Advisory Board Terms of Reference:

"14. *Conduct of meetings: Parliamentary procedure will be used in the conduct of the PAB*"

Upcoming IPHC meetings

- 98th Session of the IPHC Interim Meeting (IM098); 29-30 November 2022; Seattle, WA, U.S.A.
- 99th Session of the IPHC Annual Meeting (AM099); 23-27 January 2023; Victoria, British Columbia, Canada

Table 12. Adopted Mortality limits (TCEY) for 2022.

Contracting IPHC Regulatory Area	Mortality limits (TCEY, net weight)		
	Tonnes	Million Pounds	Percent
Area 2B (British Columbia)	3,429	7.56	18.34
Total Canada	**3,429**	**7.56**	**18.34**
Area 2A (California, Oregon, and Washington)	748	1.65	4.00
Area 2C (southeastern Alaska)	2,681	5.91	14.34
Area 3A (central Gulf of Alaska)	6,600	14.55	35.30
Area 3B (western Gulf of Alaska)	1,769	3.90	9.46
Area 4A (eastern Aleutians)	953	2.10	5.09
Area 4B (central/western Aleutians)	658	1.45	3.52
Areas 4CDE (Bering Sea)	1,860	4.10	9.95
Total United States of America	**15,268**	**33.66**	**81.66**
Total (IPHC Convention Area)	**18,697**	**41.22**	**100**

Table 13a. Mortality table projected for the 2022 mortality limits (tonnes) by IPHC Regulatory Area.

Sector	IPHC Regulatory Area								
	2A	2B	2C	3A	3B	4A	4b	4CDE	Total
Commercial discards	32	95	NA	NA	86	32	23	18	281
O26 Non-directed discards	41	95	32	327	159	109	54	889	1,706
Recreational	NA	14	494	717	5	5	0	0	1,229
Subsistence	NA	186	132	82	5	5	0	18	426
Total non-FCEY	73	386	658	1,125	249	154	77	925	3,642
Commercial discards	NA	NA	64	186	NA	NA	NA	NA	245
Recreational	272	458	372	957	NA	NA	NA	NA	2,059
Subsistence	14	NA	NA	NA	NA	NA	NA	NA	14
Commercial landings	390	2,585	1,592	4,332	1,520	798	581	934	12,737
Total FCEY	**676**	**3,044**	**2,023**	**5,475**	**1,520**	**798**	**581**	**934**	**15,055**
						4C FCEY	**417**		**17,690**
						4D FCEY	417		567
						4E FCEY	**100**		**18,257**
TCEY	**748**	**3,429**	**2,681**	**6,600**	**1,769**	**953**	**658**	**1,860**	**18,697**
U26 Non-directed discards	**0**	**14**	**0**	**132**	**32**	**36**	**5**	**336**	**558**
Total	**748**	**3,443**	**2,681**	**6,731**	**1,801**	**989**	**662**	**2,195**	**19,255**

Table 13b. Mortality table projected for the 2022 mortality limits (millions of net pounds) by IPHC Regulatory Area.

Sector	IPHC Regulatory Area								
	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
Commercial discards	0.07	0.21	NA	NA	0.19	0.07	0.05	0.04	0.62
O26 Non-directed discards	0.09	0.21	0.07	0.72	0.35	0.24	0.12	1.96	3.76
Recreational	NA	0.03	1.09	1.58	0.01	0.01	0.00	0.00	2.71
Subsistence	NA	0.41	0.29	0.18	0.01	0.01	0.00	0.04	0.94
Total non-FCEY	0.16	0.85	1.45	2.48	0.55	0.34	0.17	2.04	8.03
Commercial discards	NA	NA	0.14	0.41	NA	NA	NA	NA	0.54
Recreational	0.60	1.01	0.82	2.11	NA	NA	NA	NA	4.54
Subsistence	0.03	NA	NA	NA	NA	NA	NA	NA	0.03
Commercial landings	0.86	5.70	3.51	9.55	3.35	1.76	1.28	2.06	28.08
Total FCEY	**1.49**	**6.71**	**4.46**	**12.07**	**3.35**	**1.76**	**1.28**	**2.06**	**33.19**
						4C FCEY	**0.92**		**39.00**
						4D FCEY	0.92		1.25
						4E FCEY	**0.22**		**40.25**
TCEY	**1.65**	**7.56**	**5.91**	**14.55**	**3.90**	**2.10**	**1.45**	**4.10**	**41.22**
U26 Non-directed discards	**0.00**	**0.03**	**0.00**	**0.29**	**0.07**	**0.08**	**0.01**	**0.74**	**1.23**
Total	**1.65**	**7.59**	**5.91**	**14.84**	**3.97**	**2.18**	**1.46**	**4.84**	**42.45**

IPHC Secretariat Update

The activities highlighted in this report account for the majority of IPHC Secretariat time. However, there is also considerable effort put into public outreach, attending conferences and meetings that enhance knowledge, and contributing expertise to the broader scientific community through participation on boards and committees. As the Covid-19 pandemic continued throughout 2021, most of the external engagement was in electronic/virtual formats. This section highlights some of those activities.

Committees and Organization appointments

- Fishery Monitoring Science Committee (FMSC) – Dr. Ray Webster
- Halibut Advisory Board (HAB) – Dr. David T. Wilson
- NPFMC Bering Sea Fishery Ecosystem Plan Team - Dr. Ian Stewart
- North Pacific Research Board (NPRB) Science Panel - Dr. Josep Planas
- NPFMC Bering Sea/Aleutian Island Groundfish Plan Team - Dr. Allan Hicks
- NPFMC Scientific and Statistical Committee - Dr. Ian Stewart
- Vermilion and sunset rockfishes Stock Assessment Review Panel – Dr. Allan Hicks

Conferences, Meetings, and Workshops (chronological order)

- Alaska Marine Science Symposium, 27 January, Electronic – Dr. Josep Planas (presenter), Andy Jasonowicz (participant)
- State of the Pacific Ocean (DFO), 2-4 March, Electronic – Lauri Sadorus (participant)
- FAO-ICES-WGFTB, 19-23 April, Electronic – Dr. Josep Planas (attendee)
- Kodiak Area Marine Science Symposium, 19-24 April, Electronic – Claude Dykstra (presenter)
- SFAB Halibut Working Group, 7 May, Electronic – Dr. Josep Planas (participant)
- CAPAM Natural Mortality Workshop, 14-17 June, Electronic – Dr. Allan Hicks (presenter)
- 8th World Fisheries Congress, 20-24 September, Electronic – Dr. David Wilson, Dr. Josep Planas, Colin Jones, Andy Jasonowicz (presenters)
- PICES-2021 Annual Meeting, 18-29 October, Electronic – Dr. Josep Planas (presenter)
- MARVLS Fall 2021 Workshop, 26 October, Electronic – Dr. Josep Planas (participant)
- MSEAS Socio-Ecological Systems Symposium, 8 December, Electronic – Dr. Barbara Hutniczak (participant)

Outreach and Academic activities

- Opportunities for Lifelong Education - Alaska Pacific University - UA Anchorage, 26 February, Electronic – Dr. Josep Planas (presenter) Annual Meeting, 18-29 October, Electronic – Dr. Josep Planas (presenter)
- Alaska Pacific University affiliate faculty, Anchorage, AK, U.S.A. - Dr. Josep Planas
- University of Washington affiliate faculty, Seattle, WA, U.S.A. - Dr. Ian Stewart, Dr. Allan Hicks
- University of Washington instructor for FISH507 – Special Topics in Fisheries: survey design and implementation, Seattle, WA, U.S.A. – Dr. Ray Webster, Dr. Ian Stewart
- University of Washington student committee member, Seattle, WA, U.S.A. - Dr. Allan Hicks, Dr. Ian Stewart
- Alaska Pacific University student committee member, Anchorage, AK, U.S.A. - Dr. Josep Planas,
- University of Massachusetts Dartmouth student committee member, New Bedford, MA, U.S.A. - Dr. Allan Hicks

Financial Performance Report and Statements

The IPHC is funded jointly by the governments of Canada and the United States of America (U.S.A.). For fiscal year 2021, contributions for general operating expenses were as follows:

- Canada: US$900,407;
- U.S.A.: US$4,157,790

Additional deficit payments were made to the International Fisheries Commission's Pension Fund (IFCPF closed in 2001 to new participants) by each Party, and the U.S.A. is responsible for the IPHC Headquarters lease and maintenance (US$470,717).

Independent Auditor

The Commission's financial accounts for FY2021 were audited by the accounting firm of Moss Adams LLP. The auditor's opinion stated the IPHC's financial statements present fairly in all material respects.

The Commission has adopted a basis of accounting agreed to by the governments of Canada and the United States of America (U.S.A.). The basis of accounting differs in certain respects from generally accepted accounting principles and is known as "other comprehensive basis of accounting" (OCBOA), which is a special purpose framework. The following are the most significant differences that do not include required disclosures under Generally Accepted Accounting Principles (GAAP):

- Historically, the Commission recorded revenues in the fiscal year when appropriated by the governments of Canada and the U.S.A. and expenditures were recorded in the fiscal year in which the funds are committed by the Commission. During the fiscal year ended September 30, 2021, the Commission began accruing income in the fiscal year of the activity and expenditures are recorded in the fiscal year in which they are incurred. Fund balance prior period adjustments reflected as of September 30, 2021, are a result of fund balance corrections to prior year grant receivable in the amount of $450,492 and conversion to accrual basis for certain items in the amount of $1,032,086, including $996,688 of accrued leave and sick leave benefits not previously expensed. Carryover general, carryover program funds, and transfers between funds, are recognized as income.

- Pension (closed IFCPF) costs are charged to expense when funds necessary to fund the employer's normal pension costs are paid.
- Post-retirement health care and life insurance costs are charged to expense when the related premiums are paid.
- Rent expense related to operating leases is expensed when paid and is not recognized on a straight-line basis over the life of the lease. Contributions of free rents are not recognized in the financial statements.

Statement of financial position

The total Assets at year-end closing totaled US$4,799.210.69.
The total equity or combined fund balance at year-end closing totaled US$2,624,142.89.

Fund equity balances at year end:

- General Fund (10): US$161,560.31
- Research Fund (20): US$72,288.19
- Statistics Fund (30): US$108,439.49
- FISS Fund (40): US$1,147,516.99
- Reserve Fund (50): US$1,134,227.91

The Reserve Fund carries the majority of the equity in the checking and saving cash accounts at Wells Fargo.

Statement of financial activities

For FY2021, the IPHC total income received as US$12,693,895.96, while the budgeted income was US$10,503,611.00.

Carryover from the previous fiscal year by Fund was as follows:

- 10 - General Fund: $275,872
- 20 - Research Fund: ($5,397)
- 30 - Statistics Fund: $1,324
- 40 – FISS Fund: $535,352
- 50 - Reserve Fund: $1,134,338 (funds from 40 – FISS)

The total carryover (included in income on the audited Statement of Activities: IPHC-2022-FAC098-05) was $1,941,489.

	2021					
	10 - General	20 - Research	30 - Statistics	40 - FISS	50 - Reserve	Total
Fund balance, beginning of year	$ 275,872	$ (5,397)	$ 1,324	$ 535,352	$ 1,134,338	$ 1,941,489
Fund balance, prior period adjustment	(617,550)	-	-	(1,373)	-	(618,923)
Advances, net	4,208,232	423,935	426,000	-	-	5,058,167
IPHC headquarter maintenance	470,717	-	-	-	-	470,717
Grants, contracts and agreements	-	261,064	508,727	31,101	-	800,892
Interest	687	-	-	29	-	716
Other income	102,696	-	-	5,810,217	-	5,912,913
Commission expense	(3,517,963)	(1,032,314)	(1,354,612)	(5,036,945)	-	(10,941,834)
Fund transfers	(761,130)	425,000	527,000	(190,864)	-	6
Fund balance, end of year	$ 161,561	$ 72,288	$ 108,439	$ 1,147,517	$ 1,134,338	$ 2,624,143

MOSSADAMS

Report of Independent Auditors

To the Commissioners
International Pacific Halibut Commission

Report on the Financial Statements

We have audited the accompanying special purpose statement of revenues and expenses (compared to budget) and fund balances – regulatory basis, of the International Pacific Halibut Commission (a nonprofit organization), which comprise the statement of revenues and expenses (compared to budget) and fund balances – regulatory basis as of September 30, 2021, and the related notes to the financial statements.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation and fair presentation of these financial statements in accordance with the financial reporting practices prescribed or permitted by the governments of the United States of America and Canada. Management is also responsible for the design, implementation, and maintenance of internal control relevant to the preparation and fair presentation of financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with auditing standards generally accepted in the United States of America. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. Accordingly, we express no such opinion. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of significant accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion, the special purpose statement of revenues and expenses (compared to budget) and fund balances – regulatory basis referred to above presents fairly, in all material respects, the statement of revenues and expenses (compared to budget) and fund balances – regulatory basis of International Pacific Halibut Commission as of September 30, 2021, and for the year then ended, in accordance with the financial reporting practices prescribed or permitted by the governments of the United States of America and Canada as described in Note 1.

Other Matters

Basis of Accounting

We draw attention to Note 1 of the financial statements, which describes the basis of accounting. As described in Note 1, these financial statements were prepared in conformity with the financial reporting practices prescribed or permitted by the governments of the United States of America and Canada, which is a basis of accounting other than accounting principles generally accepted in the United States of America, to meet the requirements of the governments of the United States of America and Canada. Our opinion is not modified with respect to this matter.

Restriction of Use

Our report is intended solely for the information and use of the commissioners and management of International Pacific Halibut Commission and is not intended to be and should not be used by anyone other than these specified parties.

Moss Adams LLP

Everett, Washington
December 17, 2021

International Pacific Halibut Commission

Statement of Revenues and Expenses (Compared to Budget) and Fund Balances – Regulatory Basis

September 30, 2021

	Annual Budget	10 - General	20 - Research	30 - Statistics	40 - FISS	50 - Reserve	Total	Percent of Budget	Over (Under) Budget
Income									
Contribution from Canada	$ 900,407	$ 749,110	$ 75,465	$ 75,832	$ -	$ -	$ 900,407	100%	$ -
Contribution from the USA	4,157,760	3,459,122	348,470	350,168	-	-	4,157,760	100%	-
Headquarters (Lease and Maintenance)	470,717	470,717	-	-	-	-	470,717	100%	-
Fish Sales	4,380,000	3	-	-	5,717,690	-	5,717,693	131%	1,337,693
Grants, Contracts and Agreements	594,727	-	261,064	508,727	31,101	-	800,892	135%	206,165
Other Income	-	101,470	-	-	92,527	-	193,997		193,997
Interest Income	-	687	-	-	29	-	716		716
Foreign Exchange Rates	-	1,223	-	-	-	-	1,223		1,223
Total Income	**10,503,611**	**4,782,332**	**684,999**	**934,727**	**5,841,347**	**-**	**12,243,405**	**117%**	**1,739,794**
Carryover General Fund		275,872	-	-	-	-	275,872		
Carryover Program Funds		-	(5,397)	1,324	535,352	-	531,279		
Carryover Reserve Fund		-	-	-	-	1,134,338	1,134,338		
Prior Period Adjustments		(617,550)	-	-	(1,373)	-	(618,923)		
Transfers Between Funds		(761,130)	425,000	527,000	(190,864)	-	6		
Total Funds Available	**10,503,611**	**3,679,524**	**1,104,602**	**1,463,051**	**6,184,462**	**1,134,338**	**13,565,977**	**129%**	**3,062,366**
General Expenses									
Salaries and Wages	4,074,772	1,558,786	497,351	912,257	990,163	-	3,958,557	97%	(116,215)
Payroll Taxes	-	108,423	38,179	62,795	71,535	-	280,932		280,932
Benefits	1,588,229	625,687	136,595	282,549	156,131	-	1,200,962	76%	(387,267)
Professional Fees	134,750	261,169	3,495	1,349	796	-	266,809	198%	132,059
Training and Education	36,000	16,700	-	-	1,468	-	18,168	50%	(17,832)
Personnel Related Expenses	4,604	5,493	-	4,103	962	-	10,558	229%	5,954
General Liability Insurance	-	42,098	-	-	-	-	42,098		42,098
Other Expenses	-	22,728	-	-	11,096	-	33,824		33,824
Total General Expenses	**5,838,355**	**2,641,084**	**675,620**	**1,263,053**	**1,232,151**	**-**	**5,811,908**	**100%**	**(26,447)**
Operating Expenses									
Meetings and Conferences	104,000	19,877	-	-	-	-	19,877	19%	(84,123)
Travel	152,749	45,961	5,787	19,829	59,570	-	131,147	86%	(21,602)
Publications	15,000	5,467	-	-	-	-	5,467	36%	(9,533)
Mailing and Shipping	117,300	5,781	3,239	4,048	123,451	-	136,519	116%	19,219
Technology	150,000	152,645	2,292	19,519	125	-	174,581	116%	24,581
Vessel Expenses	400,000	-	-	-	693,366	-	693,366	173%	293,366
Customs and Bait storage	-	-	-	-	25,780	-	25,780		25,780
Leases and Contracts	2,744,773	17,521	95,033	33,216	2,165,006	-	2,310,776	84%	(433,997)
Communications	17,000	32,044	-	3,424	928	-	36,396	214%	19,396
Capital Acquisitions	86,010	22,309	16,348	3,729	14,981	-	57,367	67%	(28,643)
Supplies	871,083	12,507	231,092	2,612	721,368	-	967,579	111%	96,496
Maintenance and Utilities	161,421	106,502	2,903	2,302	-	-	111,707	69%	(49,714)
Facility Rentals	395,578	456,265	-	2,880	219	-	459,364	116%	63,786
Total Operating Expenses	**5,214,914**	**876,879**	**356,694**	**91,559**	**3,804,794**	**-**	**5,129,926**	**98%**	**(84,988)**
Total Expense	**$ 11,053,269**	**$ 3,517,963**	**$ 1,032,314**	**$ 1,354,612**	**$ 5,036,945**	**$ -**	**$ 10,941,834**	**99%**	**$ (111,435)**
Excess Revenues over Expenditures		**$ 161,561**	**$ 72,288**	**$ 108,439**	**$ 1,147,517**	**$ 1,134,338**	**$ 2,624,143**		

THANK YOU

The IPHC wishes to thank all of the agencies, industry, and individuals who helped us in our investigations during 2021 in support of the Commission's mandate. A special thank you goes to the following:

- Personnel in the many processing plants who assist the IPHC Secretariat in port sampling and the Fishery-Independent Setline Survey (FISS) by storing and staging equipment and supplies.

- IPHC Regulatory Area 2A tribal biologists and state agency staff for sampling IPHC Regulatory Area 2A tribal and non-tribal commercial fishery landings.

- CDQ managers for providing the total number and weight of undersized Pacific halibut retained by authorized persons and the methodology used to collect these data.

- The NOAA Fisheries (NMFS) Observer Program for deploying observers on the IPHC Regulatory Area 2A directed commercial fishery, and for collecting, documenting, and forwarding tags recovered during observer deployments on commercial vessels.

- The NPFMC for their ongoing coordination with the IPHC.

- Fisheries and Oceans Canada for their ongoing coordination with the IPHC, in particular with electronic logbooks, Pacific halibut removal estimates and with IPHC FISS operations given protected habitats and species.

- Provincial, state and federal agency staff from both Canada and the U.S.A., as well as government contractors, for their assistance in the provision of data for the various fisheries impacting Pacific halibut mortality, landing notifications and for their assistance in conducting the IPHC FISS.

- The captains, crew, and plant personnel, as well as those individuals from outside agencies, whose dedicated contributions and efforts make the IPHC Secretariat operations a success.

- OBI Seafoods for working closely with IPHC Secretariat throughout the FISS to provide quality chum salmon to be used as bait.

2021 Publications

The IPHC publishes three serial publications - Annual reports, Scientific reports, and Technical Reports - and also prepares and distributes regulation pamphlets, information bulletins, and news releases. Additionally, the Secretariat are encouraged to publish their research in peer reviewed journals. All items published by the IPHC can be found on the IPHC webpage (https://www.iphc.int). Articles and reports produced during 2021 and authored by the Secretariat are cited below.

Carpi, P, Loher, T, Sadorus, LL, Forsberg, JE, Webster, RA, Planas, JV, Jasonowicz, A, Stewart, IJ, and Hicks, AC (2021) Ontogenetic and spawning migration of Pacific halibut: a review. Reviews in Fish Biology and Fisheries. doi.org/10.1007/s11160-021-09672-w International Pacific Halibut Commission. IPHC Annual Report 2020. 68 p.

Kroska, AC, Wolf, N, Planas, JV, Baker, MR, Smeltz, TS, and Harris, BP (2021) Controlled experiments to explore the use of a multi-tissue approach to characterizing stress in wild-caught Pacific halibut (Hippoglossus stenolepis). Conservation Physiology. Vol. 9(1):coab001. doi.org/10.1093/conphys/coab001

Loher, T, Bath, GE, and Wischniowski, S (2021) The potential utility of otolith microchemistry as an indicator of nursery origins in Pacific halibut (Hippoglossus stenolepis). Fisheries Research 243: 106072. doi.org/10.1016/j.fishres.2021.106072.

Loher, T, Dykstra, CL, Hicks, A, Stewart, IJ, Wolf, N, Harris, BP, and Planas, JV (2021) Estimation of post-release longline mortality in Pacific halibut (Hippoglossus stenolepis) using acceleration-logging tags. North American Journal of Fisheries Management. Doi.org/10.1002/nafm.10711.

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Stewart, IJ, Scordino, J J, Petersen, JR, Wise, AW, Svec, CI., Buttram, RH, Monette, JL, Gonzales, MR, Svec, R, Scordino, J, Butterfield, K, Parker, W, and Buzzell, LA (2021) Out with the new and in with the old: Reviving a traditional Makah halibut hook for modern fisheries management challenges. Fisheries Magazine: American Fisheries Society (early view). doi.org/10.1002/fsh.10603

Taylor, IG, Doering, KL, Johnson, KF, Wetzel, CR, and Stewart, IJ (2021) Beyond visualizing catch-at-age models: Lessons learned from the r4ss package about software to support stock assessments. Fisheries Research. Vol. 439:105924. doi.org/10.1016/j.fishres.2021.105924

Commissioners

Canada

John Pease Babcock	1924-1936
William A. Found	1924-1936
George L. Alexander	1936-1937
Lewis W. Patmore	1937-1943
A. J. Whitmore	1936-1948
Stewart Bates	1948-1949
George W. Nickerson	1943-1953
George W. Clark	1949-1955
S. V. Ozere	1955-1957
Harold S. Helland	1953-1963
Richard Nelson	1953-1964
William Sprules	1957-1973
Martin K. Eriksen	1963-1973
Jack T. Prince	1974-1976
Francis W. Millerd	1964-1977
Clifford R. Levelton	1974-1979
John A. O'Connor	1978-1980
Peter C. Wallin	1977-1982
Michael Hunter	1979-1984
Sigurd Brynjolfson	1982-1986
Donald McLeod	1981-1987
Garnet E. Jones	1986-1987
Dennis N. Brock	1988-1989
Gary T. Williamson	1987-1992
Linda J. Alexander	1987-1992
Allan T. Sheppard	1991-1995
Brian Van Dorp	1993-1997
Gregg Best	1995-1999
Rodney Pierce	1997-1999
Kathleen Pearson	2000-2001
John Secord	2000-2005
Richard J. Beamish	1990-2005
Clifford Atleo	2002-2008
Larry Johnson	2009-2011
Gary Robinson	2005-2012
Laura Richards	2006-2012
Michael Pearson	2012-2014
David Boyes	2012-2016
Ted Assu	2014-2018
Jake Vanderheide	2017-2018
Robert Day	2018-2018
Paul Ryall	2013-
Neil Davis	2018-
Peter DeGreef	2018-

United States of America

Miller Freeman	1924-1932
Henry O'Malley	1924-1933
Frank T. Bell	1933-1940
Charles E. Jackson	1940-1946
Milton C. James	1946-1952
Edward W. Allen	1932-1955
J.W. Mendenhall	1954-1958
Seton H. Thompson	1952-1959
Andrew W. Anderson	1959-1961
Mattias Madsen	1955-1964
William A. Bates	1958-1964
L. Adolph Mathisen	1965-1970
Harold E. Crowther	1961-1972
Haakon M. Selvar	1964-1972
Neils M. Evens	1970-1982
Robert W. Schoning	1972-1982
William S. Gilbert	1972-1983
Gordon Jensen	1983-1983
Robert W. McVey	1983-1988
James W. Brooks	1988-1989
George A. Wade	1984-1992
Richard Eliason	1984-1995
Kris Norosz	1995-1997
Steven Pennoyer	1989-2000
Andrew Scalzi	1998-2003
Ralph Hoard	1993-2013
Phillip Lestenkof	2003-2013
Chris Oliver	2013-2013
Donald Lane	2014-2015
Jeffrey Kauffman	2015-2016
James Balsiger	2000-2018
Linda Behnken	2016-2018
Chris Oliver	2018-2020
Robert Alverson	2014-
Richard Yamada	2018-
Glenn Merrill	2021-

Executive Directors

William F. Thompson	1923-1940
Henry A. Dunlop	1940-1963
F. Heward Bell	1963-1970
Bernard E. Skud	1970-1978
Donald A. McCaughran	1978-1998
Bruce M. Leaman	1997-2016
David T. Wilson	2016-

In memory of our friend and colleague, Aaron Ranta 1967-2021

Secretariat

Seattle Headquarters

Name (Official)	Branch	Position Title (Official)
David T. Wilson, Ph.D.	Executive	Executive Director
Keith Jernigan, M.I.T.	Executive	Assistant Director
Barbara Hutniczak, Ph.D.	Fisheries Policy & Economics	Branch Manager
Tina Wisnowski, B.Sc.	Finance and Personnel Services	Staff Accountant
Kelly Chapman, B.A.	Finance and Personnel Services	Senior Administrative Specialist
Tara Coluccio, B.A. (PR)	Finance and Personnel Services	Administrative Specialist/Communications
Erin Salle, B.Sc.	Finance and Personnel Services	Administrative Specialist
Ola Wietecha, B.A.	Finance and Personnel Services	Administrative Specialist
Robert Tynes	Finance and Personnel Services	Systems Administrator
Aaron Ranta, B.Sc.	Finance and Personnel Services	Programmer
Afshin Taheri, B.Sc.	Finance and Personnel Services	Programmer
Lauri Sadorus, M.Sc.	Finance and Personnel Services	Communications/Research Biologist
Edward Henry, M.Sc.	Finance and Personnel Services	Communications Specialist
Allan Hicks, Ph.D.	Quantitative Sciences	Quantitative Scientist
Ian Stewart, Ph.D.	Quantitative Sciences	Quantitative Scientist
Raymond Webster, Ph.D.	Quantitative Sciences	Biometrician
Josep Planas, Ph.D.	Biological & Ecosystem Sciences	Branch Manager
Claude Dykstra, B.Sc.	Biological & Ecosystem Sciences	Research Biologist
Andy Jasonowicz, M.Sc.	Biological & Ecosystem Sciences	Research Biologist
Timothy Loher, Ph.D.	Biological & Ecosystem Sciences	Research Scientist
Crystal Simchick, B.Sc.	Biological & Ecosystem Sciences	Laboratory Technician
Maya Stock	Biological & Ecosystem Sciences	Undergraduate Intern
Eva Sukphon Devita	Biological & Ecosystem Sciences	Undergraduate Intern
Lara Erikson	Fisheries Statistics & Services	Branch Manager
Tom Kong, B.Sc.	Fisheries Statistics & Services	Fisheries Data Specialist/A/g Branch Mngr Fisheries
Huyen Tran, A.A.	Fisheries Statistics & Services	Fisheries Data Coordinator
Joan Forsberg, B.Sc.	Fisheries Statistics & Services	Otolith Lab Supervisor
Christopher Johnston, B.Sc.	Fisheries Statistics & Services	Otolith Technician
Dana Rudy, B.Sc.	Fisheries Statistics & Services	Otolith Technician
Robert Tobin	Fisheries Statistics & Services	Otolith Technician
Kamala Carroll	Fisheries Statistics & Services	Port Operations Coordinator
Caroline Prem, B.Sc.	Fisheries Statistics & Services	Fisheries Data Specialist
Kimberly Sawyer Van Vleck, B.Sc.	Fisheries Statistics & Services	Fisheries Data Specialist
Kayla Ualesi, B.Sc.	Fishery Independent Setline Survey	Setline Survey Coordinator
Colin Jones, M.Sc.	Fishery Independent Setline Survey	Setline Survey Specialist
Tyler Jack, M.Sc.	Fishery Independent Setline Survey	Setline Survey Specialist
Rachel Rillera, B.Sc.	Fishery Independent Setline Survey	Setline Survey Specialist
Monica Thom, B.Sc.	Fishery Independent Setline Survey	Setline Survey Specialist

Short-term contract staff

Name (Official)	Branch	Position Title (Official)
Nicholas Wilson, B.S. (BA)	Finance and Personnel Services	Staff Accountant
Steven J. Berukoff, Ph.D.	Quantitative Sciences	Programmer (Management Strategy Evaluation)
Piera Carpi, Ph.D.	Quantitative Sciences	Researcher (Management Strategy Evaluation)
Anna Simeon, M.Sc.	Biological & Ecosystem Sciences	Laboratory Technician

Fisheries Data Specialists (Field)

Fisheries Statistics & Services Branch

Name (Official)	Location
Stephen Brennan	Kodiak, AK
Chelsea Hutton	Port Hardy, B. C.
Jessica Marx	Homer, AK
Binget Nilsson	Seward, AK
Laurel Osborne	Prince Rupert, B. C.
Jennifer Rogge	Dutch Harbor, AK
Natachan (Tachi) Sopow	Sitka, AK
Matthew Thompson	Petersburg, AK

Setline Survey Specialists (Field)

Fisheries Independent Setline Survey

Name (Official)	
Colin Blackie	Lauren Kregel
Guy Boxall	Francis Maddox
Kevin Coll	Jessica Miller
Heather Colley	Silvestre R Natario
Lisa Crawford	Christopher Noren
Monica Fezuk	Samuel Parker
Nancy Franco	Jennifer Paton
Allen (Dean) Gaidica	Ricardo Salazar
Tyler Jack	Jonathan Turnea
Peter Jankiewicz	Pamela Tyhurst
Olivia Kohler	Sarah Williamson