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Pacific Halibut Bycatch in U.S. West Coast Groundfish Fisheries, 2002–19

January 2021

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

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NOAA FISHERIES

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PACIFIC HALIBUT BYCATCH 2002-2019

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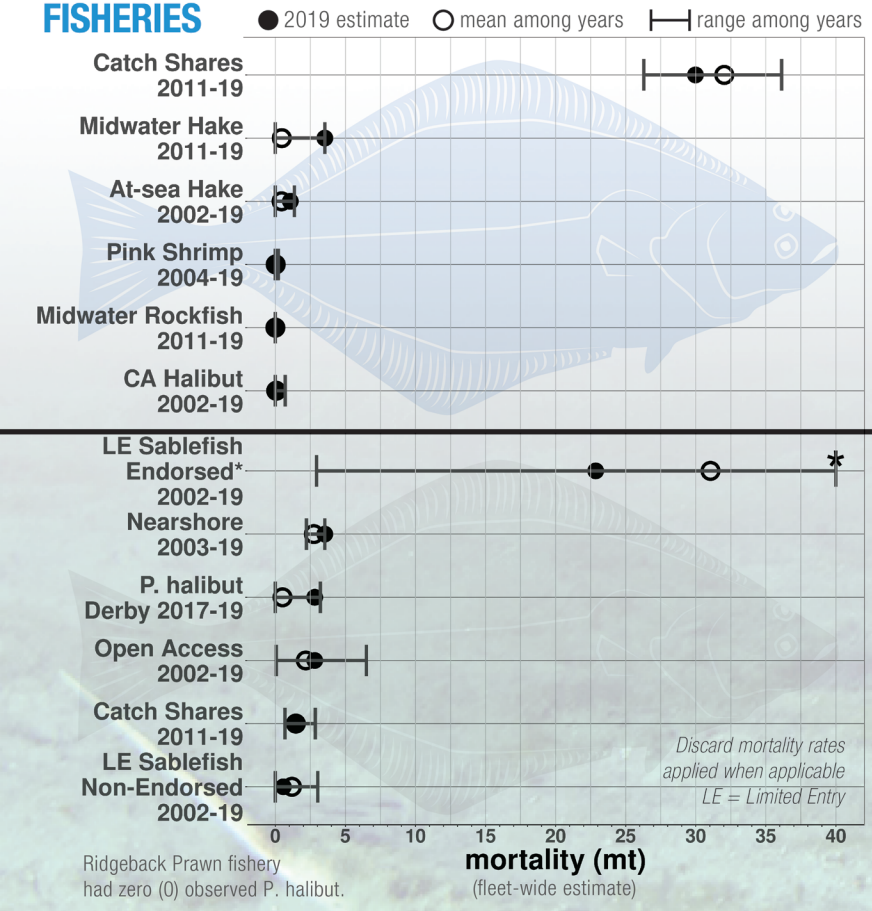
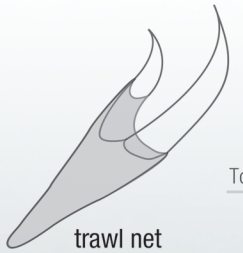
NOAA FISHERIES



Ridgeback Prawn fishery had zero (0) observed P. halibut.

2019 Catch Shares IBQ
Allocation (mt) : 69.58
Attainment (mt): 31.58



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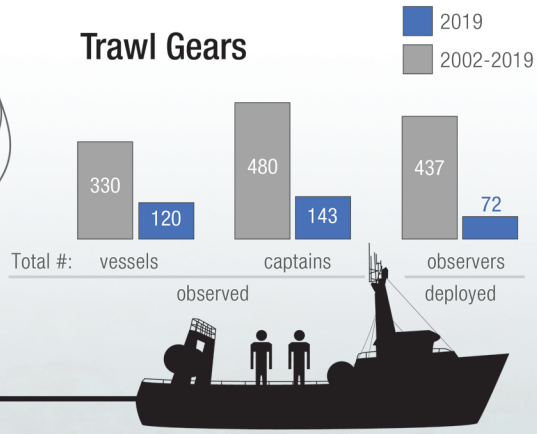
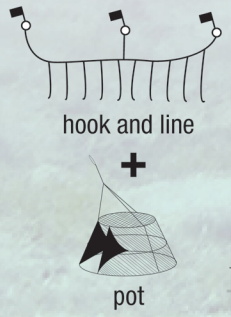


*maximum = 107.3 mt



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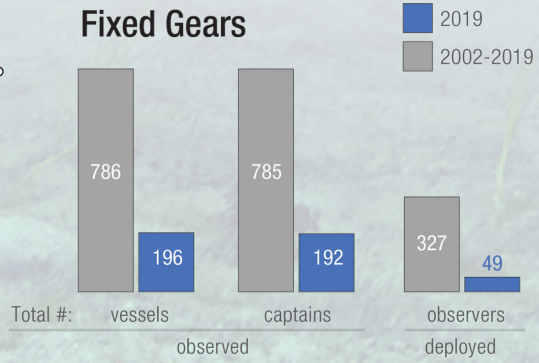
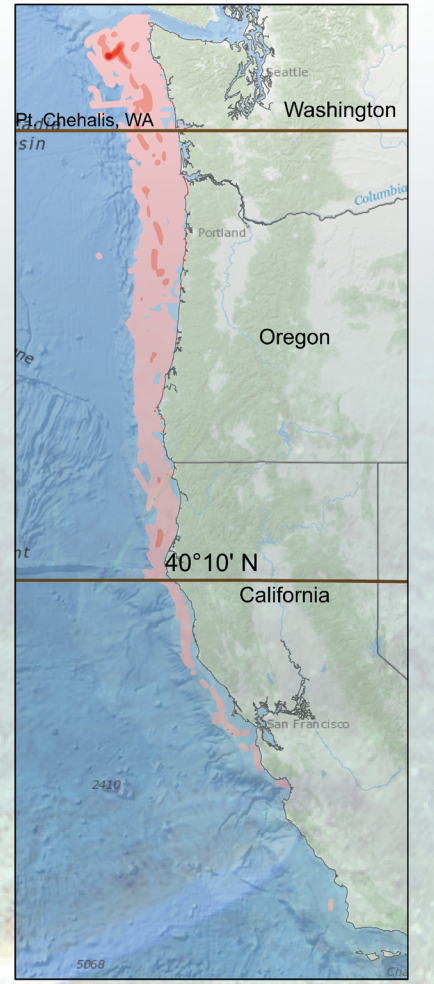
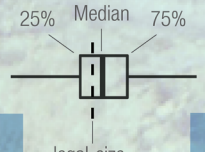


Pacific Halibut Bycatch
Observed 2002-2019





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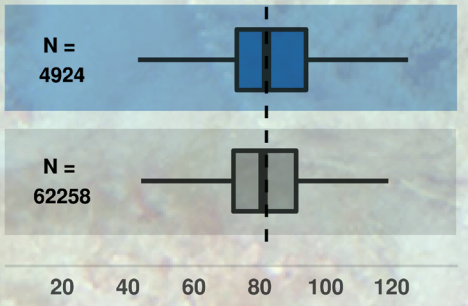

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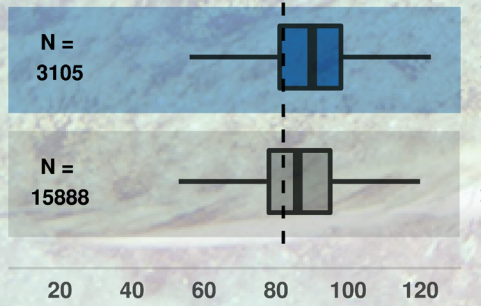

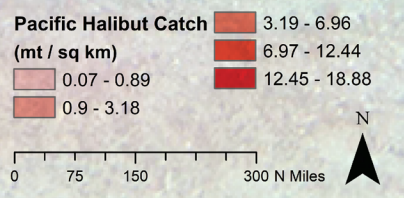

Map by K. Somers

Executive Summary

Pacific halibut (*Hippoglossus stenolepis*, henceforth P. halibut) is found in coastal waters throughout the North Pacific. Off the U.S. West Coast, it inhabits continental shelf areas (<150 fth [fathoms]) from Washington to central California (Clark and Hare 1998). Pacific halibut has long supported a directed commercial fishery in the U.S. and Canada, but it is also caught as bycatch in other fisheries that target demersal species inhabiting similar depths and seafloor habitat types (IPHC and Gustafson 2019).

The objective of this report is to provide estimates of P. halibut bycatch in the U.S. West Coast groundfish fisheries. Bycatch estimates are required for domestic and international management of P. halibut. The International Pacific Halibut Commission (IPHC), a body founded through treaty agreement between the U.S. and Canada, sets the P. halibut annual total constant exploitation yeild (TCEY). TCEY is converted to total allowable catch (TAC) for IPHC Area 2A, the collective U.S. marine waters bordering the states of Washington, Oregon, and California. TAC is based, in part, on bycatch mortality, which takes into account potential survival after being discarded. Regulations for IPHC Area 2A are set by NOAA Fisheries West Coast Region. Pacific halibut catch in IPHC Area 2A is divided between tribal and nontribal fisheries, between commercial and recreational fisheries, and between recreational fisheries in different states (Washington, Oregon, California). The Pacific Fishery Management Council (PFMC) describes this P. halibut catch division each year in a catch-sharing plan.

Pacific halibut bycatch in U.S. West Coast groundfish fisheries is estimated from data collected by fisheries observers, fish sales information, and electronic monitoring equipment mounted on some commercial fishing vessels. Fisheries observer data are the main source of information about P. halibut bycatch in these fisheries. The Northwest Fisheries Science Center (NWFSC) Fisheries Observation Science Program (FOS) has collected discard data from commercial fishing vessels since 2002.[1] Pacific halibut mortality estimates in this report are provided for the years 2002 through 2019 from all fishery sectors observed by FOS (Table 1). This report is updated annually by FOS and presented to PFMC and IPHC for use in P. halibut management.

Table 1. Pacific halibut mortality estimates for 2019 and the years of observation, for all fishery sectors observed by FOS. Estimates include individuals discarded at the dock and have mortality rates applied, where appropriate. *Key*: TDM = total discard mortality, mt = metric tons, * = confidential, EFP = exempted fishing permit.

Sector	Years Observed	2019 TDM (mt)
Individual Fishing Quota (IFQ) fisheries[a]	2011–19	27.46
IFQ Electronic Monitoring (EM) EFP[b]	2015–19	4.99
At-sea Pacific hake	2002–19	0.54
Non-nearshore fixed gear targeting groundfish	2002–19	28.67
Nearshore fixed gear	2003–19	0.57
Pink shrimp trawl	2004–19	0.00
California halibut trawl	2002–19	0.00
P. halibut directed	2017–19	3.53
Ridgeback Prawn	2017–19	0.00
Sea Cucumber	2017–19	*

[a] Does not include estimates from IFQ vessels with electronic monitoring. Includes all gears.
[b] Includes all gears.

[1] Prior to 2001, at-sea hake fisheries were observed by the Alaska Fisheries Science Center.

In 2019, non-nearshore fixed gear targeting groundfish had the largest estimated P. halibut discard mortality of any sector (28.67 mt [metric tons], Tables 1 and 2). Nearly all of that bycatch (22.94 mt, or ~80%) occurred on the limited entry (LE) sablefish endorsed vessels. These vessels fish federally permitted sablefish tier quota during the primary season (April to October). Almost all of the LE sablefish endorsed bycatch occurred while fishing longline gear north of Point Chehalis, Washington (19.01 mt or ~83%, Supplemental Table 66).[2] A smaller amount of P. halibut mortality also occurred on LE sablefish endorsed vessels fishing longline gear south of Pt. Chehalis (3.49 mt). The LE non-endorsed longline vessels caught a small amount of P. halibut (2.81 mt). LE endorsed and non-endorsed pot vessels caught a combined 0.46 mt of P. halibut bycatch. Open access (OA) vessels targeting non-nearshore groundfish species with hook-and-line gear caught substantially less than the LE sector (2.88 mt), and a trivial amount with pot gear (0.04 mt).

The 2019 IFQ fishery estimate of P. halibut discard mortality, coastwide, was 27.46 mt, with an additional 4.99 mt caught by IFQ EM EFP vessels (Table 1 and Supplemental Tables 46, 49, and 52), included in the IFQ estimate in Table 2 and Supplemental Table 91. The IFQ total (IFQ + IFQ EM EFP = 32.45 mt) is 0.08 mt less than the 2018 estimate (32.53 mt; see Table 2) and, as in past years, well below the individual bycatch quota (IBQ) for P. halibut north of lat 40°10′N allocation (2019 IBQ allocation = 69.59 mt). As in prior years, bottom trawl gear produced the largest component of IFQ discard mortality (IFQ + IFQ EM = 29.98 mt), almost half of which was from bottom trawl vessels fishing between Pt. Chehalis and lat 40°10′N in waters deeper than 60 fth (14.87 mt, Supplemental Table 21). Percent of legal-sized (>82 cm) P. halibut mortality, by weight (mt), in the IFQ bottom trawl fishery north of lat 40°10′N is provided in Table 3.

IFQ bottom trawl and LE sablefish endorsed longline vessels together comprised approximately 84% of the 2019 P. halibut discard mortality in observed U.S. West Coast groundfish fisheries.

In Supplemental Tables 48 and 51, for the third year, we compare alternative methods for calculating discard mortality rates (DMRs) in the IFQ EM EFP fishery. Electronic monitoring does not yet allow for accurate estimates of P. halibut injuries and viability according to gear type based on IPHC criteria. For in-season P. halibut IBQ management, PSMFC applies a time-on-deck model (PFMC 2017, Smith 2017) to determine mortality rate of P. halibut caught on bottom trawl IFQ vessels carrying EM. For final end-of-year reporting, in this report, we apply a 0.90 mortality rate to all P. halibut bycatch in the IFQ EM bottom trawl fishery (Supplemental Table 46). As an alternative to the 0.90 rate, we also present mortality estimates based on observer assessed viabilities and the PFMC Groundfish Management Team's time-on-deck model (see Supplemental Tables 48 and 51). Small sample sizes preclude definitive conclusions from this analysis. FOS might revisit this analysis in future reports.

The P. halibut discard mortality estimate for the 2019 IPHC directed Pacific halibut fishery was 3.53 mt (Tables 1 and 2). Observer coverage, discard ratios, fleetwide estimates of gross discards, discard mortality, and retained P. halibut are presented in Supplemental Tables 74, 76, and 78. Discard mortality estimates were calculated using the same methods as for the non-nearshore hook-and-line fishery, which uses observed estimates of P. halibut viability. Viabilities of observed P. halibut bycatch in the P. halibut directed fishery are given in Supplemental Table 77. Observed lengths of discarded P. halibut in the directed fishery are given in Supplemental Tables 79 and 80.

[2] See the Supplemental Tables.

Table 2. Pacific halibut discard mortality estimates (in mt, including a small amount discarded at the dock in IFQ BT, MW rf, and MW hake fisheries) for all sectors observed by FOS. Mortality rates <1.0 were applied in the BT fisheries (LE and IFQ), IFQ H&L, IFQ pot, and non-IFQ, non-NS FG sectors, for which some information regarding gear-specific survivorship was available. For all other sectors, a 1.0 mortality rate was applied because gear-specific survivorship information is not available. Rounding of values might mask very small weights in some categories, presented here as zero (0). All weights are estimated based on whole fish (a.k.a., round weight, not head-and-gut). Ridgeback prawn (2017–19) and sea cucumber (2017) fisheries had zero (0) observed P. halibut catch. *Key*: IFQ = individual fishing quota, FOS = Fisheries Observation Science Program, BT = bottom trawl, LE = limited entry, H&L = hook-and-line, hal. = halibut, MW = midwater, rf = rockfish, sable. = sablefish, end. = endorsed, OA = open access, NS = nearshore, A-S = at-sea, mort. = mortality rate, n/a = not applicable, * = confidential data (<3 vessels observed), — = no observer coverage.

	Total Discards (mt), mortality rates not applied																
		IFQ Fishery[h]						Non-NS FG									
Year	LE BT 2002–10	BT[a,b,j]	LE CA hal.[a,c]	H&L	Pot[j]	MW rf[c,d,j]	MW hake[b,c,e,j]	LE sable. end.	LE sable. non-end.	OA[f]	NS FG[c]	Pink shrimp[c]	CA hal.[c,g]	P. hal. directed	A-S hake[c]	All sectors	All w/ <1.0 mort.[h]	All w/ 1.0 mort.[i]
2002	524.41	n/a	n/a	n/a	n/a	n/a	n/a	141.76	0.00	—	—	—	0.00	—	1.14	667.31	666.17	1.14
2003	186.65	n/a	n/a	n/a	n/a	n/a	n/a	197.11	0.17	—	0.00	—	0.00	—	2.65	386.58	383.93	2.65
2004	212.43	n/a	n/a	n/a	n/a	n/a	n/a	238.57	0.00	—	0.97	0.00	0.70	—	1.13	453.80	451.70	2.10
2005	460.35	n/a	n/a	n/a	n/a	n/a	n/a	237.90	0.00	—	2.20	0.04	0.03	—	1.97	702.49	698.28	4.21
2006	390.91	n/a	n/a	n/a	n/a	n/a	n/a	668.62	0.00	—	0.52	—	0.02	—	0.83	1,060.90	1,059.55	1.35
2007	294.38	n/a	n/a	n/a	n/a	n/a	n/a	132.27	1.73	22.03	0.08	0.21	0.03	—	1.18	451.91	450.44	1.47
2008	305.21	n/a	n/a	n/a	n/a	n/a	n/a	259.46	2.99	40.51	0.34	0.00	0.31	—	3.98	612.80	608.48	4.32
2009	385.24	n/a	n/a	n/a	n/a	n/a	n/a	321.60	0.25	35.21	1.28	0.00	0.00	—	0.33	743.91	742.30	1.61
2010	265.08	n/a	n/a	n/a	n/a	n/a	n/a	137.60	0.39	32.60	0.08	0.00	0.00	—	1.57	437.32	435.67	1.65
2011	n/a	64.14	0.00	6.06	3.36	*	0.35	137.11	21.31	13.13	3.03	0.19	0.00	—	0.61	249.29	245.11	4.18
2012	n/a	67.13	*	14.66	1.89	0.00	0.62	151.25	16.55	23.68	2.24	0.00	0.00	—	0.64	278.66	275.16	3.50
2013	n/a	66.09	see [a]	3.00	0.98	0.00	1.34	22.23	0.01	1.81	1.35	0.00	0.00	—	1.06	97.87	94.12	3.75
2014	n/a	55.90	see [a]	3.80	0.32	0.00	1.36	174.79	0.00	3.64	0.94	0.00	0.00	—	0.37	241.12	238.45	2.67
2015	n/a	69.28	see [a]	9.49	2.21	0.00	0.70	123.48	0.46	10.19	1.43	0.01	0.00	—	0.06	217.31	215.11	2.20
2016	n/a	58.86	see [a]	6.39	1.77	0.00	0.68	174.02	5.14	42.78	3.02	0.00	0.00	—	0.15	292.81	288.96	3.85
2017	n/a	64.78	see [a]	4.14	1.84	0.00	0.51	295.12	0.76	49.95	1.72	0.00	0.00	25.35	0.55	444.72	441.94	2.78
2018	n/a	51.79	see [a]	4.66	2.64	0.00	1.34	219.15	13.79	41.73	1.57	0.01	0.00	15.60	0.66	352.94	349.36	3.58
2019	n/a	52.97	see [a]	3.25	4.22	0.00	1.07	217.99	80.21	40.17	0.57	0.00	0.00	29.19	0.54	430.18	428.00	2.18

Note: Ridgeback prawn (2017–18) and sea cucumber (2017 only) fisheries had zero (0) observed P. halibut catch. The 2018–19 sea cucumber fishery data are confidential.
[a] Starting in 2013, LE CA halibut estimates are combined with IFQ BT estimates.
[b] Includes a small amount landed and discarded at the dock.
[c] 100% mortality rate.
[d] From 2011–14, "midwater trawl."
[e] From 2011–14, "shoreside hake."
[f] Starting in 2011, this sector only includes OA CA halibut.
[g] A coastwide discard ratio and coastwide discard estimate could not be computed in the OA FG sector for 2002–06, because WCGOP only covered OA vessels in CA during this time.
[h] LE BT, IFQ BT, IFQ H&L, IFQ pot, LE and OA CA halibut, and non-NS FG.
[i] IFQ MW rf, MW hake, NS FG, pink shrimp, and A-S hake.
[j] Includes P. halibut catch from IFQ EM EFP.

Due to the amount of data it contains, this table has been typeset on legal-sized paper. Printing it on regular, letter-sized paper may result in reduced legibility.

Table 2 (continued). Pacific halibut discard mortality estimates for all sectors observed by FOS.

	Total Discard Mortality (mt), mortality rates applied																
		IFQ Fishery[h]						Non-NS FG									
Year	LE BT 2002–10	BT[a,b,j]	LE CA hal.[a,c]	H&L	Pot[j]	MW rf[c,d,j]	MW hake[b,c,e,j]	LE sable. end.	LE sable. non-end.	OA[f]	NS FG[c]	Pink shrimp[c]	CA hal.[c,g]	P. hal. directed	A-S hake[c]	All sectors	All w/ <100% mort.[h]	All w/ 100% mort.[i]
2002	344.82	n/a	n/a	n/a	n/a	n/a	n/a	22.76	0.00	—	—	—	0.00	—	1.14	368.72	367.58	1.14
2003	124.43	n/a	n/a	n/a	n/a	n/a	n/a	31.54	0.03	—	0.00	—	0.00	—	2.65	158.65	156.00	2.65
2004	133.12	n/a	n/a	n/a	n/a	n/a	n/a	38.82	0.00	—	0.97	0.00	0.70	—	1.13	174.74	172.64	2.10
2005	286.52	n/a	n/a	n/a	n/a	n/a	n/a	38.12	0.00	—	2.20	0.04	0.03	—	1.97	328.88	324.67	4.21
2006	242.47	n/a	n/a	n/a	n/a	n/a	n/a	107.30	0.00	—	0.52	—	0.02	—	0.83	351.14	349.79	1.35
2007	208.81	n/a	n/a	n/a	n/a	n/a	n/a	21.24	0.28	3.54	0.08	0.21	0.03	—	1.18	235.37	233.90	1.47
2008	207.81	n/a	n/a	n/a	n/a	n/a	n/a	41.65	0.48	6.49	0.34	0.00	0.31	—	3.98	261.06	256.74	4.32
2009	251.10	n/a	n/a	n/a	n/a	n/a	n/a	51.47	0.04	5.64	1.28	0.00	0.00	—	0.33	309.86	308.25	1.61
2010	180.97	n/a	n/a	n/a	n/a	n/a	n/a	22.12	0.06	5.23	0.08	0.00	0.00	—	1.57	210.03	208.38	1.65
2011	n/a	31.30	0.00	0.97	0.89	*	0.35	11.78	3.06	1.95	3.03	0.19	0.00	—	0.61	54.13	49.95	4.18
2012	n/a	36.13	*	2.34	0.51	0.00	0.62	27.53	0.78	1.51	2.24	0.00	0.00	—	0.64	72.30	68.80	3.50
2013	n/a	32.41	see [a]	0.48	0.21	0.00	1.34	2.85	0.00	0.07	1.35	0.00	0.00	—	1.06	39.77	36.02	3.75
2014	n/a	26.29	see [a]	0.61	0.08	0.00	1.36	27.89	0.00	0.29	0.94	0.00	0.00	—	0.37	57.83	55.16	2.67
2015	n/a	33.36	see [a]	1.52	0.38	0.00	0.70	10.30	0.02	0.40	1.43	0.01	0.00	—	0.06	48.18	45.98	2.20
2016	n/a	33.29	see [a]	1.02	0.18	0.00	0.68	16.92	1.07	2.70	3.02	0.00	0.00	—	0.15	59.03	55.18	3.85
2017	n/a	35.11	see [a]	0.66	0.78	0.00	0.51	42.01	0.03	3.62	1.72	0.00	0.00	2.22	0.55	57.21	84.43	2.78
2018	n/a	30.45	see [a]	0.75	0.29	0.00	1.34	25.52	0.62	4.43	1.57	0.01	0.00	2.48	0.66	68.12	64.54	3.58
2019	n/a	29.28	see [a]	0.52	0.96	0.00	1.07	22.94	2.81	2.92	0.57	0.00	0.00	3.53	0.54	65.84	63.66	2.18

Note: Ridgeback prawn (2017–18) and sea cucumber (2017 only) fisheries had zero (0) observed P. halibut catch. The 2018–19 sea cucumber fishery data are confidential.
[a] Starting in 2013, LE CA halibut estimates are combined with IFQ BT estimates.
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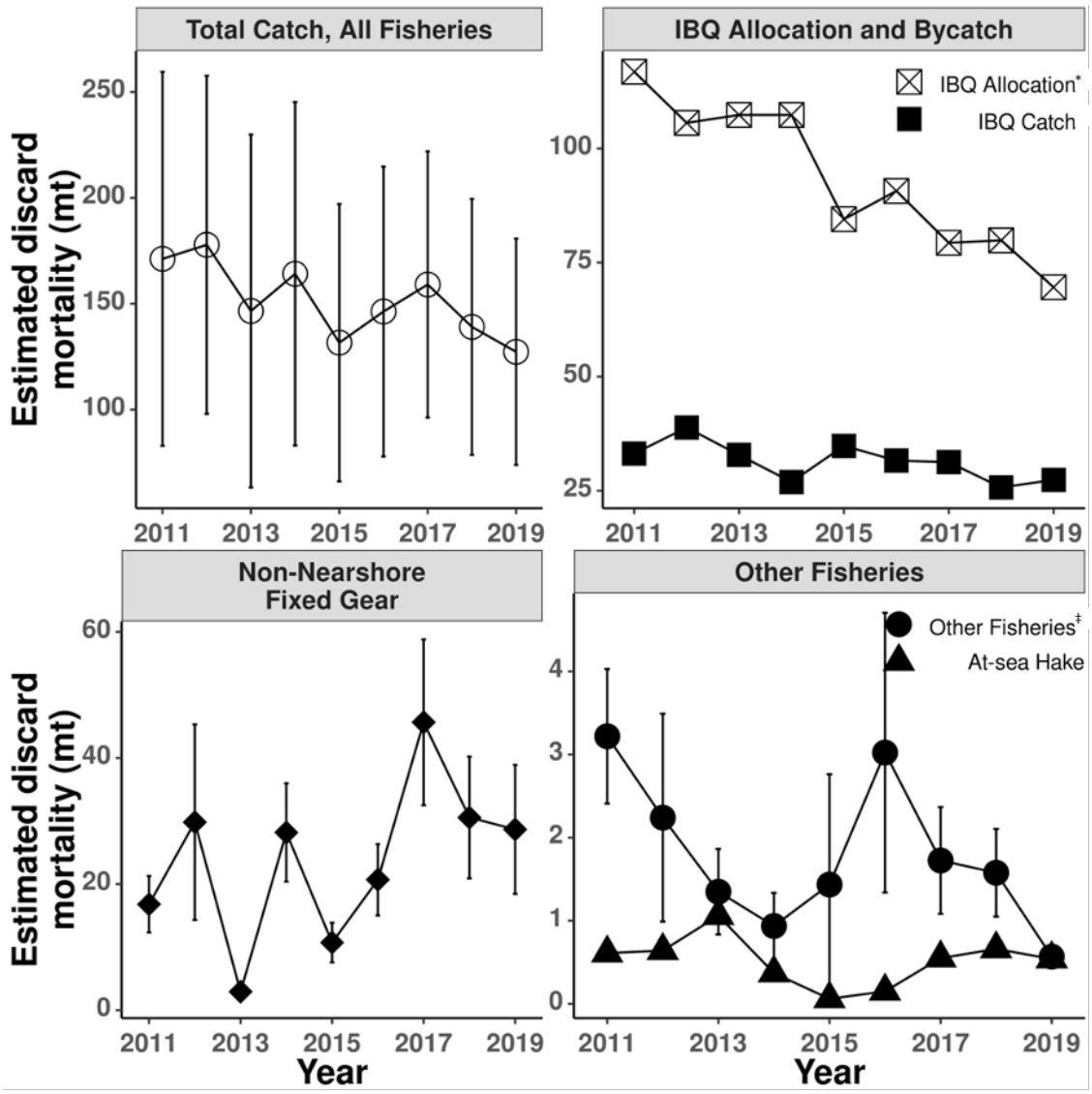

Figure 1. Total estimated P. halibut discard mortality (in mt ± 1 SE, with mortality rates applied if applicable) from all sectors observed by FOS. Estimates are not included for sectors and years where there were insufficient observer data. Values are reported in Table 2.
*Individual bycatch quota (IBQ) allocated N of lat 40°10′N.
†IBQ catch includes all catch share sectors and gears except at-sea hake, which is shown separately.
‡*Other Fisheries* includes OR and CA Nearshore, WA, OR, and CA pink shrimp, CA halibut, sea cucumber, ridgeback prawn, and IPHC P. halibut directed fisheries.

Pacific halibut discard in the nearshore fixed gear, pink shrimp trawl, California halibut trawl (combined as Other Fisheries in Figure 1), and at-sea Pacific hake pelagic trawl fisheries combined represents a very small component of total P. halibut mortality (Table 1 and Figure 1). There was zero (0) observed catch of P. halibut in the California ridgeback prawn trawl fishery (Supplemental Table 86). Estimates for the 2019 California sea cucumber trawl fishery are confidential and therefore not provided (Supplemental Table 87).

Final estimates of discards in observed fishery sectors, including the IFQ EM EFP, are shown in Tables 1, 2, and Supplemental Table 91. All three tables (and elsewhere in this report) include the small amount of P. halibut landed and subsequently discarded at the dock by IFQ bottom and midwater trawl vessels. The amounts landed and then discarded at the dock are listed by strata in Supplemental Tables 8–10. Summaries of P. halibut catch in the IFQ EM EFP are included in Tables 1, 2, and Supplemental Tables 46, 49, 52, and 91.

In addition, we provide historical estimates of P. halibut bycatch in the LE bottom trawl fishery for the 2002–10 period (Table 2 and Supplemental Tables 90 and 91) and P. halibut bycatch estimates for observed, non-IFQ vessels with an exempted fishing permit (EFP) targeting groundfish (2002–19, Supplemental Table 88). For completeness, we also include the P. halibut landed catch from PacFIN fish tickets reported by nongroundfish fisheries that are not observed by FOS for the period 2002–19 (Supplemental Table 89).

Table 3. Percent of legal-sized (>82 cm) P. halibut mortality, by weight (mt), in the IFQ bottom trawl fishery N of lat 40°10′N.

Year	% legal-sized P. halibut
2011	67.11
2012	66.69
2013	64.01
2014	60.07
2015	67.68
2016	67.26
2017	75.61
2018	79.22
2019	73.49

The FOS data used in this report have been updated to include the most recent data available (2002–19). Pacific Fisheries Information Network (PacFIN) data used in this report were accessed April 2020. The estimates for all sectors and years (except LE trawl 2002–10) have been recalculated based on these data. For ease of data access and reporting, the majority of tables have been removed from the written report and provided in the accompanying Excel file. In all other respects, this report uses the same methods as last year's report (Jannot et al. 2020a).

Acknowledgments

The authors gratefully acknowledge the hard work and dedication of observers from the Northwest Fisheries Science Center's Fisheries Observation Science (FOS) Program, Jim Fellows (NWFSC) for data acquisition assistance, and all the FOS staff for their hard work and dedication. We thank Su Kim of the NWFSC Communications Program for producing the infographic in this report. We thank Al Brown (IBSS Corporation) for technical editing. Comments and suggestions from our partners at the International Pacific Halibut Commission significantly improved this report. We thank our partners at the Pacific States Marine Fisheries Commission who provide us with data from the IFQ electronic monitoring EFP and landings data from PacFIN, and specifically Aileen Smith for providing us with the data to compare discard mortality rates in the EM fishery.

A note about tables:

Tables 1–7 have been typeset and included in this report. They are also available, together with all the other mentioned tables (Supplemental Tables 8–95), by downloading the file from the report's NOAA Institutional Repository[3] record and clicking on the *Supporting Files* tab.

[3] https://repository.library.noaa.gov/

Abbreviations

A-SHOP	At-Sea Hake Observer Program (FOS)
BT	bottom trawl
DMR	discard mortality rate
DOC	U.S. Department of Commerce
EEZ	exclusive economic zone
EFP	exempted fishing permit
EM	electronic monitoring
FG	fixed gear
FOS	Fisheries Observation Science Program (FRAM)
FRAM	Fishery Resource Analysis and Monitoring Division (NWFSC)
H&L	hook-and-line
IBQ	individual bycatch quota
IFQ	individual fishing quota
IPHC	International Pacific Halibut Commission
LE	limited entry
MW	midwater
NMFS	National Marine Fisheries Service (NOAA)
NNSFG	non-nearshore
NS	nearshore
NOAA	National Oceanic and Atmospheric Administration (DOC)
NWFSC	Northwest Fisheries Science Center (NMFS)
OA	open access
PacFIN	Pacific Fisheries Information Network (PSMFC)
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fishery Commission
SE	standard error
TAC	total allowable catch
TCEY	total constant exploitation yield
WCGOP	West Coast Groundfish Observer Program (FOS)

Introduction

Pacific halibut (*Hippoglossus stenolepis*) is found in coastal waters throughout the North Pacific. Off the U.S. West Coast, it inhabits continental shelf areas (<150 fth [fathoms]) from Washington to central California (Clark and Hare 1998, Keith et al. 2014). Pacific halibut has long supported a directed commercial fishery in the U.S. and Canada, but it is also caught as bycatch in other fisheries that target demersal species inhabiting similar depths and seafloor habitat types (IPHC and Gustafson 2019). The objective of this report is to provide estimates of P. halibut bycatch in the U.S. West Coast groundfish fisheries from 2002–19.

Observed West Coast Groundfish Fisheries

The U.S. West Coast groundfish fishery is a multispecies fishery that utilizes a variety of gear types. The fishery harvests species designated in the Pacific Coast Groundfish Fishery Management Plan (FMP; PFMC 2019) and is managed by the Pacific Fishery Management Council (PFMC). Over 90 species are listed in the groundfish FMP, including a variety of rockfish, flatfish, roundfish, skates, and sharks. These species are found in both state (0–5.6 km) and federal (>5.6 km off-shore to the EEZ) waters. Groundfish are both targeted and caught incidentally by trawl nets, hook-and-line gears, and fish pots. Under the FMP, the groundfish fishery consists of four management components:

1. The limited entry (LE) component encompasses all commercial fishers who hold a federal limited entry permit. The total number of LE permits available is restricted. Vessels with an LE permit are allocated a larger portion of the total allowable catch for commercially desirable species than vessels without an LE permit.
2. The open access (OA) component encompasses commercial fishers who do not hold a federal LE permit. Some states require fishers to carry a state-issued permit for certain OA sectors.
3. The recreational component includes recreational anglers who target or incidentally catch groundfish species. Estimates of P. halibut bycatch in recreational fisheries are compiled by the International Pacific Halibut Commission (IPHC) and are not covered by this report.
4. The tribal component includes native tribal commercial fishers in Washington State who have treaty rights to fish groundfish. Estimates of P. halibut bycatch from tribal fisheries are not included in this report, with the exception of the observed tribal at-sea Pacific hake (a.k.a. Pacific whiting, henceforth referred to as hake) sector, which is included as part of the at-sea hake values in Table 2 and Supplemental Tables 90 and 91.

These four components can be further subdivided into sectors based on gear type, target species, permit, and other regulatory factors, as shown in Supplemental Tables 92–94.

NWFSC Fisheries Observation Science Program

The Fisheries Observation Science (FOS) Program at the Northwest Fisheries Science Center (NWFSC) observes commercial sectors that target or take groundfish as bycatch. FOS has two components: the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP).

WCGOP was established in May 2001 by NOAA Fisheries (a.k.a. National Marine Fisheries Service, NMFS) in accordance with the Pacific Coast Groundfish Fishery Management Plan (USOFR 2001). This regulation requires all vessels that catch groundfish in the U.S. EEZ (from 5.6–370 km offshore) to carry an observer when notified to do so by NMFS or its designated agent. Subsequent state rule-making has extended NMFS's ability to require vessels fishing in the 0–5.6-km state territorial zone to carry observers as well.

A-SHOP moved to NWFSC in 2001. Prior to 2001, observer coverage of the U.S. West Coast at-sea hake fishery was conducted by the North Pacific Groundfish Observer Program, and P. halibut samples from that program are available back to the 1970s but are not included in this report. Current (since 2001) A-SHOP program information and documentation on data collection methods can be found in the A-SHOP observer manual (NWFSC 2020a). The at-sea hake fishery has mandatory observer coverage, with each vessel >38 m carrying two observers. Beginning in 2011, under IFQ/Co-op Program management, all catcher vessels that deliver catch to motherships are required to carry WCGOP observers or use electronic monitoring equipment.

FOS's goal is to improve estimates of total catch and discard by observing groundfish fisheries along the U.S. West Coast. WCGOP and A-SHOP observe distinct sectors of the groundfish fishery. WCGOP observes multiple sectors of the groundfish fishery, including IFQ shoreside delivery of groundfish and Pacific hake, at-sea mothership catcher vessels fishing for Pacific hake, LE and OA fixed gear, and state-permitted nearshore fixed gear sectors. WCGOP also observes several fisheries that incidentally catch groundfish, including the California halibut trawl and pink shrimp trawl fisheries. A-SHOP observes the fishery that catches and delivers Pacific hake at sea, including tribal and nontribal motherships and catcher–processor vessels.

Pacific Halibut Management and Fishery Interactions

IPHC, a body founded through treaty agreement between the United States and Canada, sets the annual P. halibut total constant exploitation yield (TCEY), which is converted to total allowable catch (TAC) for IPHC Area 2A, the collective U.S. waters off the states of Washington, Oregon, and California. The TAC is, in part, based on bycatch mortality, which takes into account potential survival after being discarded. Regulations for IPHC Area 2A are set by NOAA Fisheries West Coast Region. Pacific halibut catch in Area 2A is divided between tribal and nontribal fisheries, between commercial and recreational fisheries, and between recreational fisheries in different states (Washington, Oregon, and California). PFMC describes this P. halibut catch division each year in a catch-sharing plan. Outside the P. halibut directed fishery, P. halibut must be discarded at sea, with two exceptions. In some years, including 2019, the LE fixed gear sablefish endorsed sector is allowed to

retain and land incidentally caught P. halibut north of Point Chehalis, Washington, under IPHC regulations. Similarly, under IPHC regulations, the salmon troll fishery in Area 2A can retain and land incidentally caught P. halibut. In addition, the individual fishing quota (IFQ) midwater Pacific hake fishery is a maximized-retention fishery. Under this fishery, small amounts of incidental P. halibut take are allowed to be landed and subsequently donated to food banks or destroyed. Other than these two exceptions, small amounts of P. halibut are, on rare occasions, mixed with target species and accidentally landed. These individuals are subsequently donated or destroyed as in the IFQ midwater hake fishery.

In 2011, the LE bottom trawl sector of the U.S. West Coast groundfish fishery began fishing under an IFQ management program. An IFQ is defined as a federal permit under a limited access system to harvest a quantity of fish, representing a portion of the TAC of a fishery, that can be received or held for exclusive use by a person (Magnuson–Stevens Act of 1976). The implementation of the IFQ management program in 2011 resulted in changes to P. halibut sampling, including the mandate that vessels must carry NMFS observers on all IFQ fishing trips. A full list of changes to the fishery can be found in Jannot et al. (2012).

Under the IFQ program, P. halibut is managed at the permit level, through individual bycatch quota (IBQ) pounds. An IBQ accounts for bycatch mortality, including any potential survivorship after capture. Currently, this is the only species managed under IBQ for the U.S. West Coast groundfish IFQ fishery. Each federal groundfish permit with a trawl endorsement is allocated IBQ pounds for P. halibut caught north of lat 40°10′N. Pacific halibut caught south of lat 40°10′N are not managed by an IBQ quota, but are reported here under the IFQ fishery.

Data collection and reporting for this fishery are described by gear type in Pacific halibut data collection in the shore-based IFQ fishery. The shore-based IFQ fishery includes all IFQ fishery components with the exception of at-sea motherships and catcher–processors. Motherships and catcher–processors have a bycatch quota for P. halibut, but it is not accounted for at the permit level.

With the exception of the IFQ fishery, P. halibut bycatch mortality is accounted for at the fishery sector level only. P. halibut is regularly caught as bycatch in the LE sablefish endorsed fixed gear, LE sablefish nonendorsed fixed gear, and OA fixed gear sectors.

Results

Spatial Distribution of Observed Bycatch

Figure 2 portrays the observed P. halibut bycatch along the U.S. West Coast for all fishery sectors and gear types. The majority of observed P. halibut bycatch occurred north of lat 40°10′N, with highest concentrations of bycatch north of Pt. Chehalis.

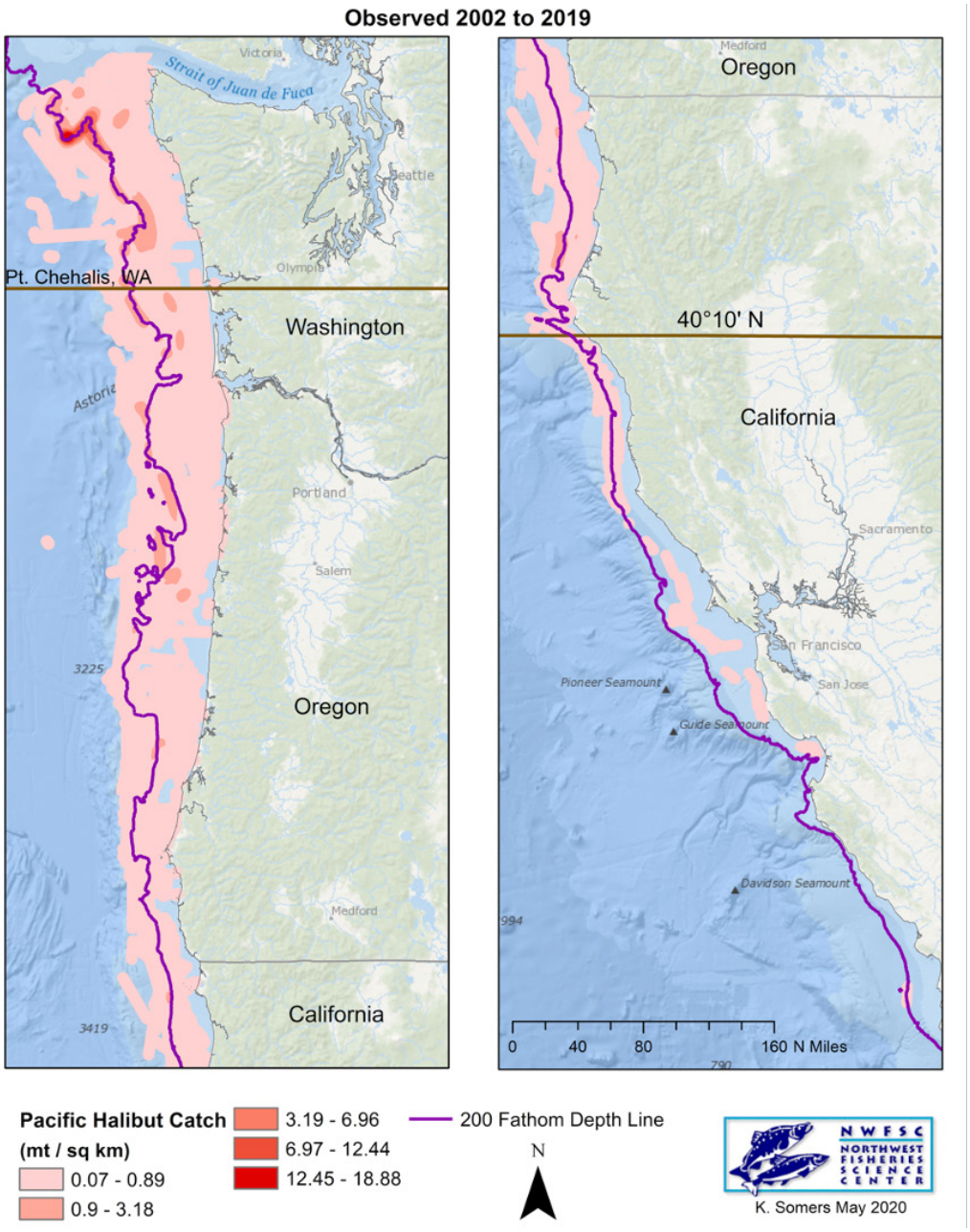

Figure 2. Spatial distribution of Pacific halibut bycatch (mt/km^2) observed by WCGOP (2002–19) off the U.S. West Coast. Gear types observed by WCGOP include bottom trawl, midwater trawl, shrimp trawl, fixed gear hook-and-line, and pot gear. The five catch classifications were defined by excluding any zero values and then applying the Jenks natural breaks classification method. Cells (200 km^2) with fewer than three vessels were omitted to maintain confidentiality.

IFQ Fishery

All participating vessels carry an observer on all fishing trips under IFQ management (100% trips observed), except those participating in the EM EFP (see IFQ Electronic Monitoring EFP). Monthly fishing effort by IFQ bottom trawl vessels is shown in Figures 3–5. For all 2019 strata, 99% or more of the observed IFQ tows or sets were sampled (Supplemental Tables 8–12). IFQ flatfish, IFQ mixed species, and unsorted catch all contributed to unsampled catch (Supplemental Tables 13–16; see NWFSC 2020c for IFQ sampling protocols). The total estimated weight of P. halibut from unsampled tows or sets in 2019 represents a small fraction (0.77 mt, or 1.4%) of the total 2019 IFQ gross discard weight of P. halibut (Supplemental Tables 13–16).

Gross bycatch estimates and total discard mortality estimates were largest for vessels fishing bottom trawl gear between Pt. Chehalis and lat 40°10′N in depths greater than 60 fth (Supplemental Table 21). This gear–area–depth stratum accounts for 55% of the 2019 P. halibut discard mortality in the IFQ fishery. The next-largest fraction (37%) of total IFQ discard mortality was caught north of Pt. Chehalis in the deep stratum (>60 fth). Altogether, bottom trawl gear fishing north of lat 40°10′N accounts for 95% of the 2019 P. halibut discard mortality in the IFQ fishery (Supplemental Table 21).

In terms of viability, the majority of P. halibut on IFQ vessels were classified as either excellent or dead, depending on the stratum (Supplemental Tables 17–20). In 2019, the individuals caught with bottom trawl were evenly split between excellent and dead condition in the area

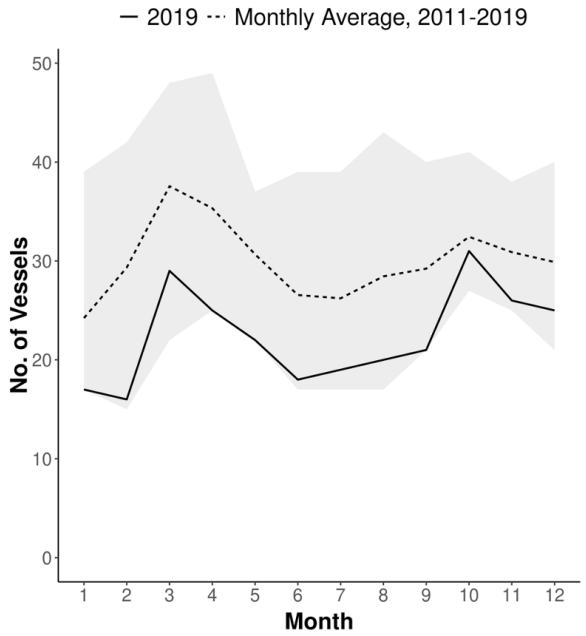

Figure 3. Number of IFQ bottom trawl vessels, by month, in 2019 (solid line) and averaged over 2011–19 (dotted line). Grey ribbon = monthly maximum and minimum across 2011–19. Data from vessels using EM not included.

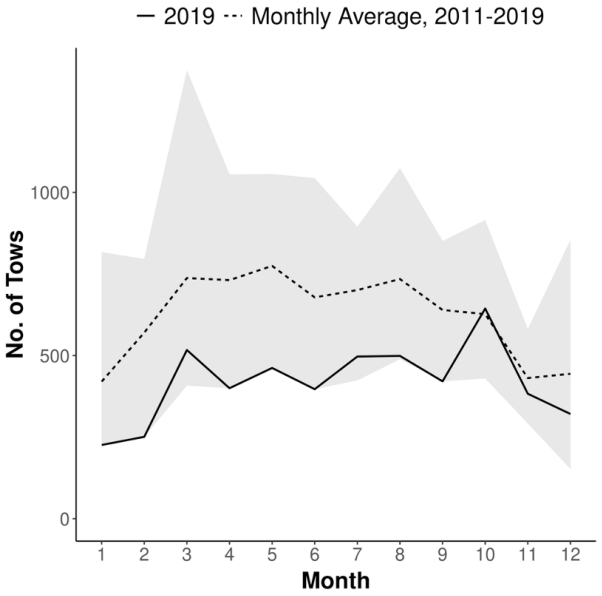

Figure 4. Number of IFQ bottom trawl tows, by month, in 2019 (solid line) and averaged over 2011–19 (dotted line). Grey ribbon = monthly maximum and minimum across 2011–19. Data from vessels using EM not included.

between Pt. Chehalis and lat 40°10′N in >60 fth. Individuals caught with bottom trawl north of Pt. Chehalis in >60 fth were slightly more likely to be excellent than dead (Supplemental Table 17). Gross and discard mortality for bottom trawl vessels, by month, for 2019 are presented in Supplemental Table 29.

Estimated 2019 P. halibut discard mortality from all IFQ sectors and gears is 1.34 mt less than the average for the previous five years (2014–18 mean = 33.87 mt, 2018 = 32.83 mt, including IFQ EM EFP). Gross and discard mortality for each of the gear types are presented in Supplemental Tables 21–24. Legal-sized (>82 cm) mortality by gear type is presented in Supplemental Tables 25–28. Length frequencies, weighted length frequencies, and percent weighted length frequency information are presented in Supplemental Tables 30–38. Length frequencies of dead individuals are displayed in Supplemental Tables 39–41.

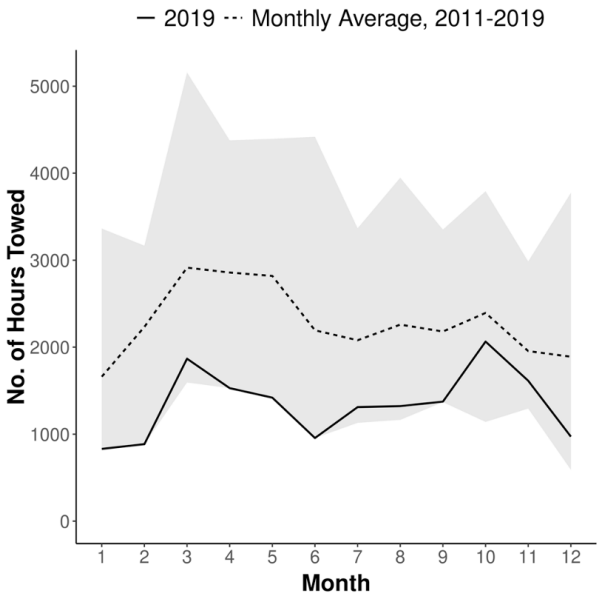

Figure 5. IFQ bottom trawl tow hours, by month, in 2019 (solid line) and averaged over 2011–19 (dotted line). Grey ribbon = monthly maximum and minimum across 2011–19 . Data from vessels using EM not included.

At-Sea Hake Fishery

Estimated bycatch weight of P. halibut from the at-sea hake component of the 2019 IFQ fishery decreased very slightly from 2018 (2019 = 0.54 mt, 2018 = 0.66 mt; Supplemental Tables 42, 43, and 91). There has been no fishing in the tribal sector since 2012 (Supplemental Table 44). At-sea hake P. halibut length frequencies are given in Supplemental Table 45.

IFQ Electronic Monitoring EFP

Estimated P. halibut discard mortality from the 2019 IFQ electronic monitoring (EM) exempted fishing permit (EFP), including fish discarded at the dock, was 3.72 mt from bottom trawl vessels (Supplemental Table 46), 0.19 mt from pot vessels (Supplemental Table 49), and 1.07 mt from midwater trawl vessels (Supplemental Table 52).

Both IFQ EM bottom trawl and IFQ EM pot vessels had higher discard mortality rates than non-EM IFQ vessels when using the observer viability method (Supplemental Tables 48 and 51). However, the observer viability method on IFQ EM bottom trawl vessels appears to give a lower discard mortality rate (DMR) than the time-on-deck model (Supplemental Table 48). Caution must be used in interpreting these DMRs, because sample sizes were very small. The number of EM vessels catching P. halibut was a small subset of the overall EM fleet, and those vessels that did catch P. halibut typically caught very few P. halibut during observer sampling (Supplemental Tables 47 and 50).

Non-Nearshore Fixed Gear Fishery

The 2019 estimated discard mortality of P. halibut in the longline portion of the LE sablefish endorsed sector decreased by 11% from 2018 (2018 = 25.14 mt, 2019 = 22.49 mt; Supplemental Table 66) but is still well within the historical range for this fishery (2.94–104.45 mt; see Figure 6 and Supplemental Table 66). Compared to 2018, the 2019 observed discard ratio increased north of, and decreased south of, Pt. Chehalis (Supplemental Table 58). Estimated discard of P. halibut from the pot portion of the LE sablefish endorsed sector increased compared to 2018 (2018 = 0.37 mt, 2019 = 0.45 mt; Supplemental Table 66).

Discard of P. halibut among the LE sablefish nonendorsed longline vessels increased in 2019 relative to 2018 (2018 = 0.61 mt, 2019 = 2.81 mt; Supplemental Table 66). Pot vessels in this sector had an increase in P. halibut bycatch (2018 < 0.01 mt, 2019 ~ 0.01 mt) but remain a tiny fraction of total P. halibut discard (Supplemental Table 66). P. halibut bycatch in OA hook-and-line decreased during 2019 (2018 = 4.41 mt, 2019 = 2.88 mt; Supplemental Table 66), but pot vessel catch increased (2018 = 0.02 mt, 2019 = 0.04 mt). Both OA fixed gear sectors still account for only a small portion of total fixed gear bycatch.

Landings of target species decreased for both LE longline and OA hook-and-line vessels in all non-nearshore sectors by about 100 mt in 2019 (Supplemental Table 57). Observer coverage was lower than 2018 levels for these vessels (Supplemental Tables 53–55), but observed P. halibut encounters were about the same (Supplemental Table 61).

Injury assessments on longline or hook-and-line vessels by year and sector are presented in Supplemental Tables 62–64. Gross discards and discard mortality are presented in Supplemental Tables 65, 66, 90, and 91. Physical measurements of P. halibut length frequency from the non-nearshore fixed gear sectors can be found in Supplemental Tables 68–71. Visual estimates of length frequencies in the non-nearshore fixed gear sectors can be found in Supplemental Table 72. A comparison of the distribution of physical and visual estimates of length frequency is presented in Figure 7.

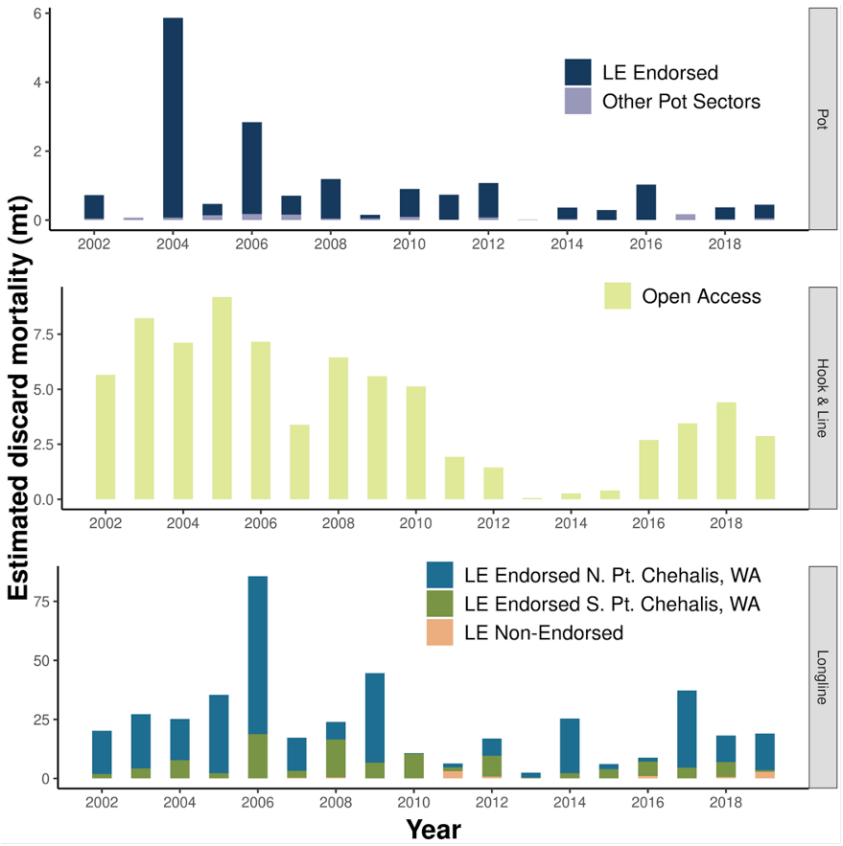

Figure 6. Estimated discard mortality of P. halibut in the non-nearshore fixed gear fishery, by sector and gear, for each year. We apply a fixed average discard rate from 2007–08 data to generate 2002–06 discard estimates for the OA sector, because only the California portion of the OA fishery was observed in 2002–06. *Other Pot Sectors* includes LE sablefish nonendorsed and OA fixed gear vessels fishing with pot gear.

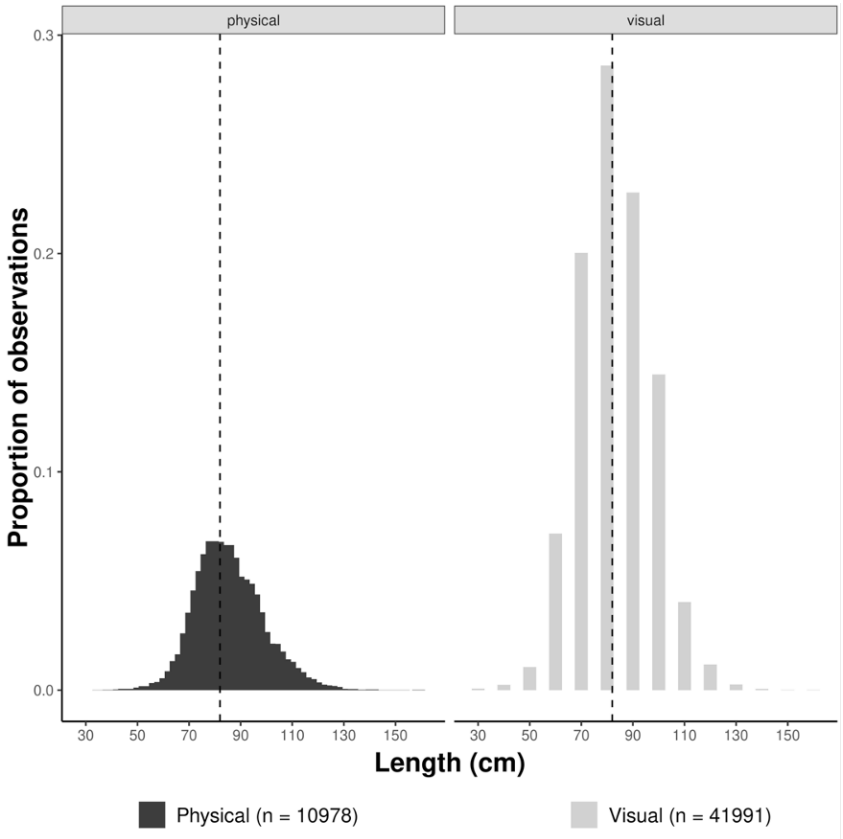

Figure 7. Length-frequency distribution of discarded P. halibut on WCGOP-observed non-nearshore fixed gear LE and OA groundfish vessels from Sep 2003 through Dec 2019. Visual estimates (gray bars) of P. halibut lengths are only estimated in 10-cm increments. The sublegal/legal size cutoff (82 cm) is indicated by a vertical dashed line.

Legal/Sublegal Length Frequencies

The number and percent of observed P. halibut that were of legal (>82 cm) or sublegal size by fishery (catch share, non-nearshore fixed gear, at-sea hake) are presented in Supplemental Table 73.

IPHC Pacific Halibut Fishery

FOS attained a 13% coverage rate (Supplemental Table 74) in the third year of covering the IPHC P. halibut directed fishery. Observer coverage was highest during the first opener, compared to the other two openings of the fishery in 2019 (Figure 8; exact dates of each opener by year are presented in Supplemental Table 75). Observer coverage in this fleet is determined by a number of factors including space on vessels, observer availability, and needed coverage in other higher-priority fisheries.

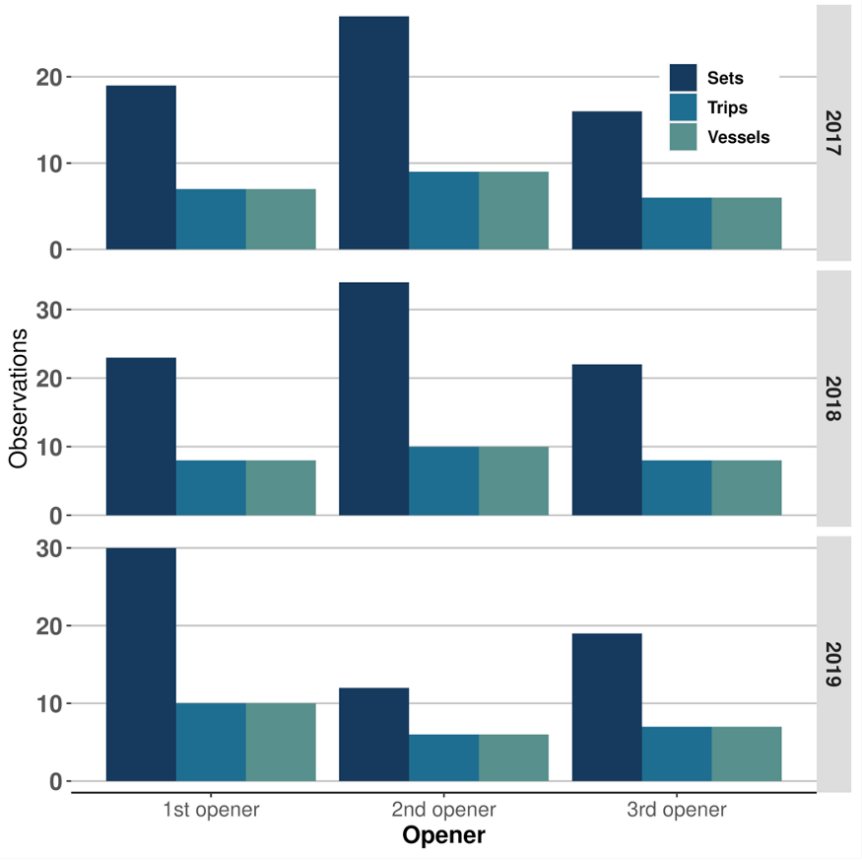

Figure 8. Number of sets, trips, and vessels, by opening day, for the P. halibut directed fishery.

The 2019 P. halibut discard to targeted landings ratio in this fishery was 0.19, leading to a gross discard weight estimate of 29.2 mt (Supplemental Table 76). The majority of discarded fish had only minor or moderate injuries (Supplemental Table 77). Thus, despite the high discard ratio, the estimated total discard mortality after accounting for viability was 3.5 mt. The majority of observed P. halibut discards were less than legal-size (82 cm), although a few were above that size (Supplemental Tables 79 and 80).

Observed State Fisheries, EFPs, and Nongroundfish Fisheries

Very small amounts of P. halibut bycatch were recorded in state-managed observed fisheries. Even assuming 100% mortality, bycatch estimates for the nearshore groundfish fixed gear sector, pink shrimp trawl fishery, and the OA sector of the California halibut trawl fishery made up a minor portion of the 2019 total mortality estimate for P. halibut (Supplemental Tables 81–85). Zero (0) catch of P. halibut was observed in the California ridgeback prawn fishery (Supplemental Table 86). Data from the 2019 California sea cucumber fishery are confidential (Supplemental Table 87), but in 2017 (the only nonconfidential observed year), the fishery recorded zero P. halibut bycatch.

Pacific halibut bycatch from non-EM EFP vessels, by year, has been zero since 2004 (Supplemental Table 88). Pacific halibut landings from nongroundfish fisheries not observed by FOS were 26.14 mt in 2019 (Supplemental Table 89).

Conclusions

IFQ Fishery

- Estimated P. halibut discard mortality in 2019 from IFQ non-EM vessels was 27.21 mt, and from IFQ EM vessels was 4.99 mt, both of which are similar to previous years.
- EM vessels had very slightly higher discard mortality rates than non-EM IFQ vessels. DMR on EM bottom trawl vessels was lower when using observer viabilities compared to the time-on-deck model. However, sample sizes are still very small, complicating interpretation.
- P. halibut discard from the at-sea Pacific hake fishery in 2019 (0.54 mt) showed a slight decrease relative to 2018 (0.66 mt) and remains below the historical average (2002–18 = 1.11 mt).

Non-IFQ Fisheries

- The 2019 estimates of P. halibut discard morality in the LE sablefish endorsed sector (22.86 mt) decreased relative to 2018 (25.76 mt), possibly due to lower effort, but it is not completely clear from available data. The 2019 P. halibut mortality estimates on LE sablefish nonendorsed vessels increased on both longline (2019 = 2.81 mt) and pot vessels (2019 ~ 0.01 mt) relative to 2018. P. halibut mortality decreased relative to 2018 on OA fixed gear hook-and-line (2.77 mt), but increased on OA pot vessels (0.04 mt).
- In the IPHC P. halibut directed fishery, observer coverage was 13%. The total P. halibut discard mortality after accounting for viability was 3.5 mt.
- Zero (0) P. halibut catch was observed in the California ridgeback prawn fishery.
- Estimated P. halibut mortality in all other non-IFQ observed fisheries remained low relative to the IFQ and non-nearshore sectors, and was within the range observed in previous years.

Methods

Data Sources

Data sources for this analysis include on-board observer data (from WCGOP and A-SHOP), landing receipt data (referred to as fish tickets, obtained from PacFIN), and data generated from vessels carrying EM equipment. Currently, only vessels in the IFQ sector fishing on an exempted fishing permit (EFP) carry EM equipment. EM data are obtained from the Pacific States Marine Fisheries Commission (PSMFC). To date, observer data are the sole source for discard estimation in the IFQ sectors, except for vessels using EM under an EFP, as stated above. All other sectors use a combination of observer and PacFIN data to estimate discard mortality. A list of fisheries, coverage priorities, and data collection methods employed by WCGOP in each observed fishery can be found in the WCGOP manual (NWFSC 2020c). A-SHOP program information, documentation, and data collection methods can be found in the A-SHOP observer manual (NWFSC 2020a).

The sampling protocol employed by WCGOP primarily focuses on the discarded portion of catch. To ensure that the recorded weights for the retained portion of the observed catch are accurate, haul-level retained catch weights recorded by observers are adjusted based on trip-level fish ticket records. This process is described in further detail on the WCGOP Data Processing webpage (NWFSC 2020b) and was conducted prior to the analyses presented in this report. All weights of P. halibut presented in this report are round weights, that is, whole fish. IPHC converts these weights to dressed weight (i.e., head and organs removed).

For data processing purposes, species and species groups were defined based on management (see Table A-1 in Somers et al. 2020). A complete listing of groundfish species is defined in the Pacific Coast Groundfish Fishery Management Plan (PFMC 2019).

Fish ticket landing receipts are completed by fish buyers in each port for each delivery of fish by a vessel. Fish tickets are trip-aggregate sales receipts for market categories that may represent single or multiple species. Fish tickets are issued to fish buyers by a state agency, and must be returned to the agency for processing. Fish ticket and species-composition data are submitted by state agencies to the PacFIN regional database. Annual fish ticket landings data were retrieved from the PacFIN database (May 2020) and subsequently divided into various sectors of the groundfish fishery (Somers et al. 2020).

Shore-Based IFQ Fishery

The methods used to report in-season IBQ estimates via the Vessel Account System (VAS) are separate from those methods used to estimate final fleetwide P. halibut mortality. Methods for in-season IBQ estimation are discussed in Jannot et al. 2020b. Results obtained by methods described here resulted in fleetwide estimates of P. halibut mortality that are very close to those reported by the VAS.

Pacific halibut data collection in the shore-based IFQ fishery

The WCGOP discard sampling methodologies ensure that P. halibut mortality can be estimated regardless of the limitations imposed by the vessel, catch composition, or catch quantity. Three pieces of information are necessary to estimate P. halibut mortality (also see Table 4):

1. A count of individual P. halibut in the haul or sample.
2. Actual or visual length measurements (in cm).
3. A viability obtained by physical assessment of individual P. halibut using IPHC-designed dichotomous keys that relate the physical condition of the fish to a viability code (NWFSC 2020c). A unique key is used for each gear type (trawl, longline, pot).

Observers could sample all or a subset of P. halibut caught in a haul/set. The proportion of P. halibut sampled is based on the number of P. halibut caught in the haul/set, the level of assistance provided by the crew, as well as other variables (e.g., physical space, weather). Sampling and assessment of P. halibut depends on crew assistance and cooperation. Regulations prohibit vessel crew from discarding any P. halibut without first notifying the observer. The vessel crew must comply with requests by the observer to ensure proper P. halibut sampling, including but not limited to: modifying P. halibut sorting procedure, assisting the observer by delivering the P. halibut to the observer, and modifying operations to ensure P. halibut sampling is completed. Table 4 describes the P. halibut data obtained on IFQ-permitted vessels fishing different gear types.

On vessels fishing fixed gear (pot or hook-and-line), observers must sample at least 50% of the gear per set. Actual length measurements are obtained on bottom trawl, midwater trawl, and pot vessels, but only visual length estimates are made on vessels fishing hook-and-line gear in the IFQ fishery. Visual estimations use 10-cm increments (55–64 cm, 65–74 cm, etc.).

The crew's cooperation is vital to the observer's sampling success during hook-and-line fishing. When an observer samples for P. halibut, the crew are not permitted to shake loose or discard any P. halibut before the observer can estimate the fish length, nor can they restrict the observer's view of the line as it comes out of the water. If requested by the observer, the crew is required to physically hand individual fish to the observer, or slow the gear retrieval.

Table 4. Data collected from P. halibut caught on IFQ vessels using different types of gear.

Gear	Years	Count	Length measurement (cm)	Viability collected?
BT	2011–present	all in the haul	actual, all or subset	Y
MW	2011–present	all in the sample	actual, all or subset	Y
Pot	2011–present	all in the sample	actual, all or subset	Y
H&L	2011–16	all in the sample	visual, all or subset	N
H&L	2016–present	all in the sample	actual, all or subset	Y

Viability is assessed at the point of fish release when returned to sea. On vessels using "resuscitation boxes" or other techniques to increase the likelihood of survival, condition sampling is performed prior to the fish being returned to sea. Observations of several condition characteristics are used to assign each fish to one of three viability categories for trawl and pot gear: Excellent, Poor, or Dead (Williams and Chen 2004, NWFSC 2020c). Observer field estimates of viability for P. halibut discarded in the IFQ fishery by vessels fishing bottom trawl or pot gear are used to compute the total estimated mortality of discarded P. halibut. IBQ weight (or simply IBQ) refers to the estimated mortality of discarded P. halibut, with the appropriate mortality rate applied based on viability.

Viability categories are used to assign mortality rates to P. halibut. Mortality rates for vessels fishing bottom trawl gear are based on mortality data collected by Hoag (1975), who found some survivorship among fish in the Dead condition category. Mortality rates for vessels fishing pot gear are based on conservative assumptions of likely survival from pot-induced injuries (Williams and Wilderbuer 1995). Because of the difficulties of collecting P. halibut viability on hook-and-line vessels, we used a DMR of 0.16, which represents an average of DMRs over all years for the Bering Sea/Aleutian region longline fishery (Williams 2008). Discard mortality was assumed to be 100% for all midwater trawl bycatch estimates.

Table 5. Mortality rates used for each viability category for IFQ BT vessels (Clark et al. 1992).

Sector	Gear	Viability	Mortality rate
Catch share	BT	Excellent	0.20
Catch share	BT	Poor	0.55
Catch share	BT	Dead	0.90

Table 6. Mortality rates used for each viability category for IFQ pot gear vessels (Williams and Chen 2004).

Sector	Gear	Viability	Mortality rate
Catch share	Pot	Excellent	0.00
Catch share	Pot	Poor	1.00
Catch share	Pot	Dead	1.00

Shore-based IFQ fishery bycatch estimation

We stratified IFQ P. halibut bycatch data based on sector (shoreside nonhake groundfish, shoreside Pacific hake, at-sea Pacific hake, and LE California halibut) and gear (bottom trawl, midwater trawl, pot, hook-and-line). LE California halibut tows were separated from IFQ bottom trawl tows in 2011–12, but have been combined with IFQ bottom trawl since 2013 because of minimal fishing and to maintain confidentiality. Within the shoreside nonhake groundfish sector, we further stratified using area and depth within each gear type. When confidentiality criteria were met (>2 vessels per stratum), we maintained area and depth strata that were applied to bottom trawl, hook and line, and pot gear in previous reports (Heery et al. 2010, Jannot et al. 2011, 2012, 2013) because prior work demonstrated that these variables were correlated with P. halibut bycatch (Heery et al. 2010). Observations from IFQ vessels fishing midwater trawl gear targeting Pacific hake or other midwater target species were not post-stratified. In addition to the strata described above, we also provide bycatch estimates north and south of the groundfish management line (lat 40°10′N) for each sector and gear type.

Despite the 100% observer coverage mandate since 2011, there were some rare occasions (e.g., observer illness, trawl net ripped) when tows or sets were only partially or not sampled, or sampled data failed quality control. Data that failed quality control are treated as completely unsampled hauls. In all these cases, we used ratio estimators to apportion unsampled weight to P. halibut within each stratum. To obtain the estimated weight of P. halibut ($\hat{W}$) when the entire haul or set was unsampled (or data failed), the unsampled discard weight, summed across unsampled hauls within the stratum, was multiplied by the ratio of the weight of P. halibut discard (summed across fully sampled hauls within a stratum) divided by the total discard weight of all species in all fully sampled hauls within a stratum:

$$\widehat{W}_{u,s} = \sum_{u} x_{u,s} \times \frac{\sum w_{f,s}}{\sum x_{f,s}}$$

where, for each stratum:

s = stratum, which includes sector and year and could include area, depth, and/or gear,
u = unsampled haul,
f = fully sampled haul,
x = weight of discarded catch,
$\hat{W}$ = estimated weight of unsampled P. halibut in the stratum, and
w = sampled weight of P. halibut.

The unsampled weight of partially sampled hauls or sets was categorized into weight of non-IFQ species (NIFQ) or IFQ species. Unsampled IFQ species weight was further categorized into IFQ flatfish (IFQFF), IFQ rockfish (IFQRF), IFQ roundfish (IFQRD), and IFQ mixed species (IFQM). Unsampled P. halibut would only occur in NIFQ (south of lat 40°10′N only), IFQM, or IFQFF unsampled categories. Thus, those are the only categories for which P. halibut is estimated. IFQM included all 2019 IFQ managed species (see USOFR 2011 for a listing of IFQ species). NIFQ included all species encountered that were not designated as an IFQ-managed species. IFQFF included all IFQ flatfish species managed as a complex under the groundfish FMP. North of the lat 40°10′N groundfish management line, P. halibut would be included in unsampled IFQFF or IFQM categories. South of the groundfish management line, P. halibut would only be included in the unsampled NIFQ category.

To obtain the estimated weight of P. halibut ($\hat{W}$) in partially sampled hauls or sets, the unsampled discard weight, summed across partially sampled hauls within the stratum, was multiplied by the ratio of the weight of P. halibut (summed across fully sampled hauls within a stratum) divided by the total discard weight of all species occurring within a category (NIFQ, IFQFF, IFQM) in all fully sampled hauls within a stratum. Estimated P. halibut weight was summed across unsampled categories.

$$\widehat{W}_{p,s} = \sum_{y} \left(\sum_{p} x_{p,y,s} \times \frac{\sum w_{f,s}}{\sum x_{f,y,s}} \right)$$

where, for each stratum:

s = stratum, which includes year and sector, and could include, area, depth, and/or gear,
y = unsampled category (either NIFQ, IFQFF, or IFQM),
p = partially sampled haul,
f = fully sampled haul,
x = weight of discarded catch,
$\hat{W}$ = estimated weight of unsampled P. halibut in the stratum, and
w = sampled weight of P. halibut.

Expanded weights of P. halibut obtained using the equations above for unsampled or partially sampled hauls were then added to the sampled weight of P. halibut within each stratum to obtain the total P. halibut weight per stratum.

Viability analysis

We used observer field estimates of viability for P. halibut discarded in the IFQ fishery by vessels fishing bottom or pot gear to compute the total estimated mortality of discarded P. halibut by IFQ gear, sector, and stratum.

To account for the impact of fish size on survivorship, we computed a weighted mortality rate for each condition category. Length measurements associated with each viability record were converted to weight based on the IPHC length–weight table provided in Supplemental Table 95.

A discard mortality rate for each condition category was then computed as the proportion of P. halibut sampled weight in a viability category multiplied by the viability category-specific mortality rate (see Tables 5 and 6):

$$DMR_{csj} = m_c \times P_{csj}$$

where:

c = viability condition (Excellent, Poor, Dead),
s = stratum, which could include area, depth, gear, and sector,
j = year,
m = mortality rate,
P = proportion of sampled P. halibut weight (w), and
DMR = discard mortality rate.

DMRs for each condition category *c* and stratum *s* were then multiplied by gross discard estimates to compute total estimated discard mortality for each gear type separately:

$$\hat{F}_{sj} = \sum_{c} \left(B_{sj} \times DMR_{sj} \right)$$

where:

s = stratum, which could include area, depth, gear, and sector,
j = year,
c = viability condition (Excellent, Poor, Dead),
$\hat{F}$ = total estimated discard mortality,
B = gross estimated discard weight, and
DMR = discard mortality rate.

Viability data are collected from only a subsample of the P. halibut that observers encounter. Based on previous evaluations by Wallace and Hastie (2009), we expect that survivorship of P. halibut in bottom trawl tows is most directly affected by the length of the tow and the amount of catch that fills the net. These variables are not part of the bycatch ratio stratification process (above), and their use in stratifying viability data would make it difficult to then apply discard mortality rates to initial gross estimates of bycatch. We found that tow duration was directly related to depth, one of the variables used to stratify discard ratios and initial gross discard estimates for bottom trawl gear. Because depth and tow duration appeared to co-vary, we used depth and area to stratify IFQ viability data collected from bottom trawl gear. For IFQ viability data collected from pot gear, only area is used to stratify the data. For longline gear, we used a discard morality rate of 16%, which represents an average of DMRs over all years for the Bering Sea/Aleutian region longline fishery (Williams 2008).

Final estimates of P. halibut bycatch and discard mortality are also presented in the context of the estimated mortality of legal-sized halibut. This was computed by applying the proportion of sampled P. halibut weighed in each depth stratum that was from legal-sized fish (82 cm or larger) to initial estimates. Viabilities were then applied to gross legal-sized discard estimates in the same manner as described above.

IFQ Electronic Monitoring DMR comparison

PFMC staff, the NMFS West Coast Region, and IPHC have requested a comparison of discard mortality rates (DMR) for bottom trawl and pot vessels in the IFQ program that carry electronic monitoring (EM) equipment versus those that carry observers on 100% of the fishing trips. When notified, EM vessels are required to carry observers for scientific observation, including the collection of P. halibut viabilities. WCGOP aims to observe approximately 30% of EM fishing trips. DMRs for EM vessels were calculated and compared using two methods:

1. The observer viability method.
2. The time-on-deck model.

The observer viability method used human observer data collected on EM vessels. These data were stratified to match, as closely as possible, the current stratification used in the IFQ fishery while meeting confidentiality requirements. Confidentiality of EM data required combining strata across years, depths, and areas. Mortality data from non-EM IFQ vessels are also shown for comparison purposes. Other than slight modification of stratification to maintain confidentiality, the observer viability method is identical to the method described in Pacific halibut data collection in the shore-based IFQ fishery.

The time-on-deck model was developed in a collaborative process between PSMFC and the PFMC's Groundfish Management Team (GMT). The model measures the time each fish spends out of the water, which correlates with P. halibut viability: the less time a fish spends out of the water, the higher the probability of the fish being in the Excellent condition category and therefore having a lower estimated mortality rate. The time-on-deck model substitutes for a viability assessment on EM vessels when fisheries observers are not present on the vessel to assess viabilities. The model and discussion are detailed in a PSMFC report to the PFMC (Smith 2017) and a GMT report (PFMC 2017).

The comparison is provided for informational purposes only. Due to low sample sizes, FOS cautions against using these estimates for management purposes. Data from 2015–19 were obtained on pot vessels using EM, and from 2016–19 on bottom trawl vessels using EM. The corresponding non-EM data (i.e., 2015–19 pot and 2016–19 bottom trawl) were used to allow direct comparison between vessels with and without EM. Confidentiality in the EM fleet precluded the use of the full stratification currently used in the catch share fishery.

Length frequencies

The length-frequency distribution for P. halibut in the 2011–19 IFQ fishery is provided in Supplemental Tables 30–32. Pacific halibut pose unique challenges for observer sampling. Observers typically measure the length of P. halibut and then convert the measurement to weight using the IPHC length–weight conversion table (Supplemental Table 95). Occasionally, observers weigh individual fish. Sometimes crew members presort the catch by removing P. halibut and immediately return them to sea. Vessel crews presort P. halibut to increase the likelihood of survival of the discarded fish. Presorting is prevalent on vessels fishing with hook-and-line gear. Fishers have raised concerns regarding crew safety when landing large P. halibut. In addition, hook-and-line fishers are concerned that P. halibut individuals would be injured during landing because of their interaction with the vessel "crucifier" (gear used to strip the bait and any catch off of the hook-and-gangion line). Therefore, shake-offs prior to the crucifier (a form of presorting) are almost universal on IFQ hook-and-line vessels. Another case of presorting can occur when P. halibut are too heavy and/or awkward to weigh in observer baskets. In all cases of presorting, random samples are not available. Therefore, observers visually estimate the length of the halibut in 10-cm units (40 cm, 50 cm, 60 cm, etc.), which are later converted to weight using the IPHC length–weight conversion table (Supplemental Table 95).

The weighted length-frequency distributions of discarded P. halibut for vessels fishing IFQ using bottom trawl or pot gear are provided in Supplemental Tables 34 and 37 and Jannot et al. (2019). Length frequencies have been weighted based on the ratio of total estimated P. halibut discard weight to the weight of P. halibut that was measured in each stratum (see Jannot et al. 2019 for further details). We have summarized the proportion of length measurements in each condition category (Excellent, Poor, and Dead) in Jannot et al. (2019) to inform size-specific modeling of mortality. Within each of these three condition categories, the frequency of sampled fish was weighed in the same manner as length-frequency distributions and then summarized for each 2-cm length bin. In addition, we also provide an estimated count of the number of dead individuals in each 2-cm length bin (Jannot et al. 2019). These values were obtained by multiplying the number of individuals in a length bin within a viability category by the condition-specific mortality rate (Tables 5 and 6), or by 1.0 in the case of midwater trawl. We then summed these values across viabilities and rounded to an integer to obtain the number of dead per length bin. This method assumes there is no size-specific mortality.

Non-Nearshore Fixed Gear Fishery

WCGOP samples each non-nearshore fixed gear sector through separate random selection processes, with the limited entry (LE) sablefish endorsed season permits receiving the highest level of coverage, then LE sablefish nonendorsed permits, and open access (OA) fixed gear the lowest. LE sablefish endorsed vessels that fish outside of the primary season or that have reached their tier quota in the primary season are not randomly chosen for observation. Given this sampling structure and anticipated differences in variance from one sector to the next, we chose to maintain sector as a stratification variable in our analysis. Testing of alternative stratification schemes (Heery et al. 2010) indicated that latitude and gear type were the most important variables with respect to P. halibut bycatch in the non-nearshore fixed gear groundfish fishery. Bycatch estimates were produced separately for each sector and gear combination. Two latitudinal strata were applied to the LE sablefish endorsed longline sector (north and south of Pt. Chehalis, Washington = lat 46°53′30″N) because previous modeling demonstrated that these strata significantly improved the fit of predicted bycatch amounts to the amounts observed (Heery et al. 2010). Pt. Chehalis was used in previous estimates of P. halibut bycatch in the LE sablefish endorsed season longline sector because of its relevance to groundfish management and its apparent ability to split out higher bycatch rates off the northern coast of Washington (Heery and Bellman 2009). Evaluations of latitudinal strata for the other fixed gear sectors did not improve the fit of models to an extent that justified their use. Thus, we maintained previous stratifications for the other groundfish fixed gear sectors (Heery and Bellman 2009, Heery et al. 2010, Jannot et al. 2011, 2012, 2013).

Discard estimation

A deterministic approach was used to estimate P. halibut discard for all sectors of the non-nearshore groundfish fixed gear fishery. Discard ratios were computed from observer data as the discarded weight of P. halibut divided by the retained weight (Supplemental Table 57). Retained weight varies by sector in this fishery and can be either sablefish or all FMP groundfish except Pacific hake (see Supplemental Table 56 for type of retained used;

for list of FMP groundfish species, see PFMC 2019). Ratio denominators were identified for each sector of the non-nearshore fixed gear fishery based on the targeting behavior of that sector. Discard ratios were then multiplied by the total sector landed weight of either sablefish or FMP groundfish (except Pacific hake), corresponding to the denominator used to compute the observed discard ratio for each sector. This provided an expanded gross estimate of P. halibut discard for each sector. A discard mortality rate (discussed below) was then applied to compute estimated discard mortality.

Total landed weights for each sector are obtained from fish ticket landing receipts. Fish tickets for fixed gear that included recorded weights for sablefish were included in the non-nearshore fixed gear sector. In addition, fixed gear fish tickets without recorded sablefish were included in the non-nearshore fixed gear sectors only if groundfish landings were greater than nongroundfish landings on a unique vessel and landing date. Any P. halibut caught on fixed gear fish tickets with a majority of nongroundfish landings are either captured in the estimates from the P. halibut directed fishery (Supplemental Table 78) or nongroundfish fisheries (Supplemental Table 89).

Fish tickets from the non-nearshore fixed gear sector were partitioned into the three commercial fixed gear sectors (LE sablefish endorsed season, LE sablefish nonendorsed, and OA fixed gear) through the following process. Commercial fixed gear fish tickets were first divided out by whether the vessel had a federal groundfish permit (limited entry) or no federal groundfish permit (open access). OA fish tickets were placed in the OA fixed gear groundfish sector. Next, LE fish tickets were separated based on whether the vessel's federal groundfish permit(s) had a sablefish endorsement with tier quota for the primary season or were not endorsed (also referred to as zero-tier). Fish tickets for all LE sablefish vessels with tier endorsements that were operating within this period and within their allotted tier quota were placed in the LE sablefish endorsed sector. If LE sablefish endorsed vessels fished outside of the primary season (season = April to September) or made trips within the season after they had reached their tier quota, the fish tickets were placed in the LE sablefish nonendorsed sector. In addition, fish tickets from nonendorsed LE vessels were also placed in the LE sablefish nonendorsed sector.

Further processing of fish tickets identified and removed the directed commercial P. halibut fishery landings from the non-nearshore fixed gear analysis. The directed P. halibut fishery occurs for only a few days each year, during ten-hour openings that are designated by IPHC. LE and OA fixed gear vessels that typically target groundfish can participate in the directed fishery. For most fixed gear vessels (other than LE sablefish endorsed vessels north of Pt. Chehalis), this is the only time during which they are allowed to land P. halibut. For prior years (2002–18), we identify P. halibut directed fishery fish tickets using defintions supplied by IPHC. For the current year (2019), fish tickets that included P. halibut landings on or within the two days after a directed fishery opening were considered to be part of the directed fishery and not part of the non-nearshore fixed gear fishery targeting federal FMP groundfish. These fish tickets are excluded from the non-nearshore fixed gear analyses. This approach may have resulted in the removal of some non-directed fishery landings north of Pt. Chehalis, but any bias introduced by this step is considered to be extremely small given the short time period across which fish tickets were removed.

WCGOP observer data were stratified according to sector and gear type (longline and pot/trap). As previously described, one additional latitudinal stratum at Pt. Chehalis (lat 46°53′30″N) was used for the LE sablefish endorsed longline sector. Some retention of P. halibut was allowed in the LE sablefish endorsed season in the area north of Pt. Chehalis. The Pt. Chehalis line was the only latitudinal stratification incorporated into this portion of the analysis and was only applied to the LE sablefish endorsed sector. Discard amounts provided for the other two gear sectors represent coastwide estimates.

The numbers of observed trips, sets, and vessels are summarized for each sector, gear type, and area, where applicable (Supplemental Tables 53–55). The landed weight of sablefish and FMP groundfish (excluding Pacific hake) is used as a measure for expanding discard from observed trips to the entire fleet (Supplemental Tables 56 and 57). Observed discard ratios were calculated by sector, gear type, and area, based on the following equation:

$$\widehat{D}_s = \frac{\sum_t d_s}{\sum_t r_s} \times F_s$$

where:

s = stratum, including gear, sector, gear type, and area,
t = observed sets,
d = observed discard (in mt) of P. halibut,
r = observed retained weight (mt) of sablefish or all FMP groundfish except Pacific hake,
F = weight (mt) of retained sablefish or all FMP groundfish excluding Pacific hake recorded on fish tickets in stratum s, and
$\hat{D}$ = discard estimate for stratum s.

For all strata except the LE sablefish nonendorsed longline and the OA sectors, discard ratios were calculated by dividing the stratum discard weight of P. halibut by the retained catch weight of sablefish. Retained groundfish was used as the ratio denominator for these sectors because they target a wider range of groundfish species. A broader denominator was therefore necessary to effectively capture the level of fishing effort in these sectors.

Where FMP groundfish (excluding Pacific hake) was used to compute discard ratios, retained weights recorded by the observer not appearing on fish tickets were excluded from the denominator. This prevents double-counting associated with differences in the species codes used by observers and processors. For instance, while observers may record rockfish catch at the species level, various species of rockfish are often grouped, weighed, and recorded together on the fish ticket by the processor under a grouped market category (e.g., “northern unspecified scope rockfish”). In some cases, this difference in species coding prevents observer and fish ticket weights from being matched and adjusted properly. Species coding on fish tickets varies considerably between processors and over time, and it is not possible to make assumptions regarding which individual observer-recorded species likely coincide with species grouping codes on fish tickets. By using only the retained groundfish weight from fish tickets in discard ratio denominators, we prevent double-counting of retained weights. This is not a factor when using a single species, such as sablefish, in the denominator, as any retained weights in observer and fish ticket data that share the same species code will match and adjust properly.

The expansion factors for each fishery sector and gear type can be found in Supplemental Table 57. The discard rate multiplied by the expansion factor yielded an expanded gross P. halibut discard estimate for each stratum (Supplemental Table 65). If landings were made by a fixed gear sector for which there were zero or very few WCGOP observations, the most appropriate observed discard ratio was selected and applied to those landings based on similarities in the fishery management structure, fishing and discard behavior, and the gear fished. The LE sablefish endorsed vessels fishing outside of the primary season with pot gear often land a small amount of groundfish; however, this portion of the fleet is not observed by WCGOP. Given similarities in gear type and catch composition, OA fixed gear pot observations were selected as the most appropriate source of information for an observed discard rate (Supplemental Table 56).

Discard mortality rates

Once an initial gross P. halibut discard weight was estimated, this value was multiplied by a discard mortality rate (Table 7) to generate final discard mortality estimates (Supplemental Tables 66 and 67, Figure 6). Discard mortality is approximated based on viabilities in a manner similar to the approach used for IFQ bottom trawl. Observers have systematically collected viability data on hook-and-line vessels in the non-nearshore fixed gear sector since 2011. Current methods require observers to collect a length and viability on the first five P. halibut observed in each set on these vessels and to ignore any injuries incurred during landing when assessing viability. For the period 2002–10, we used a single mortality rate for all bycatch (16%) on longline and hook-and-line vessels, which represents an average of DMRs over all years for the Bering Sea/Aleutian region longline fishery (Williams 2008). For the period 2011–19, we used observer field estimates of discarded P. halibut viability on non-nearshore fixed gear vessels fishing longline or hook-and-line gear to estimate mortality of discarded P. halibut. (Note: Observers currently do not take viability of P. halibut caught on IFQ hook-and-line vessels).

Methods used to calculate discard mortality based on viability condition are almost identical to those methods currently accepted for use with IFQ bottom trawl vessels (see Shore-based IFQ fishery bycatch estimation). To account for the impact of fish size on survivorship, we computed an annual weighted mortality rate for P. halibut in each condition category in the LE sablefish endorsed fishery (Supplemental Table 62). For the LE sablefish nonendorsed and OA fixed gear sectors, sample sizes were too small to calculate an annual rate. Therefore, we calculated a five-year running average of weighted mortality rates for each condition category in these two sectors (Supplemental Tables 63 and 64). Length measurements associated with each viability record were converted to weight based on the IPHC length–weight table provided in Supplemental Table 95.

Table 7. Mortality rates used for each of the injury categories for non-nearshore hook-and-line vessels (Kaimmer and Trumble 1998, Trumble et al. 2000).

Sector	Gear	Injury status	Mortality rate
Non-nearshore fixed gear	H&L	minor	0.04
Non-nearshore fixed gear	H&L	moderate	0.36
Non-nearshore fixed gear	H&L	severe	0.66
Non-nearshore fixed gear	H&L	dead	1.00

The proportion of P. halibut sampled weight in a viability category was multiplied by the viability category-specific mortality rate (Table 7). Discard mortality rates for each condition category *c* and stratum *s* were then multiplied by gross discard estimates to compute total estimated discard mortality for each subsector separately.

Viabilities from pot gear would be appropriate to use in estimating discard mortality; however, bycatch of P. halibut in pot gear is infrequent and the sample size is too small to utilize in this analysis. Consistent with past reports, we relied on DMR computed for Alaska groundfish fisheries (Williams 2008). An 18% DMR was applied to estimates for pot gear, coinciding with the DMR used for the sablefish pot fishery in Alaska.

For additional context, we present the length-frequency distribution of P. halibut from visual length estimates and physically measured lengths in non-nearshore fixed gear sectors (Supplemental Tables 68–72) and the proportion of sampled P. halibut discard of legal (>82 cm) and sublegal (<82 cm) sizes in non-nearshore fixed gear sectors (Supplemental Table 73). The majority of P. halibut lengths recorded in these fisheries were visual estimates of length, rounded to the nearest 10 cm. In other words, specimens that are 76 cm and 82 cm are both visually estimated to be 80 cm. With this level of resolution, it was not possible to compute the exact proportion of sublegal versus legal P. halibut from visually estimated lengths. Visual estimates were instead summarized in the manner in which they are recorded, with both sublegal- and legal-sized halibut falling within the 75–84-cm length bin.

IPHC Pacific Halibut Directed Fishery

In 2017, WCGOP began observing the P. halibut directed fishery and estimating fleetwide discard mortality using WCGOP observer and fish ticket data. This fishery was defined based on using fixed gear and landing P. halibut within two days of the halibut directed openings (Somers et al. 2020). Prior to 2017, landings in this fishery were identified using criteria from IPHC and reported in the nongroundfish fisheries not observed by NWFSC in previous versions of this report. No estimates of discards were calculated prior to 2017. Effort in this fishery occurs primarily in Washington and Oregon and uses only hook-and-line gear. Gross discard and mortality estimates for P. halibut were computed based on the same methods as described above for the non-nearshore hook-and-line fisheries. However, for the P. halibut directed fishery, we used P. halibut as the retained weight for both discard rates and expansion factors. We estimated landings, discard, and total mortality in the P. halibut directed fishery (Supplemental Tables 74, 76, and 78). Because the gear and effort in this fishery are similar to the non-nearshore hook-and-line fisheries, the same mortality rates based on viability (Table 7) were applied to discarded P. halibut in the directed fishery (Supplemental Table 77). We also present the number of observed vessels, trips, and sets for each opening of the fishery (Figure 8) and the observed physical and visual length frequencies of discarded P. halibut (Supplemental Tables 79 and 80).

Observed State Fisheries

If present, P. halibut bycatch was also sampled in the following state-managed fisheries:

- Oregon and California nearshore groundfish fixed gear sectors (Supplemental Tables 81 and 82).
- Washington, Oregon, and California pink shrimp trawl fisheries (Supplemental Tables 83 and 84).
- OA California halibut trawl fishery (Supplemental Table 85).
- California ridgeback prawn trawl fishery (Supplemental Table 86).
- California sea cucumber trawl fishery (Supplemental Table 87).

Note that the LE California halibut fishery is covered under the IFQ fishery. Bycatch estimates for these fishery sectors were computed within each fishery based on the following equation:

$$\hat{B} = \frac{\sum_t b}{\sum_t r} \times F$$

where:

b = observed discard (in mt) of P. halibut on set/haul t,
t = observed sets,
r = observed retained weight (mt) of target species on set/haul t,
F = weight (mt) of retained target species in the fishery in question in a particular year, and
B = discard estimate of P. halibut (mt) in the fishery in question in a particular year.

The nearshore fixed gear fishery targets a variety of groundfish and state-managed nearshore species that inhabit areas less than 50 fth deep. All species included in the nearshore target group, as listed on the WCGOP data processing web page (NWFSC 2020b), were included in the denominator when calculating bycatch ratios for the nearshore fixed gear sector. Pink shrimp and California halibut were considered the target species in their respective fisheries. Discard mortality rates are not available for California halibut and pink shrimp fisheries due to a lack of information regarding survivorship. To maintain confidentiality, the nearshore fisheries cannot be split out by gear type (hook-and-line vs. pot). For these reasons, we assumed 100% mortality in the nearshore, pink shrimp, and California halibut fisheries.

In 2017, WCGOP began placing observers on California sea cucumber trawl and California ridgeback prawn trawl vessels. Prior to 2017, landings in these fisheries were included in nongroundfish fisheries not observed by NWFSC, and no estimates of discards were calculated. Effort in these fisheries occurs only in California, uses shrimp and bottom trawl gears, and targets sea cucumbers or ridgeback prawns. Discard estimates for each species were computed based on the same equation as described above for the OA California halibut fishery, but utilizing sea cucumber or ridgeback prawn as the retained weight for both discard rates and expansion factors. We assume 100% mortality. In 2017, there was no observed catch of P. halibut in the California sea cucumber trawl fishery (Supplemental Table 86). Confidentiality protections prevent reporting of the 2018–19 California sea cucumber trawl fishery P. halibut bycatch (Supplemental Table 87).

Exempted Fishing Permits

EFPs are federal permits, issued by NMFS, authorizing vessels to engage in fishing operations that otherwise would be prohibited by regulations (PFMC Council Operating Procedure 19).[1] EFPs directed toward groundfish species have been required to carry WCGOP observers on 100% of trips. Thus, to obtain the catch from EFPs, we sum the at-sea discards and landed P. halibut catch.

Since 2015, vessels in the IFQ fishery could elect to participate in an EM EFP. To obtain the catch from the IFQ EM EFP, we sum the P. halibut catch from the electronic monitoring data supplied to FOS by PSMFC. Unlike the normal IFQ program, IFQ vessels fishing under an EM EFP are not required to carry an observer on every fishing trip, because EM is used to ensure compliance with the IFQ program. FOS targets 30% of randomly selected IFQ EM trips for observer coverage for the purposes of scientific observation (e.g., biological sampling). Comparisons of the discard mortality rates between the EM and non-EM IFQ vessels and between the observer viability method versus the time-on-deck model are presented in Supplemental Tables 48 and 51.

Nongroundfish Fisheries Not Observed by NWFSC

Nongroundfish fisheries that are not observed by FOS occasionally record P. halibut catch on fish tickets. Data from these fisheries are only available to FOS from PacFIN fish ticket records. We provide a summary of landed P. halibut from these fisheries by year in Supplemental Table 89.

[1] https://www.pcouncil.org/documents/2019/10/agenda-item-h-5-attachment-1-council-operating-procedure-19-protocol-for-consideration-of-exempted-fishing-permits-for-groundfish-fisheries-electronic-only.pdf/

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