Weighted Length Frequency Distributions for Pacific Halibut in U.S. West Coast Limited Entry and Catch Share Bottom Trawl and Pot Fisheries, 2004–18

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Background

Pacific halibut (*Hippoglossus stenolepis*) is found in coastal waters throughout the North Pacific. Off the U.S. West Coast of the United States, it inhabits continental shelf areas (<150 fth) fromWashington 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 2018).

The objective of this data report is to provide data that supports annual estimates of P. halibut bycatch in the U.S. West Coast groundfish fisheries (Jannot et al. 2020). Specifically, the data presented here include the weighted length frequencies from observed P. halibut fishing on limited entry trawl vessels (2002–10) and in the catch share (a.k.a., individual fishing quotas, or IFQ) fisheries. For full explanation of fisheries definitions, data sources, and P. halibut bycatch estimation, please consult Jannot et al. 2020.

Detailed descriptions of data sources, collection, and reporting for these fisheries in relation to P. halibut bycatch is given in Jannot et al. 2020. Below, we provide a brief summary of the methods that apply to the data in this report.

Methods

Data sources for this analysis include on-board observer data from the West Coast Groundfish Observer Program (WCGOP) administered by the NOAA Northwest Fisheries Science Center, Seattle, WA. To date, observer data are the sole source for discard estimation in the IFQ sectors, except for vessels using EM under an EFP (see Jannot et al. 2020). A list of fisheries, coverage priorities and data collection methods employed by WCGOP in each observed fishery can be found in the WCGOP manuals (NWFSC 2019). Data from the At-sea Hake Observer Program and from the PacFin fish landing receipts are not used in this report.

The sampling protocol employed by the WCGOP is primarily focused on the discarded portion of catch. All weights of P. halibut presented in this report are round weights, that is, whole fish. The International Pacific Halibut Commission (IPHC) converts these weights to dressed weight (i.e., head and organs removed).

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:

1. A count of individual P. halibut in the haul or sample.
2. Actual or visual length measurements (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 2019). 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 or set. The proportion of P. halibut sampled is based on the number caught in the haul or 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 is dependent on crew assistance and cooperation. Regulations prohibit vessel crew from discarding 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 1 describes the P. halibut data obtained on IFQ-permitted vessels fishing different gear types.[1]

On vessels fishing fixed gear (pot or hook & 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. Visual length estimates can be made to supplement actual lengths on vessels fishing hook & line gear in the IFQ fishery. Visual estimates are in 10-cm increments (55–64 cm, 65–74 cm, etc.).

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[1] Tables can be downloaded from the NOAA Institutional Repository. See Tables.

The crew's cooperation is vital to the observer's sampling success during hook & 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.

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 (NWFSC 2019; Williams and Chen 2004). 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. Individual Bycatch Quota weight (or simply IBQ) refers to the estimated mortality of discarded P. halibut, with the appropriate mortality rate applied based on viability (Tables 2 & 3).

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 & line vessels, we used a discard mortality rate (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.

Shore-based IFQ fishery Bycatch Estimation

We stratified IFQ P. halibut bycatch data based on sector (shoreside non-hake groundfish, shoreside Pacific hake, at-sea Pacific hake, and LE California halibut) and gear (bottom trawl, midwater trawl, pot, hook & 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 non-hake groundfish sector, we further stratified using area and depth within each gear type. We maintained area and depth strata that were applied to bottom trawl, hook & line, and pot gear originally reported in Heery et al. 2010, because Heery et al. demonstrated that these variables were correlated with P. halibut bycatch. 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 sampled, not sampled, or data failed quality control. In all these cases, we used ratio estimators to apportion unsampled weight to P. halibut within each stratum; see Jannot et al. 2020 for details.

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 Table 4.

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 2 and 3; see Jannot et al. 2020 for details). Viability data are collected from only a sub-sample of the P. halibut that observers encounter. See Jannot et al. 2020 for details.

Length Frequencies

The length frequency distribution for P. halibut in the 2011–18 IFQ fishery is provided in Jannot et al. 2020. 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 (Table 4). 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 & line gear. Fishers have raised concerns regarding crew safety when landing large P. halibut. In addition, hook & 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 ganglion line). Therefore, shake-offs prior to the crucifier (a form of pre-sorting) are almost universal on IFQ hook & line vessels. Another case of pre-sorting can occur when halibut are too heavy and/or awkward to weigh in observer baskets. In all cases of pre-sorting, random samples are not available. Therefore, observers visually estimate the length of the halibut in ten-centimeter units (40 cm, 50 cm, 60 cm, etc.), which are later converted to weight using the IPHC length–weight conversion table (Table 4).

Tables 5 & 6 provide the weighted length frequency distributions of discarded P. halibut for vessels fishing with bottom trawl gear under the limited entry fishery prior to Catch Shares (2002–10, Table 5) and under the current IFQ program (2011–present, Table 6). Weighted length frequency distributions are also given for discarded P. halibut for vessels fishing with pot gear under the IFQ program (Table 7). 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:

$$n_{w_l} = n_l \times \frac{W_{st}}{\sum_l w_{stl}} \times \frac{\sum_t W_{st}}{W_{st}} \times \frac{\hat{W}_s}{\sum_t W_{st}} = n_l \times \frac{\hat{W}_s}{\sum_l w_{stl}} \tag{1}$$

where:

- s = stratum,
- t = tow,
- l = length bin,
- n = number of measured fish,
- w = total weight of fish, as determined through the IPHC length–weight relationship (Table 4),
- W = total observed discard weight of Pacific halibut, and
- $\hat{W}$ = estimated total discard weight of P. halibut.

We have summarized the proportion of length measurements in each condition category (Excellent, Poor, and Dead) in Tables 8, 9, & 10 to inform size-specific modeling of mortality. Within each of these three condition categories, the frequency of sampled fish was weighted in the same manner as length frequency distributions and then summarized for each 2-cm length bin. In addition, we also provide a count of the number of dead individuals in each 2-cm length bin (Table 11). 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 2 & 3), or by 1.0 in the case of midwater trawl, and summing these values across viabilities, and then rounding to an integer to obtain the number of dead per length bin. This method assumes there is no size-specific mortality.

Tables

The tables in this data report (filename: `DR-2019-03.xlsx`), described below, can be downloaded from the report's <u>NOAA Institutional Repository</u>[2] record by clicking on the "Supporting Files" tab.

Table 1. Data collected from Pacific halibut caught on IFQ vessels using different types of gear.

Table 2. Mortality rates used for each of the condition categories for IFQ bottom trawl vessels (Clark et al. 1992).

Table 3. Mortality rates used for each of the condition categories for IFQ pot gear vessels (IPHC 2019).

Table 4. IPHC length–weight conversion table for Pacific halibut.

Table 5. Weighted length frequency distributions for Pacific halibut in the limited entry bottom trawl fishery, 2002–10. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm.

Table 6. Weighted length frequency distributions for Pacific halibut in the IFQ fishery for vessels using bottom trawl gears, 2011–present. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm. Since 2013, IFQ bottom trawl lengths could also include lengths taken on both IFQ and LE California halibut bottom trawl fisheries.

Table 7. Weighted length frequency distributions for Pacific halibut in the IFQ fishery for vessels using pot gears, 2011–present. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm.

Table 8. Percentage of weighted length measurements in each condition category for the limited entry bottom trawl fishery, 2002–10. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm.

Table 9. Percentage of weighted length measurements in each viability category for IFQ bottom trawl vessels, 2011–present. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm. Since 2013, IFQ bottom trawl lengths could also include lengths taken on both IFQ and LE California halibut bottom trawl fisheries.

Table 10. Percentage of weighted length measurements in each viability category for IFQ pot vessels, 2011–present. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm.

Table 11. Number of dead Pacific halibut in each length bin, summed across viability categories, for IFQ vessels by gear type, 2011–present. Length bins are inclusive of the bin value (lower) and exclude the upper value, e.g., 10 = lengths 10.0 to 11.99 cm. Since 2013, IFQ bottom trawl lengths could also include lengths taken on both IFQ and LE California halibut bottom trawl fisheries. This analysis assumes that there is no size-dependent mortality within viability categories.

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

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