11.8.2010 November Groundfish Plan Team Document

Methods for the estimation of non-target species catch in the unobserved halibut IFQ fleet

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1.0 Introduction

The discarded catch of non-target species in the halibut IFQ fishery is largely unobserved, undocumented and has not previously been incorporated into most of the BSAI and GOA stock assessments. Bycatch of some groundfish species in the halibut IFQ fishery has been estimated using the IPHC annual longline survey as a proxy for observer data (Gaichas et al. 2005, Courtney et al. 2006, Brylinsky et al. 2009, Ormseth et al. 2009, Tribuzio et al. 2009). However, there has been no consensus among authors as to the best method to account for removals for all groundfish species.

At its December 2009 meeting, the SSC requested improvements to estimation methods of discard and continued monitoring of estimated bycatch in the halibut IFQ fishery (NPFMC 2009). Specifically, the SSC recommended monitoring at-sea discard of rockfish species, skates and sharks:.

Rougheye Rockfish: "In particular, the authors should monitor the bycatch trends in the sablefish, halibut longline fisheries, and look for evidence of "topping off" in the POP fishery."

Skate complex: "The new method of bycatch estimation used the IPHC halibut survey bycatch data to estimate skate bycatch in the commercial fishery and used only those survey stations with the highest one-third of halibut catch rates. The rationale for this approach is the expectation that most of the commercial effort in the halibut fishery is likely to be in the high CPUE areas. The plan team was uncomfortable with this new approach, noting that the impact on the estimate of skate bycatch, which is primarily taken in the halibut fishery, is to reduce that estimate by an order of magnitude. The SSC concurs with the plan team's request for an investigation of alternative methods of estimating skate bycatch in the commercial halibut fishery, to include stratification based on the geographic distribution of the commercial fishery, as well as depth and area stratification."

Shark complex: "The SSC supports further development of both proposed methods to estimate shark bycatch in halibut fisheries reported in the Appendix. When completed, reconstructed historical estimates of shark catch should be added to the historical catch time series for sharks."

To address these recommendations, a working group composed of scientists from AFSC, AKRO, ADF&G, IPHC and NPFMC was formed in January of 2010. The goal of the working group is to investigate quantitative methods to estimate incidental catches in the unobserved halibut IFQ fishery. The purpose of this document is to provide Plan Team and SSC members with an overview of the analytical methods and associated estimates for several example species: Pacific cod, spiny dogfish, Pacific sleeper shark and salmon shark within the GOA. The working group has focused on three areas: 1) estimation of variance for extrapolated survey catch and CPUE; 2) data filters of annual survey data to better represent commercial fishing behavior; and 3) ratio estimators to extrapolate survey catch to commercial effort.

1.1 Timeline

January-August 2010: Working group meetings and method developments
September 2010: Presentation of methods to joint Plan Teams, discussion and feedback, selection of best method
November 2010: Presentation of best method with catch estimates of example species to joint Plan Teams
December 2010: Presentation of best method to SSC for approval
January 2011: Institutionalization of best method
August 2011: Estimation of catches for non-target species prepared and provided to stock assessment authors

2.0 Methods

Survey and commercial effort data were provided by the IPHC. To preserve confidentiality, commercial effort data (effective skates and total landings) were grouped by year into NMFS reporting areas (541, 542, 543, 610, 620, 630, 640+649, 650, 659), all Bering Sea areas combined, and binned into three depth categories (0-99, 100-199, and 200+ fathoms). Further, because some areas had a limited number of vessels some depth categories were binned within an area, for example areas 542 and 543 had all depths combined. Survey stations were similarly grouped by year/area/depth stratum.

2.1 Survey Catch and CPUE Variance

Catch estimates and catch rates (CPUE) from the IPHC annual longline survey are point estimates only, without estimates of variance. The goal here was to estimate approximate 95% confidence intervals for the extrapolated catch (numbers) and the CPUE (numbers of fish/hooks). Following the IPHC assumptions that the 20% stratified subsample of hooks is an adequate representation of the total hooks fished at each station for bycatch of common species, we assumed that the subsample of observed hooks was representative of the station and was in essence a complete census of the hooks. Stations within strata were resampled with replacement and the mean CPUE for each species within a stratum were calculated. The upper and lower 95th percentile of the replicates were taken as the approximate confidence interval around the species specific average CPUE. One potential deficiency with this methodology occurs if there is serious bias in the bootstrap estimate, resulting in under coverage of the confidence interval. This potential source of error will be discussed later.

Estimating rare species presents a problem due to low detection probabilities, resulting in zero observations that cause over dispersion and potential bias in estimates. In other words, species that are estimated, but do not occur in the subsample result in an estimate of zero catch and CPUE despite likely occurrence in the area. Conversely, if individuals are clustered, the catch and CPUE may be over estimated. In both situations, estimates of variance are likely not accurate.

2.2 Filtering Survey Data

During the September 2010 Joint Plan Team meeting, the teams and working group participants discussed three options for filtering the survey data to more accurately represent commercial behavior: no filter, the top 1/3rd of survey stations (based on halibut CPUE within a strata) and a proportional filter where stations are weighted based on the proportion of commercial effort that occurs in that area (described below). The joint Plan Teams recommended the working group “use the proportional to catch filtering method, which was considered most likely to reflect spatial differences in species composition while sacrificing little survey data compared with the top-third method.” (Groundfish Plan Team minutes, September 2010). This proportional method retains more survey stations, broader spatial coverage than the top 1/3rd filter (figure 1), and may more accurately represent commercial effort.

Here we are presenting catch estimates based on the recommended proportional data filter as well as catch estimations made with the full survey data set for comparison. Detailed methods for each of the data filters are below.

1) No filter: All the survey stations were included.
2) Proportional to catch filter: (note: depth was not available for commercial data at this spatial resolution, therefore the proportions are stratified by year/area not year/area/depth)
    a. Additional data: halibut commercial catch by ADF&G stat area for each year (1995-2009), provides commercial effort at the lowest resolution possible
    b. Map IPHC survey stations into ADFG stat areas used in catch reporting
    c. Stratify both IPHC survey and commercial catch by NMFS area and year
    d. Calculate proportion of commercial catch in ADFG stat area within a NMFS area and year
    e. Match to survey dataset (not all areas with survey have catch)
    f. Renormalize proportion of commercial catch (setting surveyed areas with no catch to 0) to get the weighted proportion for each station

2.3 Average Weight

A separate issue that is enveloped in this catch estimation procedure is data quality of species specific average weights for converting numbers to biomass. For the purposes of this report we are not proposing a universal method for calculating species specific average weight, but for the four example species, we have attempted to find the best available data. Observer data from longline vessels was used to calculated mean weights for three shark species and Pacific cod and were compared between reporting areas, depth strata, and by year to look for significant differences between strata. Strata (year, area, and depth combinations) were the same as those used on the catch estimation analysis, further comparisons of mean weight between “shallow” (< = 99 fathoms) and “deep” (> 99 fathoms), FMP (BSAI vs. GOA) and regions (BSAI, WGOA, CGOA and EGOA) were also conducted.

The extrapolated weights and numbers used to derive the mean weights are calculated by FMA (North Pacific Observer Program) and take into account sampling fractions. Mean weights were derived from the extrapolated weights divided by the extrapolated numbers. Data was pulled from the Alaska Region Catch Accounting System, which contains the necessary data fields from the observer database (NORPAC).

For spiny dogfish and Pacific cod, a non-parametric bootstrap was used to compare means, 95 percentile intervals between post strata, and bias. Results from this analysis showed that the year/area/depth strata categories resulted in certain categories having small sample sizes (e.g., 3 sets) and are thus not robust to the population caught on hook-an- line gear.. Further investigation of alternative data groupings (deep vs. shallow, WGOA vs. CGOA vs. EGOA) found that fairly robust sample sizes with strata specified by year, GOA, and deep (>99.1 fathoms) vs shallow (<99.1 fathoms). For both cod and dogfish, weight differences were observed for the depths (Table 1). Thus, this analysis uses mean weights for spiny dogfish and Pacific cod that are stratified by year, FMP, and depth (deep or shallow).

Observer data was not used to estimate weights for salmon sharks and sleeper sharks. The number of samples was very low for both species and the weights collected by observers may not represent the true population of shark bycatch. Further, the larger specimens of these shark species are generally not brought aboard a vessel due to safety and logistical reasons, resulting in smaller sharks in the weighed samples. For both species, mean weights were calculated based on targeted research surveys.

Salmon shark are rarely encountered in federal surveys, especially on longline gear. However, weight data is available from targeted research surveys in Prince William Sound (seine and hook and line gear, Goldman and Musik 2006) and from sport fishery data (S. Meyer pers. comm.). Sport fish data were not used in this case because it is possible that it is biased towards larger animals. Salmon shark are highly migratory and data collected in Prince WilliamSound may be an appropriate proxy for GOA caught salmon shark.

Weight data on Pacific sleeper shark is difficult to obtain due to the large size of the animal and generally larger individuals are not brought on board to be sampled for safety and logistical reason. In addition, the weight of some specimens may be estimated by the observer or proxy weights (for trawl data) are used from RACEBASE. For this analysis weight data collected during a targeted longline survey near Kodiak, in which all sharks were weighed, is assumed to be the best available data for this species and gear type (M. Sigler, unpublished data).

2.4 Ratio Estimators

Catch Per Unit Effort Method

Commercial fishery data were used to estimate the number of effective hooks fished. Commercial logbook data were reported by weight (landings), effective skates hauled (skate is defined as 1,800 feet of groundline with 100 hooks), and number of vessels by depth bin within each year/area/depth strata. Fish ticket data were reported by weight and number of vessels by year/area/depth strata. Logbook coverage provides a view of how effort is proportioned by depth and was used to proportion the fish ticket landings into depth categories. We assumed that fishing gear was universal in that all skates consisted of 100 hooks (Gaichas et al. 2005, Courtney et al. 2006), consistent with the survey, and estimated the number of effective hooks fished from the number of effective skates hauled in each grouped statistical area and depth category. The species specific survey CPUE in each stratum was multiplied by the number of effective hooks in the fishery to estimate the total number of the species of interest caught. Biomass for a species was estimated as the product of the estimated number and the average weight..

Weight Ratio Method

The IPHC stock assessment survey data are used to determine the weight ratio of the species of interest to halibut weight by depth and area. The catch (in numbers) of the species of interest observed in the 20% of subsampled hooks was extrapolated to the entire set, and a total weight of species of interest is estimated by multiplying the average weight of the species of interest by the number caught on each survey set that occurred in a particular area. The ratio estimator is then the weight of the species of interest to the total weight of legal sized halibut for each stratum. Note that we are using the round weight of the species of interest to the net weight (dressed, head-off) of halibut. However, since these weight ratios are consistent through the calculations, this is not a problem. This weight ratio is then applied to the commercial halibut landings in the same stratum, resulting in bycatch pounds of the species of interest.

3.0 Results and Discussion

Average CPUE were calculated for each stratum based on the full survey dataset and the proportionally weighted dataset. Bootstrapped average CPUE and upper and lower 95th percentile intervals were calculated and compared to the survey estimates to determine bias. For all species and all strata, the bootstrapped full dataset produced less biased estimates than the proportionally weighted dataset, however, on average the bias was close to zero for both datasets and there was no evidence of systematic bias (Figure 2, only results for Pacific cod from 2006-2008 shown here for the sake of brevity). Thus, a bias correction for the bootstrap interval was not necessary. The CPUE results based on the full survey dataset were used to calculate total estimated survey catch of each species, in numbers, with approximate confidence intervals. The extrapolated total estimated survey catch will be used by all assessment authors in the future as part of accounting for research catch (Table 2).

The CPUE results from both datasets and the average weights were used in the procedures described above to estimate total fishery catch of the species of interest. Estimates of catch for Pacific sleeper shark were the greatest of the four species examined (ranging from 3,387 mt to 9,599 mt, depending on method/filter and year, Table3). Pacific cod and spiny dogfish catch estimates were similar in range (from 2,191 mt up to 6,756 mt, and 1,994 mt to 5,547 mt, respectively, depending on method/filter and year, Table 2). Catch estimates for salmon shark were much lower, ranging from 0 mt to 181 mt, and in most catch estimation scenarios the lower confidence bound for the catch estimate included zero, reflecting uncertainty due to rare occurrences (Table 2). For all species catch estimates made using the weight ratio method, regardless of the data filter, were greater than those made using the CPUE method, although the approximate confidence intervals were overlapping. Likewise, catch estimates based on non-filtered survey data were generally greater than those estimates based on filtered survey data, but again, the 95% confidence intervals were overlapping, indicating statistical similarity.

The purpose of this analysis was to determine the best method for estimating incidental catch of non-target species. Because no statistical tests were conducted, and data do not exist to groundtruth these estimates, the "best" method is to be determined by qualitative means.

1. Should the full survey dataset be used or should the survey data be "filtered" to better represent the commercial fishery?
    a. IPHC annual survey is designed to survey halibut habitat, not fishery areas, thus the survey efforts may not reflect commercial effort.
    b. The proportional filter proposed here attempts to account for commercial effort by spatially weighting each survey station based on the effort that occurs in that area.
    c. It is likely a better spatial representation of commercial effort than both the full survey data set and the top 1/3rd filter used in the IPHC stock assessments.
2. Which catch estimation method is most appropriate?
    a. Each catch estimation procedure has caveats.
        i. CPUE method bases the extrapolation on estimated effective hooks, calculated from fishticket and log book data for effective skates and landings.
        ii. CPUE method assumes that all effective skates consist of 100 hooks, similar to the IPHC survey design, which may or may not be similar to commercial gear configuration.
        iii. Weight ratio method is based on the actual fishticket landings, and require no assumptions about gear
        iv. Weight ratio method assumes a biological relationship between the species of interest and halibut. Because the linkages between species are elastic and species specific habitat needs are different, this assumption may be easily violated.
        v. Uncertainty in average weight estimates for rare or difficult to sample species (e.g. salmon and Pacific sleeper sharks) is not taken into account in either method, but the average weight estimates are integral to the weight ratio method, it likely has a greater impact in that method. The CPUE method is not reliant on average weights, except to convert estimated catch to weight if desired.

For the reasons described above, the working group recommends moving forward with the CPUE catch estimation procedure and using the proportionally weighted survey data. If this method is approved, catch estimates should be available for stock assessment authors for the next assessment cycle. Also, an alternative bootstrap approach may be possible to estimate confidence intervals around the catch estimates, but results are not available at this time.

4.0 Sources

Brylinksy, C., J. Stahl, D. Carlile and M. Jaenicke. 2009. Assessment of the demersal shelf rockfish stock for 2010 in the Southeast Outside district of the Gulf of Alaska. In: Stock assessment and Fishery

Evaluation Report for the groundfish resources of the Gulf of Alaska for 2009. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

Courtney, D., Tribuzio, C., Goldman, K., Rice, J. 2006. Gulf of Alaska Sharks. In: Stock assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska for 2006. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

Gaichas, S., Sagalkin, N., Gburski, C., Stevenson, D., Swanson, R. 2005. Gulf of Alaska Skates. In: Stock assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska for 2005. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

NPFMC 2009. (http://www.fakr.noaa.gov/npfmc/minutes/SSC1209.pdf)

Ormseth, O. and B. Matta. 2009. Assessment of the skate complex in the Gulf of Alaska. In: Stock assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska for 2009. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

Tribuzio, C.A., C. Rodgveller, J. Heifetz and K. Goldman. 2009. Assessment of the shark complex in the Gulf of Alaska. In: Stock assessment and Fishery Evaluation Report for the groundfish resources of the Gulf of Alaska for 2009. North Pacific Fishery Management Council, 605, W. 4th Ave Ste 306, Anchorage, AK 99501.

5.0 Tables and Figures

Table 1. Average weight parameters, with upper and lower confidence bounds used in this analysis. In this case, n represents the number of sets with observer data.

		Depth	Avg wt (kg)	LL	UL	n
Pacific cod	2006	< = 99 fa	3.56	3.49	3.64	755
	2006	> 99 fa	2.43	2.05	2.76	8
	2007	< = 99 fa	3.65	3.55	3.73	534
	2007	> 99 fa	2.92	2.72	3.17	23
	2008	< = 99 fa	3.56	3.47	3.66	470
	2008	> 99 fa	2.21	1.95	2.52	12
Spiny dogfish	2006	< = 99 fa	2.67	2.60	2.73	560
	2006	> 99 fa	1.91	1.80	2.04	232
	2007	< = 99 fa	2.59	2.52	2.67	382
	2007	> 99 fa	2.06	1.94	2.20	198
	2008	< = 99 fa	2.52	2.37	2.67	95
	2008	> 99 fa	2.05	1.94	2.16	179
Pacific sleeper shark			79.63	74.32	84.94	186
Salmon shark			146.90			146

Table 2. Summary of extrapolated survey catches (in numbers) with approximate confidence intervals and boostrap bias for the four example species.

	No Data Filtering			
	Extrapolated Numbers Caught by the IPHC Survey			
		Survey Est	Boot Est	Bias %
Pacific Cod	1997	23,276	23,579(18,322-29,367)	1%
	1998	27,042	27,277(21,387-33,447)	1%
	1999	19,783	20,036(15,743-24,883)	1%
	2000	24,103	24,404(19,026-30,472)	1%
	2001	13,665	13,925(10,467-17,880)	2%
	2002	19,166	19,236(14,886-24,158)	0%
	2003	28,024	28,128(21,206-36,104)	0%
	2004	23,102	23,661(18,542-29,256)	2%
	2005	25,470	25,683(19,602-32,544)	1%
	2006	21,639	21,717(16,590-27,237)	0%
	2007	21,516	21,486(16,772-26,722)	0%
	2008	25,049	25,057(20,347-30,082)	0%
	2009	46,615	47,105(39,708-55,191)	1%
Spiny Dogfish	1997	13,013	12,962(8,816-17,771)	0%
	1998	38,976	38,785(29,166-49,419)	0%
	1999	17,963	18,043(11,321-25,892)	0%
	2000	24,221	24,388(16,851-32,781)	1%
	2001	30,185	29,889(23,015-37,310)	-1%
	2002	17,989	17,792(12,263-24,208)	-1%
	2003	61,960	62,071(48,436-76,809)	0%
	2004	41,379	41,779(31,183-53,417)	1%
	2005	40,265	40,325(29,579-52,108)	0%
	2006	38,186	38,276(28,749-48,590)	0%
	2007	31,683	31,912(24,703-39,635)	1%
	2008	22,331	22,355(16,523-28,907)	0%
	2009	27,133	27,107(19,745-35,378)	0%
Salmon Shark	1997	27	27(0-78)	1%
	1998	19	19(0-51)	2%
	1999	5	5(0-17)	9%
	2000	25	25(0-70)	0%
	2001	5	5(0-15)	-1%
	2002	5	5(0-15)	-1%
	2003	8	8(0-24)	1%
	2004	0	0(0-0)	0%
	2005	0	0(0-0)	0%
	2006	20	20(0-50)	0%
	2007	5	5(0-15)	-7%
	2008	1	1(0-3)	-2%
	2009	10	10(0-30)	4%
Pacific Sleeper Shark	1997	1,084	1,111(491-1,873)	3%
	1998	3,642	3,686(2,068-5,688)	1%
	1999	3,775	3,922(2,376-5,788)	4%
	2000	4,034	4,214(2,414-6,274)	4%
	2001	3,237	3,603(2,168-5,290)	11%
	2002	3,425	3,597(2,130-5,382)	5%
	2003	5,090	5,757(3,598-8,541)	13%
	2004	3,202	3,919(2,169-6,072)	22%
	2005	3,343	3,464(1,626-5,789)	4%
	2006	2,487	2,632(1,242-4,390)	6%
	2007	2,035	2,043(854-3,524)	0%
	2008	1,595	1,590(685-2,710)	0%
	2009	1,739	1,884(785-3,309)	8%

Table 3. Estimates of catch for each method (CPUE or Weight Ratio) and both data sets (not filtered, i.e. full dataset, or proportionally weighted).

		CPUE		Weight Ratio	
	Year	No Filter	Proportional	No Filter	Proportional
Pacific Cod	2006	2,194 (1,645-2,802)	2,191 (1,545-3,033)	3,671 (2,735-4,726)	3,761 (2,585-5,243)
	2007	2,610 (2,021-3,268)	2,534 (1,570-3,847)	3,862 (2,927-4,963)	3,908 (2,286-6,031)
	2008	3,676 (3,011-4,393)	3,332 (2,321-4,498)	6,756 (5,514-8,085)	6,002 (4,136-8,174)
Spiny Dogfish	2006	4,183 (3,042-5,449)	3,871 (2,783-5,225)	5,214 (3,678-6,951)	4,652 (3,248-6,468)
	2007	3,590 (2,753-4,565)	3,149 (2,342-4,136)	5,547 (4,124-7,206)	4,796 (3,504-6,383)
	2008	2,070 (1,490-2,731)	1,994 (1,210-2,956)	3,263 (2,298-4,367)	3,083 (1,828-4,724)
Salmon Shark	2006	90 (0-231)	61 (3-172)	181 (0-469)	117 (5-329)
	2007	21 (0-64)	3 (0-17)	34 (0-100)	5 (0-26)
	2008	9 (0-28)	0 (0-0)	14 (0-42)	0 (0-0)
Pacific Sleeper Shark	2006	5,583 (2,160-10,595)	4,765 (1,574-11,187)	9,599 (3587-18,442)	9,143 (2,407-20,790)
	2007	6,192 (2,448-10,849)	3,781 (927-9,285)	13,900 (3,622-25,993)	6,764 (1,321-24,826)
	2008	4,366 (1,779-7,601)	3,387 (981-6,744)	7,944 (3,145-13,819)	6,493 (1,819-13,177)

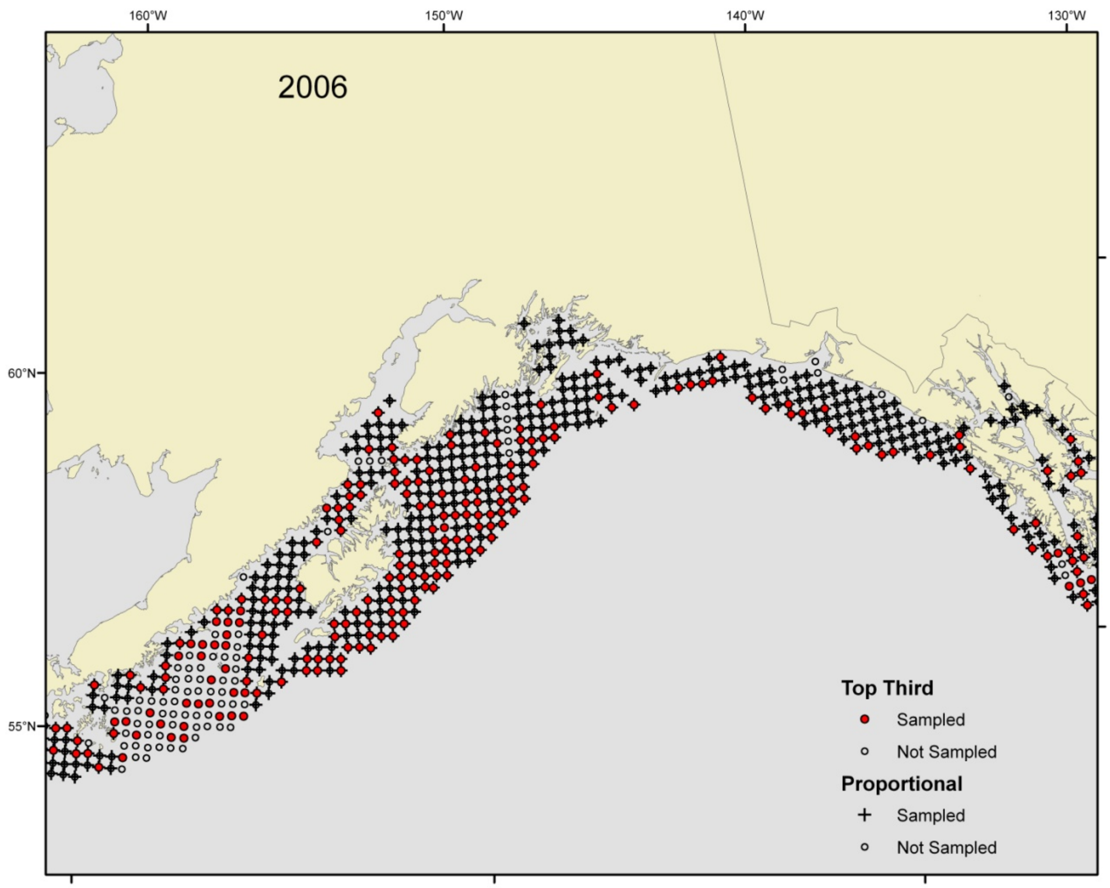

Figure 1. Map of IPHC survey stations (2006 shown here as an example) showing stations that were in the top 1/3rd of stations based on halibut CPUE (red circles) and stations that were given a proportional weight based on commercial effort (black crosses). Stations that were excluded from analysis based on both filters are in the open circles.

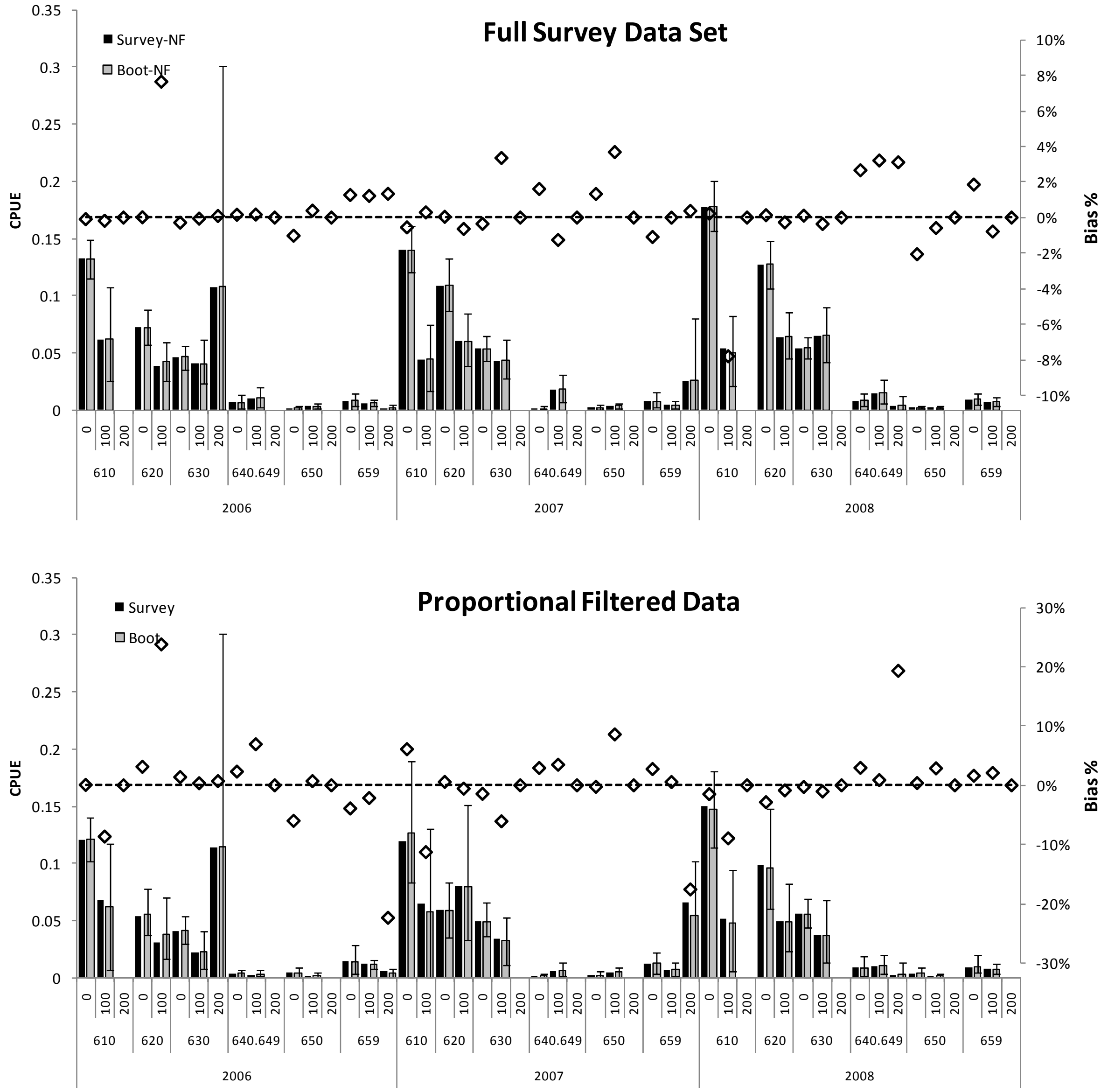

Figure 2. Example showing survey CPUE of Pacific cod (black bars) and estimated average CPUE and 95th percentile confidence intervals (grey bars) from the bootstrapping procedure. Open diamonds show the percent bias for the bootstrap estimates. Estimates are shown by year/area/depth strata. The CPUE estimates made with the full survey dataset is on top and estimates made with the proportionally weighted dataset are on bottom.

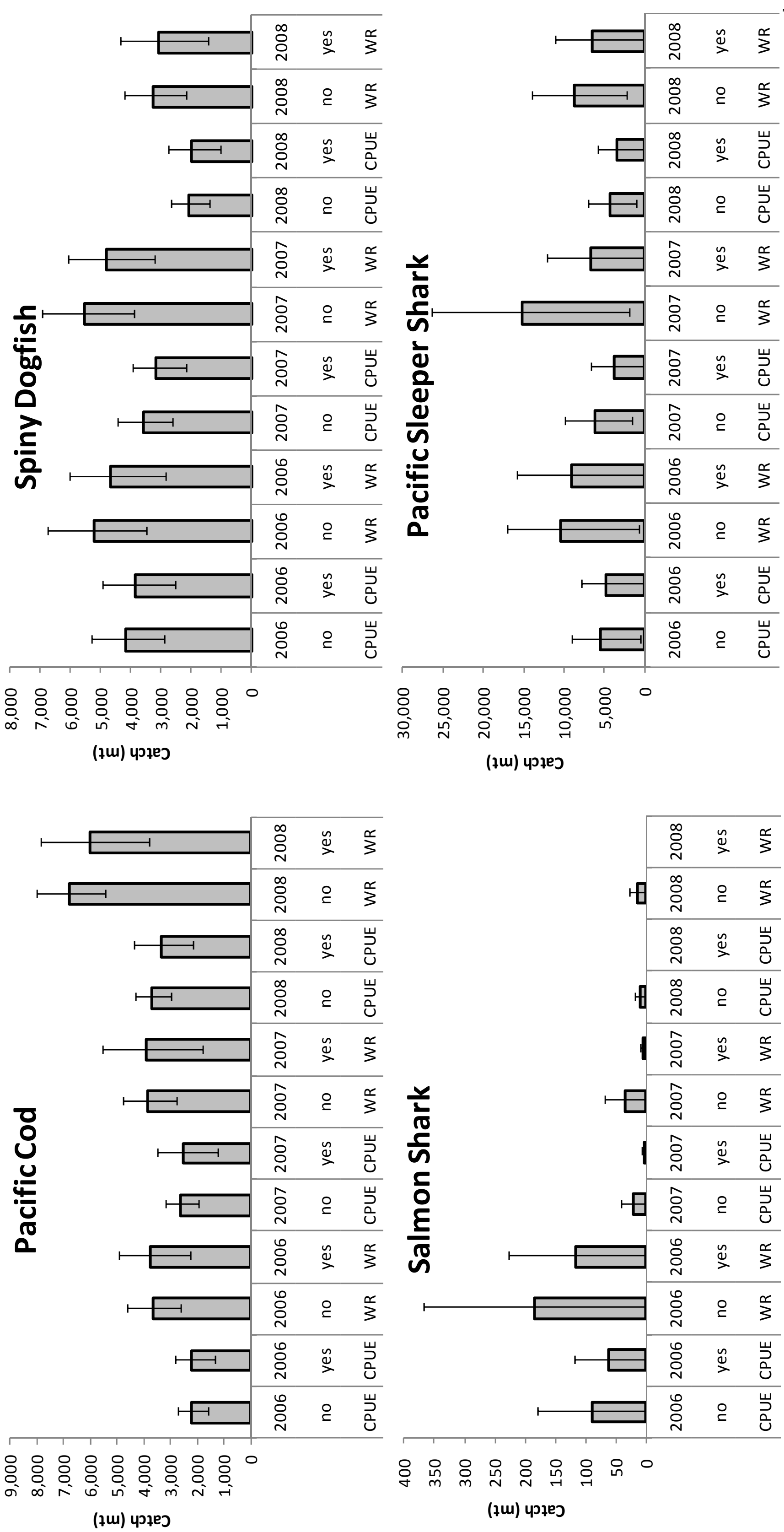

Figure 3. Estimates of catch in metric tons for each of the four example species. Each bar represents a different method/dataset scenario with 95th percentile confidence intervals (based on the CPUE estimates). The x-axis is composed of year, filtered (no=full dataset, yes=proportionally weighted dataset) and method of estimation (CPUE or Weight Ratio).