Preliminary estimation of nearshore groundfish catch distribution shoreward and seaward of 3 nmi to inform future fishery management planning

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Introduction

The Council is embarking on an effort to refine stock, and stock complex definitions within the Pacific Coast Groundfish Fishery Management Plan (FMP). One facet of this effort will be aided by improving our understanding of the spatial distribution of groundfish species catch, in terms of distance from shore. Some of the groundfish species currently included in the FMP occur in nearshore waters, with varying degrees of catch in state territorial waters (0-3 nautical miles (nmi) from shore), versus the Exclusive Economic Zone (EEZ) (3-200 nmi from shore) along the West Coast. Although the preferred depth range is known for many groundfish species, these depth bins map to different distances from shore with changing latitude, according to variation in benthic topography. We developed the approach in this document to estimate two-category proportions of catch for selected nearshore species using commercial fishery-dependent data, shoreward vs seaward of 3 nmi from shore, for each West Coast state; California, Oregon, and Washington. We expect this information to support scoping of future plans for stock definitions and area-specific fishery management by federal and state agencies.

This was a preliminary exploration; we expect later expansion to additional species, evaluation of recreational fishery proportions, automation and refinement of the approach. Results appear in Table 1. Estimates are inclusive of shoreside commercial, non-whiting groundfish fishery sectors only (no recreational, research, or tribal fishery data are included).

As of 2022, the primary data source for location-specific catch for shoreside non-whiting groundfish sectors is observer data. The commercial fishery sectors that fish in the nearshore are subject to partial observer coverage. Fishery sectors show dramatically different amounts of catch, and those distributions vary according to species; therefore we needed to scale catch estimates by relative catch among fishery sectors, as well as within each state and area. No one data source had sufficient information alone to accomplish this, so three sources were utilized in concert as described below in the Methods section, in collaboration, and with guidance from the West Coast Groundfish Observer Program (WCGOP). With implementation of the fixed gear logbook program, we expect to have logbook data available to contribute to spatial catch information in the near future.

This document is presented to the SSC for review and comments on the approach used in this preliminary analysis, before expanding the number of species, and expanding/unifying coding efforts.

Methods

<u>Data sources used</u>

Three sources of data were used, which included (1) the Groundfish Expanded Multiyear Mortality (GEMM) product from WCGOP (summarizes Somers et al. 2021 and Jannot et al. 2021), (2) the Pacific Coast Fisheries Information Network (PacFIN) database, and (3) haul-level WCGOP observer data (OBproc data product).

(1) The GEMM product provided coastwide annual estimates of total catch by species and sector. This provided the total amounts of annual catch to be distributed among states, and between state and federal waters, informed by data sources (2) and (3) below.

(2) The PacFIN database provided annual groundfish landings data by species, sector and state. These data were used to estimate the among-state distribution of catch of each species, from annual GEMM estimates.

    It was considered the best available means to apportion GEMM coastwide total catch among states using the state agency field within PacFIN, which is based on port of landing, since PacFIN represents the most complete source of state-specific catch data, with all trips represented (haul-specific observer data is limited to observed hauls only, see below). However, this is something of a compromise, as in some instances, near state borders (e.g. Astoria), some catch may be landed across state borders. There may be potential to augment this solution with use of PacFIN catch area codes (latitudinal areas), which is currently being investigated.

    The recent addition of the Fishery Observation Science (FOS) sector field to PacFIN data was also available in a beta form of the comprehensive fish ticket table in the database, as well as state agency, at the time of query. The FOS sector field has made utilization of landings data more efficient, and less challenging to align fishery sectors among data sources (Appendix A), in a standardized form among analysts.

(3) Haul-level groundfish observer data from WCGOP (OBproc data product) provided fine scale location data for the portion of hauls that were observed, and enabled determination of whether a specific haul was inside or outside of 3 nmi from shore. FOS sectors were also available in the haul-level observer data. However, this data source is limited to observed hauls only, observation rates vary substantially among sectors, and can only cover a small fraction of total hauls in most sectors.

PacFIN landings were queried on March 23, 2022 (SQL script appears in Appendix B). Haul-level observer data were received on March 22, 2022. The GEMM data product used was the August 2021 version, provided for the September, 2021 PFMC (Pacific Fishery Management Council) meeting.

<u>Approach overview</u>

The basic approach was to distribute total catch estimates for each species from the GEMM data product in two stages; first, among states using PacFIN landings, and second, between the EEZ and state waters within each state (inside versus outside of 3 nmi from shore) using haul-level observer data.

WCGOP representatives (Dr. Kayleigh Somers, together with Jon McVeigh) outlined a specific approach and provided haul-level observer data. Richard Morse (GIS analyst) from the West Coast Region assigned haul locations to within or outside of 3 nmi from shore, using ArcGIS 10.3. PacFIN landings data were queried using Oracle SQL Developer. Final estimates of average annual proportion of catch within vs outside of 3 nmi from shore, for select nearshore species, for each state, in commercial fisheries were produced using R version 3.5.1 (Great Truth) and traditional spreadsheets.

The most recent five-year period of data available from all three sources was used for the analysis, from 2016 through 2020; a five-year a period is customary for many management action-focused analyses, e.g.

harvest specifications impact projections modeling, salmon bycatch modeling for groundfish sectors, etc. Species queried/filtered were primarily nearshore, with a few commercially important shelf and shelf-slope species included in addition, for context. The current estimates are limited to quillback rockfish, copper rockfish, and China rockfish. Some species planned for inclusion in subsequent efforts include bocaccio, black, blue/deacon, canary, China, copper, cowcod, shortbelly, vermillion, widow, yelloweye, and yellowtail rockfish, as well as lingcod, petrale sole and sablefish.

<u>Summarized algorithm:</u>

To estimate average annual proportions of catch made shoreward vs seaward of 3 nmi, of select nearshore species, for each state, in commercial fisheries, we used the following algorithm, when we:

A) Calculated among-state distributions of PacFIN landings by species, sector and year and applied them to **apportion among states**, the coastwide catch from GEMM for each species, by sector and year.

$$(TC)_{sp,y,sec,st} = (TC)_{sp,y,sec} \cdot \frac{(L)_{sp,y,sec,st}}{(L)_{sp,y,sec}} \qquad \text{Equation (A)}$$

Where *TC* is GEMM total catch estimates (mt), *L* is amount of PacFIN landings (mt); *sp* in the subscript stands for species, *y* for year, *sec* for year and *st* for state.

B) Used haul-specific observer data to **spatially distribute** the state-distributed GEMM catch estimates from (1) **between areas** (in versus outside of 3 nmi), within each state.

$$(TC)_{sp,y,sec,st,a} = (TC)_{sp,y,sec,st} \cdot \frac{\frac{1}{5} \cdot \sum_{y=1}^{5} (OBS)_{sp,y,sec,st,a}}{\frac{1}{5} \cdot \sum_{y=1}^{5} (OBS)_{sp,y,sec,st}} \qquad \text{Equation (B)}$$

Where *TC* is GEMM total catch estimates (mt), *OBS* is haul level catch observed by WCGOP (mt), *sp* in the subscript stands for species, *y* for year, *sec* for sector, *st* for state and *a* for catch in shoreward (and then seaward) of 3 nmi.

C) Next, **summed over sectors**, to aggregate distributed catch to the species-state-area-year level $\left((TC)_{sp,y,st,a}\right)$, calculated mean values among years, and uncertainty of distributed catch (as CV), resulting in mean annual catch among years, within state and area strata (shoreward vs seaward of 3 nmi), for each species.

D) Last, **calculated proportions** of catch, between areas and within state, from those mean (annual) distributed catch estimates, for each species.

$$(TCP)_{sp,sec,st,a} = \frac{(\overline{TC})_{sp,sec,st,a}}{(\overline{TC})_{sp,sec,st}} \qquad \text{Equation (D)}$$

Detailed steps:

The estimations proceeded at the species-sector-year level, according to the following steps:

1) Aggregate GEMM data to the species-sector-year level, and PacFIN to the species-sector-state-year (from step A in Summarized Algorithm, above).
2) Calculate annual coastwide total catch by species and sector, from GEMM data (summary step A).
3) Calculate annual proportion of landings within each state, for each species, by sector from PacFIN data (summary step A).
    - Multiply coastwide catch (GEMM) by state-specific landings proportions (PacFIN), to yield state-distributed catch.
4) If necessary, borrow data (e.g. substitute one missing stratum from synonymous averaged strata in other years), to correct for missing information among data sources (summary step A).
5) Calculate state-specific sums of observed catch shoreward vs seaward of 3 nmi (observer/OBproc), by species and year (summary step B).
6) Average those sums among years (summary step B).
7) Calculate proportions (area proportions within state) from sums (6) – summary step B.
8) Multiply state-specific distributed catch (3) by area (3 nmi) proportions (7) – summary step B.
    - Result is annual estimates of area-within-state distributed, species-specific catch.
9) Aggregate among sectors, to year-state-area level (summary step C).
10) Calculate annual means of (area w/in state) distributed catch (7), and uncertainty (CV) – summary step C.
11) Convert distributed annual mean (area w/in state) catch to proportions, for each species (Table 1a) – summary step D.

Annual catch for each species was aggregated by sector (in addition to state), to scale catch estimates by relative catch among fishery sectors, since fishery sectors exhibit substantial differences in amounts of catch, and those distributions vary by species.

Gear type, within sector, was initially considered as a more granular stratification to add precision, but was ultimately abandoned as over-stratifying, given existing challenges of merging several different data sources (see Detailed Steps) at the present level of aggregation.

In cases when there were no PacFIN landings available to distribute the total catch (GEMM) among states with for a particular species-sector catch (only discard present, e.g. quillback 2016 in LE DTL sablefish, and pink shrimp), we used the state catch distribution from observer data (OBproc) instead. The affected catch amounts were minimal, often involved non-nearshore, non-groundfish sectors (e.g. halibut, prawn, sea cucumber), and appear to involve discarded catch. Most instances were in 2020, the most recent available data at the time. Most fishery data discrepancies typically occur in the most recent data year, and we expected many of the instances to resolve with a more recent query, as updates are made to the PacFIN database. Contingency imputation practices are congruent with those routinely used for catch reconstruction and data expansion exercises in contemporary West Coast groundfish stock assessments (Gertseva et al. 2019; Karnowski et al. 2014, Taylor et al. 2019).

In only two instances, when there were no landings (PacFIN), nor observer data (OBproc) available from which to distribute total catch (GEMM) among states for a particular species-sector, we used the average catch of available years for which either landings (1st choice) or observer data (2nd choice) were available to estimate state-specific catch distribution. This was only the case for two instances in 2020, and the amounts were less than 0.135 mt. The situation was later resolved with a subsequent query in April of 2023; landings were at that time populated for the sectors in PacFIN, which made imputation unnecessary. Two factors which may have contributed to the resolution include additional time elapsed, in which corrected fish tickets may have been submitted, and the integration of the FOS fishery sectors directly into PacFIN landings tables had by then been more fully implemented. The latter also makes translating between other sector definitions in PacFIN (such as Dahl sectors) and FOS outside of the database, as shown in Table 3, unnecessary for future analyses.

Results and discussion

Table 1 shows the (a) estimated proportions corresponding to mean, distributed annual catch for three nearshore species, for selected non-whiting commercial groundfish fishery sectors, by area and state. “In” refers to the area inside 3 nmi from shore, “Out” refers to outside that distance (EEZ); (b) estimated mean, distributed annual catch (mt) for three nearshore species, by area and state for the same sectors; and (c) the corresponding coefficient of variance (CV) for those mean (annual), distributed catch values appearing in Table 1b. Note that nearshore commercial fishing is not permitted off Washington. This is reflected in the zero (and one trace amount) catch estimates for these three nearshore species in Washington state (Table 1). CV values in Table 1c reflect variability among states and years in landings, but not areas. Averaging area-distributed, observed catch amounts among years was needed to better inform apportionment of catch among areas, within each state, given the density of observer estimates at the species-sector-year-state-area level of granularity.

Table 1a. Estimated proportions corresponding to mean (annual), distributed catch for three nearshore species, for selected non-whiting commercial groundfish fishery sectors, by area within state. “In” refers to the area inside 3 nmi from shore, “Out” refers to seaward of that distance.

	CA		OR		WA	
Species	In	Out	In	Out	In	Out
China	0.9640	0.0360	0.9842	0.0158		
Copper	0.8573	0.1427	0.9771	0.0229		
Quillback	0.8606	0.1394	0.9726	0.0274	0	*1

*Represents only 0.0001mt of estimated catch among selected shoreside sectors

Table 1b. Estimated mean (annual), distributed catch (mt) for three nearshore species, for selected non-whiting commercial groundfish fishery sectors, by area within state. "In" refers to the area inside 3 nmi from shore, "Out" refers to seaward of that distance.

	CA		OR		WA	
Species	In	Out	In	Out	In	Out
China	1.7893	0.0669	7.4352	0.1191	0.0000	0.0000
Copper	12.4010	2.0645	1.8000	0.0422	0.0000	0.0000
Quillback	1.3422	0.2174	4.2700	0.1204	0.0000	0.0001

Table 1c. Coefficient of variance (CV) among years for mean (annual), distributed catch (mt) for three nearshore species, for selected non-whiting commercial groundfish fishery sectors, by area within state. "In" refers to the area inside 3 nmi from shore, "Out" refers to seaward of that distance.

	CA		OR		WA	
Species	In	Out	In	Out	In	Out
China	18%	158%	33%	33%		
Copper	30%	53%	30%	30%		
Quillback	120%	146%	48%	39%		224%

Table 2 shows that the vast majority of landings (=> 95 percent) for these three nearshore species occur in the nearshore sector. Thus, this sector has the bulk of influence on the aggregated estimates in Table 1. The values of CV are much smaller for the nearshore sector than other sectors, indicating their relative stability in catch among years; the CV does not incorporate additional sources of variability.

Proportional estimates in the literature with which to compare or validate those in Table 1a. have so far not been found. However, the high proportions inside 3 nmi from shore are in agreement with accepted classification of these three species as nearshore rockfish, used in West Coast groundfish management. Further, China rockfish are reported as having an overall depth distribution of 0-70 fm with highest density from 2-50 fm; copper rockfish's overall, and highest density depth distribution are both reported as 0-100 fm (PFMC 2018), or 0-150 fm with most from 0-35 fm (Love 2011); and quillback rockfish are reported as having an overall depth distribution of 0-150 fm, with highest density between 22-33 fm (PFMC 2018; Love 2011). These relative depth ranges among the three species are generally in keeping with the proportional estimates in Table 1a. The relative proportions for California, with China rockfish showing >0.96 within 3 nmi from shore, and copper and quillback rockfish showing a less abrupt nearshore distribution (both at approximately 0.86 inside 3 nmi, within California), also reflect relative depth distributions from PFMC (2018), with tails of copper and quillback distributions running deeper than for China rockfish. Nearshore rockfish south of 40° 10' N. lat. are further subdivided into shallow nearshore and deeper nearshore rockfish, with China rockfish included the former, and copper and quillback in the latter, also in agreement with our relative proportional results.

Table 2. Proportional distribution of landings for quillback, copper and China rockfish, among selected (commercial shorebased) observed sectors that showed non-zero catch, coastwide; based on average annual landings (round weight, mt) in 2016-2020.

Species	Sector	Average (mt)	Std. dev. (mt)	CV (%)	Sector proportion
Quillback rockfish	Catch Shares	0.059	0.022	38%	0.01
	Directed P Halibut	0.001	0.002	153%	0.00
	LE Fixed Gear DTL	0.075	0.148	198%	0.01
	Limited Entry Sablefish	0.099	0.211	214%	0.02
	Nearshore	4.764	2.219	47%	**0.95**
	OA Fixed Gear	0.025	0.020	83%	0.00
Copper rockfish	Catch Shares	0.001	0.001	99%	0.00
	Catch Shares EM	0.000	0.001	142%	0.00
	Directed P Halibut	0.001	0.002	224%	0.00
	LE Fixed Gear DTL	0.111	0.127	114%	0.01
	Limited Entry Sablefish	0.206	0.460	223%	0.01
	Nearshore	14.148	3.907	28%	**0.97**
	OA CA Halibut	0.009	0.010	108%	0.00
	OA Fixed Gear	0.041	0.024	59%	0.00
	Ridgeback Prawn	0.002	0.002	93%	0.00
	Sea Cucumber	0.021	0.008	37%	0.00
China rockfish	LE Fixed Gear DTL	0.027	0.034	128%	0.00
	Limited Entry Sablefish	0.038	0.086	224%	0.01
	Nearshore	6.401	1.144	18%	**0.98**
	OA Fixed Gear	0.051	0.048	94%	0.01

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Appendix A. Sector mapping for those included in the three data sources used; "OB proc sectors" (right column, from granular observer data) were ultimately used for the analysis. The number of sectors that each species appeared in varied by state, and not necessarily all sectors were included. E.g. whiting sectors, and electronically monitored (EM) sectors were not included.

GEMM sectors	PacFIN FOS sectors	OB proc sectors
CS - Bottom Trawl	CATCH SHARES	Catch Shares
CS - Hook & Line	CATCH SHARES	Catch Shares
CS - Pot	CATCH SHARES	Catch Shares
CS EM - Bottom Trawl	CATCH SHARES EM	Catch Shares EM
CS EM - Pot	CATCH SHARES EM	Catch Shares EM
Directed P Halibut	DIRECTED P HALIBUT	Directed P Halibut
Midwater Hake	MIDWATER HAKE	NA
Midwater Hake EM	MIDWATER HAKE EM	NA
Midwater Rockfish	MIDWATER ROCKFISH	NA
Midwater Rockfish EM	MIDWATER ROCKFISH EM	NA
Nearshore	NEARSHORE	Nearshore
LE Fixed Gear DTL - Hook & Line	LE FIXED GEAR DTL	LE Fixed Gear DTL
LE Fixed Gear DTL - Pot	LE FIXED GEAR DTL	LE Fixed Gear DTL
LE Sablefish - Hook & Line	LIMITED ENTRY SABLEFISH	Limited Entry Sablefish
LE Sablefish - Pot	LIMITED ENTRY SABLEFISH	Limited Entry Sablefish
OA CA Halibut	OA CA HALIBUT	OA CA Halibut
OA Fixed Gear - Hook & Line	OA FIXED GEAR	OA Fixed Gear
OA Fixed Gear - Pot	OA FIXED GEAR	OA Fixed Gear
Pink Shrimp	PINK SHRIMP	Pink Shrimp
Research	RESEARCH	NA
Ridgeback Prawn Trawl	RIDGEBACK PRAWN	Ridgeback Prawn
Sea Cucumber Trawl	SEA CUCUMBER	Sea Cucumber
Tribal Shoreside	TRIBAL	NA
Incidental	OTHER FISHERIES	NA
NA	EFP	NA
At-Sea Hake CP	NA	NA
At-Sea Hake MSCV	NA	NA
Washington Recreational	NA	NA
California Recreational	NA	NA
Oregon Recreational	NA	NA

Appendix B. SQL script used to query PacFIN landings.

```
SELECT T.AGENCY_CODE AS "AGENCY_CODE",
      ROUND(SUM(T.ROUND_WEIGHT_MTONS),4) AS "ROUND_WEIGHT_MTONS",
      T.NOMINAL_TO_ACTUAL_PACFIN_SPECIES_NAME AS "NOMINAL_TO_ACTUAL_PACFIN_SPECIES_NAME",
      T.MANAGEMENT_GROUP_CODE AS "MANAGEMENT_GROUP_CODE",
      T.COUNCIL_CODE AS "COUNCIL_CODE",
      T.DAHL_GROUNDFISH_CODE AS "DAHL_GROUNDFISH_CODE",
T.FOS_GROUNDFISHSECTOR_CODE,
      T.PACFIN_YEAR AS "PACFIN_YEAR",
      T.PACFIN_GROUP_GEAR_CODE AS "PACFIN_GROUP_GEAR_CODE"
 FROM NWFSC.COMPREHENSIVE_FT_WITH_FOS_CODES T
 WHERE T.PACFIN_YEAR BETWEEN 2015 AND 2021
  AND T.COUNCIL_CODE = 'P'
  AND T.MANAGEMENT_GROUP_CODE = 'GRND'
 GROUP BY T.AGENCY_CODE,
        T.NOMINAL_TO_ACTUAL_PACFIN_SPECIES_NAME,
        T.MANAGEMENT_GROUP_CODE,
        T.COUNCIL_CODE,
        T.DAHL_GROUNDFISH_CODE,
      T.FOS_GROUNDFISHSECTOR_CODE,
        T.PACFIN_YEAR,
        T.PACFIN_GROUP_GEAR_CODE
```