Catch Reconstruction Update

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2025-03-06

Contents

List of Tables

List of Figures

1 Introduction

Within the package **PBStools**, there is a function called '`buildCatch`', which provides an efficient method for reconstructing rockfish (RRF) catch from 1918 to the present along the BC coast (Haigh and Yamanaka, 2011). The latest stock assessment to use `buildCatch` was Silvergray Rockfish (SGR, *Sebastes brevispinis*) in 2025. The Offshore Rockfish Program (ORP), currently headed by Rowan Haigh, usually updates the code during each stock assessment.

While the catch reconstruction (CR) extends back to 1918, the start of any rockfish fishery is usually set to 1935, before the fishery started to increase during World War II. Prior to this, trawl catches of RRF were negligible, and non-trawl fleet catches occurred in trace amounts. During the period 1950-1975, US vessels routinely caught more rockfish than did Canadian vessels. Additionally, from the mid-1960s to the mid-1970s, foreign fleets (Russian and Japanese) removed large amounts of rockfish, primarily POP. These large catches were first reported by various authors (Westrheim et al., 1972; Gunderson et al., 1977; Leaman and Stanley, 1993); however, Ketchen (1980*b*,*a*) re-examined the foreign fleet catch, largely because statistics from the USSR called all rockfish 'perches' while the Japanese used the term 'Pacific ocean perch' indiscriminately. In the catch reconstruction, all historical foreign catches (annual rockfish landings) are tracked separately from Canadian landings, converted to foreign-caught RRF, and added to total RRF landings during the reconstruction process.

2 Data sources

Starting in 2015, all official Canadian catch tables from the databases below (except `PacHarv3`) have been merged into one table called '`GF_MERGED_CATCH`', which is available in DFO's `GFFOS` database. All groundfish DFO databases are housed on the `DFBCV9TWVASP001` server (soon to change again). RRF catch by fishery sector ultimately comes from the following seven DFO databases:

- `PacHarv3` sales slips (1982-1995) – hook and line only;
- `GFCatch` (1954-1995) – trawl and trap;
- `PacHarvHL` merged data table (1986-2006) – halibut, Schedule II troll, ZN rockfish;
- `PacHarvSable` fisherlogs (1995-2005) – sablefish trap and longline;
- `PacHarvest` observer trawl (1996-2007) – primarily bottom trawl;
- `GFFOS` groundfish subset from Fishery Operation System (2006-present) – all fisheries and modern surveys; and
- `GFBioSQL` joint-venture hake and research survey catches (1947-present) – multiple gear types.

`GFBioSQL` is an SQL Server database that mirrors the `GFBio` Oracle database. All data sources other than `PacHarv3` were superseded by `GFFOS` beginning in 2007 because this latter repository was designed to record all Canadian west coast landings and discards from commercial fisheries and research activities. Reporting changed in `GFFOS` to reflect fishing 'sectors' that were different for some of the fisheries; primarily, Schedule II became 'Spiny Dogfish' and 'Lingcod' while ZN hook and line became 'Rockfish Inside' (waters between Vancouver Island and the BC mainland) and 'Rockfish Outside' (waters offshore and excluding Inside waters).

Prior to the modern catch databases, historical landings of aggregate rockfish – either total rockfish (TRF) or rockfish other than POP (ORF) – were reported by eight different data sources

(see Haigh and Yamanaka 2011). The earliest historical source of rockfish landings comes from the Canada Dominion Bureau of Statistics (1918-1950). Ketchen (1976) provides the bulk of trawl landings in the middle period (1950-1975).

The CR algorithm is coded in the R function '`buildCatch`', which can be found in the R package PBStools. The goal is to estimate the reconstructed catch of any rockfish species, generically designated as '`RRF`', from reported|estimated landings and reported|estimated discards. Estimated landings are calculated using a ratio (called '`gamma`' herein), either `RRF/ORF` or `RRF/TRF`, to derive `RRF` from either `ORF` (rockfish other than `POP`) or `TRF` (total rockfish). Similarly, estimated discards are calculated using a ratio (called '`delta`' herein) `RRF/TAR`, where `TAR` is the target species landed by fishery.

3 Reconstruction details

3.1 Definition of terms

A brief synopsis of the catch reconstruction follows, with a reminder of the definition of terms:
Fisheries: there are five fisheries in the reconstruction (even though trawl dominates most RRF catches):

- T = groundfish trawl (bottom + midwater),
- H = Halibut longline,
- S = Sablefish trap/longline,
- DL = Dogfish and Lingcod troll/longline (originally called 'Schedule II'),
- ZN = hook and line rockfish (sector called 'ZN' from 1986 to 2006 and 'Rockfish Outside' and 'Rockfish Inside' from 2007 on).

TRF: acronym for 'total rockfish' (all species of *Sebastes* & *Sebastolobus*)

ORF: acronym for 'other rockfish' (= TRF minus POP), landed catch aggregated by year, fishery, and PMFC (Pacific Marine Fisheries Commission) major area

POP: Pacific Ocean Perch

RRF: reconstructed rockfish species (e.g., `SGR`)

TAR: target species landed catch, used for discard calculations

L & D: L= landed catch, D= releases (informally called 'discards')

gamma: geometric mean of annual ratios of landed catch, $\sum_i \text{RRF}_i^{\text{L}}/\text{ORF}_i^{\text{L}}$, grouped by major PMFC area and fishery. For `RRF` generally, reference years can be chosen from 1996 to the current year for each fishery. For any particular `RRF`, annual `gamma` ratios should be inspected to choose a suitable set of years (employ function '`plotGREFS`' after an initial reconstruction).

delta: geometric (or arithmetic) mean of annual ratios of discarded catch to landed catch, $\sum_i \text{RRF}_i^{\text{D}}/\text{TAR}_i^{\text{L}}$, grouped by major PMFC area and fishery using selected reference years i between 1996 and 2006 for the trawl fishery and between 2000 and 2004 for all other fisheries. The reduced set of years reflects periods when 'reliable' observer records where available for releases—discards.

4 Changes to the reconstruction algorithm since 2011

Stock assessments since Haigh and Yamanaka (2011) have made either permanent changes to the catch reconstruction algorithm or choices specific to the stock being assessed.

4.1 Pacific Ocean Perch (2012)

In stock assessments for POP in areas 3CD and 5DE (Edwards et al., 2014*b*,*a*), the authors documented several departures from the catch reconstruction algorithm introduced by Haigh and Yamanaka (2011).

Item 1 : drop trawl and trap records from `PacHarv3` (1954-1995) (✓ `SGR` 2025)

The initial reconstuction algorithm (Haigh and Yamanaka, 2011) used both `GFCatch` (logbook records, Rutherford 1999) and `PacHarv3` (sales slips) because it was assumed that the two databases should be recording the same landings. Under this assumption, the two sources could be compared by year and major area, and the maximum values used. Unfortunately, sales slips used large statistical areas while logbooks used PMFC areas and subareas. Conversion from the former to the latter can be performed reasonably well, but two large statistical areas in particular straddle PMFC boundaries with no easy way to assign the catch (Figure 1). The first area, coded 9021, comprises statistical areas 2E and 102, which cover large portions of PMFC 5B, 5C, and 5D. For POP in particular, area 9021 includes Moresby Gully in PMFC areas 5B and 5C. The second area, coded 9270, comprises statistical areas 27 and 127 which include a POP agglomeration in PMFC areas 3D and 5A off the NW tip of Vancouver Island. The problem occurs, for example, when `GFCatch` reports POP landings from 3D and 5A in the 9270 region while the POP landings reported by `PacHarv3` are assigned to 3D or 5A only, neither of which matches the `GFCatch` landings. There is no method for splitting the `PacHarv3` catch from these two large statistical areas.

Therefore, only the `GFCatch` database for the trawl and trap records from 1954 to 1995 were used, rather than trying to mesh `GFCatch` and `PacHarv3`. The point is somewhat moot as stock assessments since 2015 by the ORP use the merged-catch data table from `GFFOS`.

Item 2 : retain use of `PacHarv3` data for H&L fisheries (✓ `SGR` 2025)

Retain use of data for the H&L fisheries from `PacHarv3`; these data do not appear in other databases.

Item 3 : include additional BC rockfish catch for Japanese fleet (✓ `SGR` 2025)

In an earlier POP stock assessment for 5ABC (Edwards et al., 2012), Russian and Japanese catches were estimated by Ketchen (1980*b*) for the Queen Charlotte Sound (QCS) area; however, the author only supplied a one-page Appendix for estimates of Russian rockfish catch for the west coast of Vancouver Island (WCVI) and the west coast of Haida Gwaii (WCHG). Japanese catch numbers were not supplied for WCVI and WCHG in the QCS reconstruction. Fortunately, Ketchen (1980*a*) reported landings estimates of 'Pacific Ocean Perch', a term most likely including all rockfish, by the Japanese fleet. Therefore, both the Russian catch in Ketchen (1980*b*) and the Japanese catch in Ketchen (1980*a*) were used.

current defaults: `useCA = TRUE, useUS = TRUE, useFF = TRUE`

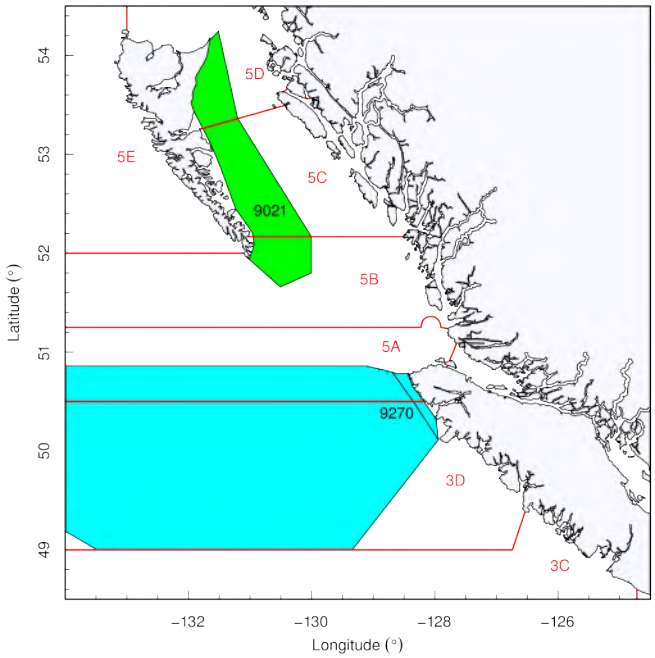

Figure 1. (*CR-PH3-Problem-Areas*) Problematic statistical areas in the `PacHarv3` database that span multiple PMFC areas : 9021 (shaded green) shows DFO statistical area 102 (inshore area 2E excluded); 9270 (shaded blue) shows DFO statistical area 127 (inshore area 27 excluded).

4.2 Yellowtail Rockfish (2014)

Item 4 : add supplementary YTR catch to '`rrfhistory`' data object (✓ `SGR` 2025)

The Yellowtail Rockfish (YTR) assessment (DFO, 2015) added supplementary data to the '`rrfhistory`' object[1], specifically YTR catch data from Canadian, US, and Polish fleets (Ketchen, 1980*a*). This was done to incorporate high catches of YTR (6,700 t in 1975 and 2,339 t in 1976) by Polish vessels in 3D.

Traditional groundfish species[2] catches were reported for 1950-1975 by Ketchen (1976). A subset of these data, '`POP`' and '`ORF`' (other rockfish excluding POP, also reported in Ketchen 1976), appear in the historical catch object called '`orfhistory`'. (`TRF`, total rockfish, is simply `POP` + `ORF`.) These data contribute to the historical rockfish catch by year that can be used to calculate `RRF` via `gamma` (e.g., `RRF/ORF`).

Primary rockfish species[3] catches were reported for the years 1967-1978 by Ketchen (1980*a*). This latter set can be added to '`rrfhistory`' (only YTR, sablefish, lingcod, and the common flatfish species were present in 2014). The CR code creates an array of reported catches called

[1] `rrfhistory` parallels the primary `POP|ORF|TRF` object called '`orfhistory`', see Haigh and Yamanaka (2011) for all historical sources

[2] English Sole (*Parophrys vetulus*), Rock Sole(*Lepidopsetta bilineatus*), Petrale Sole (*Eopsetta jordani*), Dover Sole (*Microstomus pacificus*), Rex Sole (*Errex zachirus*), Pacific Cod (*Gadus macrocephalus*), Lingcod (*Ophiodon elongatus*), Sablefish (*Anoplopoma fimbria*), Pacific Ocean Perch (*Sebastes alutus*), Spiny Dogfish (*Squalus acanthias*)

[3] Yellowtail Rockfish (*S. favidus*), Canary Rockfish (*S. pinniger*), Silvergray Rockfish (*S. brevispinis*), Yellowmouth Rockfish (*S. reedi*), Bocaccio (*S. paucispinis*), Widow Rockfish (*S. entomelas*), Redstripe Rockfish (*S. proriger*), Rougheye Rockfish (*S. aleutianus*), Redbanded Rockfish (*S. babcocki*)

'catmod'[4] (year × major × fid × catch), which are primarily Canadian but can include foreign catches if supplied through rrfhistory. Therefore, catmod is an array that contains *reported* landings and discards for RRF, as well as *reported* landings of ORF and TRF.

Item 5 : use offshore areas to calculate gamma and delta (✗ SGR 2025)

Use selected offshore areas that reflected the activity of the foreign fleets' impact on this species to calculate gamma (RRF/ORF) and delta ratios (RRF/TAR)[5]. Initially, specific areas (major, minor, locality) were provided to the CR algorithm; however, feedback from the Canadian Groundfish Research and Conservation Society (CGRCS), specifically Brian Mose, provided a fixed set of gamma values by major area for estimating YTR caught by the trawl fleet.

current defaults : `refarea = NULL, refgear = NULL`
ad hoc arguments : `pjs = FALSE, outside = FALSE`

Item 6 : specify start years for adopting reported landed catch (✓ SGR 2025)

Allow user to specify years by fishery (five-element vector called 'useYR1') for the CR to start using reported (database) catch. The default value is 1996; exceptions : 1956 for POP caught by Trawl (FID=1) and 1982 for POP|YYR caught by Dogfish-Lingcod (FID=4) or H&L Rockfish (FID=5). Estimate RRF landings (using gamma) for years earlier than the specified|default years.

current default : `useYR1 = c(1996, 2000, 2007, 2007, 1986)`

Item 7 : use a random binomial-gamma distribution to estimate gamma (✗ SGR 2025)

An experimental method was implemented to calculate gamma using a binomial-gamma distibution (Schnute and Haigh, 2003), conditioned on the data. The results provided similar gamma ratios as those derived by the mean of annual estimates. This method was only tried for YTR and RBR.

current default : `useBG = FALSE`

4.3 Shortspine Thornyhead (2015)

Item 8 : use merged catch table GF_MERGED_CATCH in GFFOS (✓ SGR 2025)

The Shortspine Thornyhead (SST) assessment (Starr and Haigh, 2017) was the first to use the merged catch table 'GF_MERGED_CATCH' in GFFOS. Previous assessments required the meshing together of catches from six separate databases: GFBioSQL (research, midwater joint-venture Hake, midwater foreign), GFCatch (trawl and trap), GFFOS (all fisheries), PacHarvest (trawl), PacHarvHL (hook and line), and PacHarvSable (trap and longline). In the end, the CR algorithm was not used for SST because it was estimating non-existent catches prior to 1996 (Brian Mose, pers. comm. 2015). Reported catches were used with a tweak to disaggregate SST catch prior to 1996 (because all thornyhead catch was called SST before this year) into SST and Longspine Thornyhead (LST).

current default : `useGFM = TRUE`

[4] from two database (DB) sources : GFFOS.GF_MERGED_CATCH and PacHarv3.CATCH_SUMMARY
[5] Redbanded Rockfish (RBR) assessment (Edwards et al., 2017) also tried defining gamma from specified areas.

4.4 Yelloweye Rockfish Outside (2015)

Item 9 : use depth-stratified `gamma` and `delta` (✗ SGR 2025)

The Yelloweye Rockfish (YYR) assessment (Yamanaka et al., 2018) introduced the concept of depth-stratified `gamma` and `delta` ratios for an inshore rockfish (shallow water, reef-based species); however, this functionality has not been used for offshore rockfish to date.

For each fishery and PMFC area, landings records were stratified by reference year and 100-m depth interval. Within each depth stratum, records that contained a non-zero ORF landing were used to calculate a ratio of total YYR to total ORF and then weighted by the number of observations within each year-depth stratum to derive a stratified-weighted `gamma` for each fishery-area combination. Within any given year, area, and fishery, at least 10% of the records had to contain a non-zero depth value to be stratified by depth. Otherwise, the year-area-fishery stratum was assumed to contain one depth zone. During the 14 May 2015 workshop, only records with a non-zero YYR catch were used in the depth-stratified `gamma` calculation, and industry pointed out that this would likely bias the estimation of YYR landings. Therefore, the YYR assessment used all records that contained a non-zero ORF landing.

current defaults: `strat.gamma = FALSE, strat.delta = FALSE`

Item 10 : fix values for the halibut fishery (✗ SGR 2025)

The Pacific Halibut Management Association (PHMA) requested a few tweaks to the YYR base case reconstruction:

- fix `gamma` for the halibut fishery (`fid`=2) by area (5A=0.25, 5B=0.25, 5C=0.375, 5D=0.3);
- set the 1999 halibut fishery catch of YYR to be 17.5% less than that for the 1998 catch.

ad hoc argument : `phma = FALSE`

Item 11 : exclude catch records from seamounts (✓ SGR 2025)

A number of commercial fishing events came from various seamounts : Bowie=4,171 records, Brownbear=472, Cobb=790, Dellwood=102, Eickelberg=804, Union=1,381. However, only Bowie and Dellwood Seamounts recorded landed catch of YYR : Bowie with 282 records (31.3 t) and Dellwood with 8 records (1.5 t). Up until this point, seamount data had been ignored (and included in CRs).

current default : `useSM = FALSE`

Item 12 : do not reconstruct catch from foreign fleets (✗ SGR 2025)

Discussion with industry at the 14 May 2015 workshop revealed that foreign catches were likely POP with no YYR bycatch.

current default : `useFF = TRUE`

Item 13 : exclude data from the experimental Langara Spit POP fishery (✗ SGR 2025)

This option is likely appropriate for inshore and/or reef-based rockfish species because they would not have been impacted by offshore experiments (or historical offshore foreign fleet activity).

current default : `useLS = TRUE`

4.5 Pacific Ocean Perch 5ABC (2017)

Item 14 : expand 5C to include southern 5E (Anthony Island) (✗ SGR 2025)

The Pacific Ocean Perch (POP) assessment in Queen Charlotte Sound (QCS, 5ABC, Haigh et al. 2018) included catches from the Anthony Island area. That is, PMFC 5C was expanded around Cape St. James (from Moresby Gully) to inclue southern 5E:

- a tow occurred in PMFC 5E with a valid latitude $\leq$ 52° 20′ North or
- a tow occurred in PMFC major 5E, minor 34, and localities 1 or 5.

current default : `useAI = FALSE`

4.6 Redstripe Rockfish (2018)

Item 15 : calculate `gamma` and `delta` using geometric means (✓ SGR 2025)

The Redstripe Rockfish (RSR) assessment (Starr and Haigh, 2021*b*), introduced the use of summarising annual `gamma` and `delta` ratios from reference years (Section A.2.2) by calculating the geometric mean across years instead of using the arithmetic mean. This choice reduces the influence of single anomalously large annual ratios.

current default : `useGM = FALSE`

Item 16 : replace observed landings with estimated ones (✗ SGR 2025)

Estimate RRF (using `gamma`) for observed landings later than 1996 for trawl and/or later than 2006 for the non-trawl fisheries, should the user have reason to replace observed landings with estimated ones.

Item 17 : specify years by fishery for discard regimes (✓ SGR 2025)

Specify years by fishery for discard regimes when discard ratios are applied. Previously, these had been fixed to 1954-1995 for the trawl fishery and 1986-2005 for the non-trawl fisheries. Note : years before the discard period assume no discarding, and years after the discard period assume that discards have been reported in the databases.

current default : `disyrs = list(1954:1995, 1986:2005, 1986:2005, 1986:2005, 1986:2005)`

4.7 Widow Rockfish (2019)

Item 18 : allocate post-EEZ foreign catch to fisheries by gear type (✓ SGR 2025)

The Widow Rockfish (WWR) assessment (Starr and Haigh, 2021*a*) found a substantial amount of WWR reported as foreign catch in the database `GFBioSQL` that came from midwater gear off WCVI. Subsequently, the catch reconstruction algorithm was changed to assign `GFBio` foreign catch to four of the five fisheries based on gear type:

- bottom and midwater trawl gear assigned to the Trawl fishery,
- longline gear assigned to the Halibut fishery,

- trap and line-trap mix gear assigned to the Sablefish fishery, and
- h&l gear assigned to the ZN rockfish fishery.

The assignment only happens if the user chooses to use foreign catch in the reconstruction. These foreign catches occurred well after the foreign fleet activity between 1965 and the implementation of an exclusive economic zone in 1977.

4.8 Bocaccio (2019)

Item 19 : specify flexible reference years to calculate `gamma` (✓ `SGR` 2025)

The Bocaccio rockfish (BOR) assessment (Starr and Haigh, 2022) used advice from the technical working group, which identified specific reference years for the calculation of `gamma`: 1990-2000 for trawl (to capture the years before decreasing mortality caps for BOR were placed on the trawl fleet) and 2007-2011 for non-trawl (to capture years after some form of observer program like electronic monitoring was applied to the hook and line fleets). The catch reconstruction algorithm was previously coded to only allow one set of reference years to be applied across all fisheries. The algorithm was changed so that a user can now specify separate reference years for each fishery.

current default : `refyrs = c(list(1996:2023), rep(list(2007:2011),4))`

Item 20 : reconcile catches from `GFM` and `PH3` (✓ `SGR` 2025)

Once the merged catch table (`GF_MERGED_CATCH` in `GFFOS`) was introduced (SST 2015), catch from all databases other than `PacHarv3` have been reconciled so that caches are not double counted. The remaining two catch data sources (GFM and PH3, for brevity) were re-assessed by comparing ORF data, and the CR algorithm was changed in how the data sources were merged for the categories `RRF landed`, `RRF discard`, `ORF landed`, `POP landed`, and `TRF landed`:

- GFM catch is the only source needed for FID 1 (Trawl fishery), as was previously assumed;
- GFM and PH3 catches appear to supplement each other for FIDs 2 (Halibut fishery), 3 (Sablefish fishery), and 4 (Dogfish/Lingcod fishery), and the catches were added in any given year up to 2005 (electronic monitoring started in 2006 and so the `GFFOS` database was reporting all catch for these fisheries by then);
- GFM and PH3 catches appear to be redundant for FID 5 (H&L Rockfish fishery), and so the maximum catch was used in any given year.

Item 21 : use historical `SBF` and `LIN` to calculate discards for `FID`s 3 & 4 (✓ `SGR` 2025)

Use historical Sablefish (SBF) and Lingcod (LIN) trawl landings from 1950 to 1975 (Ketchen, 1976) to calculate historical discards for FIDs 3 and 4 during this period. These landings could not be used directly because they were taken by the trawl fleet; therefore, an estimation of SBF and LIN landed catch by FIDs 3 and 4, respectively, relative to SBF and LIN landed catch by FID 1 (trawl) was calculated from GFM. Annual ratios of SBF_3/SBF_1 and LIN_4/LIN_1 from 1996-2011 were chosen to calculate a geometric mean; the ratios from 2012 on started to diverge from those in the chosen period. The procedure yielded average ratios: SBF_3/SBF_1 = 10.235 and LIN_4/LIN_1 = 0.351, which were used to scale the 1950-1975 trawl landings of SBF and LIN, respectively. From these estimated landings, discards of the RRF were calculated by applying `delta`.

Item 22 : reallocate PH3 records to five fisheries (✓ SGR 2025)

Re-allocate PH3 records to the various catch reconstruction fisheries based on data from 1952 to 1995. The distribution of effort (events) and catch by species for each gear type (Table 1) led to the code revision in Table 2.

Table 1. PacHarv3 (PH3) number of events reportedly catching each species and catch (t) of species from 1952-95 by gear type and species code, where SCO = Scorpionfishes, POP = Pacific Ocean Perch, YTR = Yellowtail Rockfish, YMR = Yellowmouth Rockfish, YYR = Yelloweye Rockfish, SST = Shortspine Thornyhead, PAH = Pacific Halibut, SBF = Sablefish, DOG = Spiny Dogfish, and LIN = Lingcod.

Code	PH3 Gear Description	SCO	POP	YTR	YMR	YYR	SST	PAH	SBF	DOG	LIN
EVENTS											
10	GILL NET, SALMON	55				17					164
11	NET, SET									1	
20	SEINE, PURSE, SALMON	4				2					14
30	TROLL, SALMON	4281	49	69	1	2587	11	613	40	77	5201
31	TROLL,FREEZER,SALMON	614	1	14	2	294	2	91	8	31	1752
36	JIG, HAND, NON-SALMON	1126	25	241	13	914	4	1	1	152	845
40	LONGLINE	2893	109	355	100	2738	327	4484	603	1248	2377
50	TRAWL, OTTER, BOTTOM	3910	2419	2335	1521	557	1435		2469	748	3098
51	TRAWL, MIDWATER	770	155	770	175	21	26		51	210	173
57	SHRIMP TRAWL	173	10	2		21			2	12	82
70	SEINE, BEACH	4									2
90	TRAP	74		1	1	14	18		753	3	34
CATCH											
10	GILL NET, SALMON	3.6				1.0					16
11	NET, SET									2.5	
20	SEINE, PURSE, SALMON	0.2				0.7					4.3
30	TROLL, SALMON	3060	1.3	5.6	0.0	925	2.0	538	20	70	5757
31	TROLL,FREEZER,SALMON	73	0.0	2.2	0.4	31	4.0	52	0.1	99	695
36	JIG, HAND, NON-SALMON	2133	5.2	40	4.6	745	0.1	0.3	1.1	175	1883
40	LONGLINE	6921	11	29	35	7922	91	48384	10785	21799	6119
50	TRAWL, OTTER, BOTTOM	117534	79327	28758	17609	1818	3468		6090	12637	45811
51	TRAWL, MIDWATER	17737	469	14867	735	3.3	7.7		7.9	1400	103
57	SHRIMP TRAWL	23	0.6	2.1		0.3			0.0	18	34
70	SEINE, BEACH	0.1									0.6
90	TRAP	76		0.0	0.6	3.6	6.4		50886	34	4.4

Table 2. Code extract from an SQL query 'ph3_fcatORF.sql' that defines catch reconstruction FIDs (1 = Trawl, 2 = Halibut, 3 = Sablefish, 4 = Dogfish/Lingcod, 5 = H&L Rockfish) from gear types and dominant species caught (by weight) per event in PH3 table 'CATCH_SUMMARY'.

FID definition in SQL query 'ph3_fcatORF.sql'

```
(CASE -- in order of priority
   -- originally TRAWL (otter bottom, midwater, shrimp, herring)
   WHEN TAR.GR_GEAR_CDE IN (50,51,57,59) THEN 1
   -- Partition LONGLINE
   WHEN TAR.GR_GEAR_CDE IN (40) AND TAR.Target IN ('14') THEN 2
   WHEN TAR.GR_GEAR_CDE IN (40) AND TAR.Target IN ('455') THEN 3
   WHEN TAR.GR_GEAR_CDE IN (40) AND TAR.Target IN ('044','467') THEN 4
   WHEN TAR.GR_GEAR_CDE IN (40) AND TAR.Target NOT IN ('614','455','044','467')) THEN 5
   -- Partition TROLL (salmon, freezer salmon)
   WHEN TAR.GR_GEAR_CDE IN (30,31) AND TAR.Target IN ('614') THEN 2
   WHEN TAR.GR_GEAR_CDE IN (30,31) AND TAR.Target IN ('455') THEN 3
   WHEN TAR.GR_GEAR_CDE IN (30,31) AND TAR.Target IN ('044','467') THEN 4
   WHEN TAR.GR_GEAR_CDE IN (30,31) AND TAR.Target NOT IN ('614','455','044','467')) THEN 5
   -- Partition JIG (hand non-salmon)
   WHEN TAR.GR_GEAR_CDE IN (36) AND TAR.Target IN ('614') THEN 2
   WHEN TAR.GR_GEAR_CDE IN (36) AND TAR.Target IN ('455') THEN 3
   WHEN TAR.GR_GEAR_CDE IN (36) AND TAR.Target IN ('044','467') THEN 4
   WHEN TAR.GR_GEAR_CDE IN (36) AND TAR.Target NOT IN ('614','455','044','467')) THEN 5
   -- originally TRAP (experimental, salmon, longline, shrimp & prawn, crab)
   WHEN TAR.GR_GEAR_CDE IN (86,90,91,92,97,98) THEN 3
   -- Unassigned Trawl, Halibut, Sablefish, Dogfish-Lingcod, H&L Rockfish
   WHEN TAR.Target IN ('394','396','405','418','440','451') THEN 1
   WHEN TAR.Target IN ('614') THEN 2
   WHEN TAR.Target IN ('455') THEN 3
   WHEN TAR.Target IN ('044','467') THEN 4
   WHEN TAR.Target IN ('388','401','407','424','431','433','442') THEN 5
   ELSE 0 END) AS "fid",
```

4.9 Pacific Ocean Perch (2023)

Item 23 : adjust the 5C boundary to include areas from 5B and 5E (✗ SGR 2025)

In the 2023 stock assessment of POP (Starr and Haigh, 2025*a*), the catch reconstruction (and other biological functions) were updated to more fully transfer catches from Moresby Gully in PMFC 5B and from Flamingo Inlet and Anthony Island in southern 5E to area 5C, the boundaries of which were extended around Cape St. James in 1996 for Pacific Ocean Perch and Yellowmouth Rockfish. This reallocation was previously achieved (but not implemented in catch reconstructions) by determining if tows' geographical coordinates fell within a 5C polygon extension (Figure 2). However, catch data prior to 1996 typically did not contain specific coordinate information, and an update to the historical data extract included minor PMFC areas and fishing localities to better characterise the major PMFC area identifier. Combinations of these three areas were used to reallocate fishing events to 5C when no geographical coordinates were provided:

- 5B – SE Cape St. James (major 6, minor 8, locality 6)
- 5B – Outside Cape St. James (major 6, minor 8, locality 12)
- 5E – Anthony Island (major 9, minor 34, locality 1)
- 5E – Flamingo Inlet (major 9, minor 34, locality 5)

Item 24 : adjust the 3D-5A boundary for POP south to Brooks Peninsula (✗ SGR 2025)

A year after the POP assessment had been accepted, GMU noticed a discrepancy in 3CD catch from their reporting system, Quota Management System (QMS), compared to the catch reconstruction, which relies on the Fishery Operations System (FOS). The issue was traced back to a boundary change between 3D and 5A for POP, which according to a footnote in the 2013/14 IFMP, indicated that the 5A boundary had been moved south to match the latitude at Brooks Peninsula (50.8° N). This 3D-5A adjustment (Figure 2) will be used in subsequent POP stock assessments.

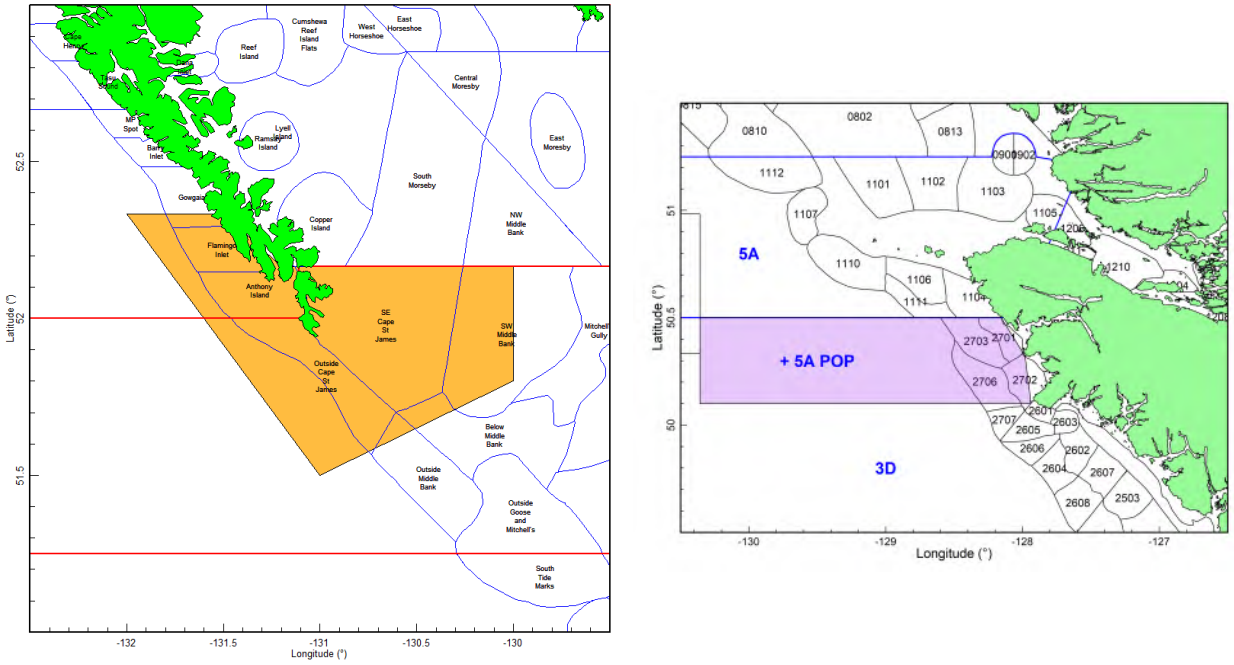

Figure 2. (Left) PMFC area extension of PMFC area 5C around Cape St. James used to manage Pacific Ocean Perch and Yellowmouth Rockfish since 1996. (Right) PMFC area extension of PMFC area 5A south to Brooks Peninsula used to manage Pacific Ocean Perch (only) since 2013. Fishing localities are labelled by PMFC minor area and locality code.

4.10 Yellowtail Rockfish (2024)

Item 25 : keep derived and reported catch periods separate (✓ SGR 2025)

The Yellowtail Rockfish (YTR) assessment (Starr and Haigh, 2025*c*) used a CR algorithm that was revised to more clearly delineate the reconstructed-catch periods from the reported-catch periods.

As previously, the reconstuction of catch prior to 1950 used early records from 1918 to 1950 (Canada Dominion Bureau of Statistics, 1918-1950). Catch of RRF in this period is *always* reconstructed from:

- `lambda` – proportion of catch by gear type '`trawl`', '`trap`', '`h&l`';
- `beta` – proportion of `h&l` by fishery (2=halibut, 4=dogfish/lingcod, 5=h&l rockfish);
- `gamma` – proportion of `ORF | TRF` allocated to RRF.

The intermediate period (1951-1995) can be a mixture of reconstructed and reported catch, or it can be entirely reconstructed. This period is almost never represented entirely by reported catch; POP would be the only exception because the earliest reported catches occurred in 1950 (Ketchen, 1976). Additionally, POP is a special case because it can be an RRF (in a POP assessment) or a reference catch for other species (although this has never been done). This middle period is complicated, but generally:

- reported catch is stored in the object '`catmod`' (primarily CA catch but can include foreign catch, see above); catches have been summed across nations;
- each component of reported catch (landed, discard, ORF/TRF) is extracted from `catmod` into two-dimensional matrices (e.g., '`repcatRRF`');
- reconstructed CA RRF is calculated two ways : (i) using `catmod` (`RRF` = `gamma` $\times$ `ORF`) and (ii) using `orfhistory` (`RRF` = `beta` $\times$ `gamma` $\times$ `ORF`), and adopts the greatest value for each year, major area, and fishery;
- reconstructed catch is summed across nations by year : 1951-1995 for CA and US, 1951-1977 for foreign fleets;
- knit the two periods together – reconstructed catch followed by reported catch.

Previously, there were sometimes grey zones where catch was a mixture of reconstructed (usually foreign) and reported (Canadian) catch within the trawl fishery. This may still be desirable (hard to anticipate) but for now, reconstruct catch prior to the EEZ year (1977) and use reported thereafter when believable records for RRF occur. Otherwise, reconstruct prior to observer years (e.g., 1996 for trawl).

4.11 Silvergray Rockfish (2025)

Item 26 : add supplementary SGR catch to '`rrfhistory`' data object (✓ `SGR` 2025)

The Silvergray Rockfish (SGR) assessment (Starr and Haigh, 2025*b*) added supplementary catch data, specifically for SGR from 1968 to 1977 from Canadian, US, and Japanese fleets (Ketchen, 1980*a*), to the `rrfhistory` object.

4.12 Changes adopted by `SGR` in 2025

A summary of the historical changes to the original catch reconstruction appears in Table 3, with the final column showing those changes adopted by the `SGR` assessment in 2025.

5 Caveats

The available catch data before 1996 (first year of onboard observer program) present difficulties for use in a stock assessment model without some form of interpretation, both in terms of misreporting (i.e., reporting catches of one species as another) or misidentifying species. There is also the possible existence of at-sea discarding due to catches exceeding what was permitted for retention. Although there were reports that fishermen misreported the location of catches, this issue is not a large problem for an assessment of a coastwide stock. Additionally, there was a significant foreign fishery for rockfish in BC waters, primarily by the United States, the Soviet Union and Japan from 1965 to 1976. These countries tended to report their catches in aggregate form, usually lumping rockfish into a single category. These fisheries ceased after the declaration of the 200-nm exclusive economic zone by Canada in 1977.

Table 3. Summary of changes made to the catch reconstruction algorithm since its inception in 2011. Final column indicates which changes might be adopted for a typical rockfish species using a check mark (e.g., SGR 2025). Acronyms: BOR = Bocaccio (rockfish), EEZ = Exclusive Economic Zone, FID = Fishery Identification number, GFFOS = Groundfish Fishery Operations System database, GFM = groundfish merged catch table in GFFOS, H&L = hook and line, LIN = Lingcod, PH3 = PacHarv3 database, POP = Pacific Ocean Perch, RSR = Redstripe Rockfish, RRF = reference rockfish, SBF = Sablefish, SGR = Silvergray Rockfish, SST = Shortspine Thornyhead, WWR = Widow Rockfish, YTR = Yellowtail Rockfish, YYR = Yelloweye Rockfish.

Item	Assessment	Description	SGR(2025)
1	POP 2012	drop trawl and trap records from PacHarv3 (1954-1995)	✓
2	POP 2012	retain use of PacHarv3 data for H&L fisheries	✓
3	POP 2012	include additional BC rockfish catch for Japanese fleet	✓
4	YTR 2014	add supplementary YTR catch to 'rrfhistory' data object	✓
5	YTR 2014	use offshore areas to calculate gamma and delta	✗
6	YTR 2014	specify start years for adopting reported landed catch	✓
7	YTR 2014	use a random binomial-gamma distribution to estimate gamma	✗
8	SST 2015	use merged catch table GF_MERGED_CATCH in GFFOS	✓
9	YYR 2015	use depth-stratified gamma and delta	✗
10	YYR 2015	fix values for the halibut fishery	✗
11	YYR 2015	exclude catch records from seamounts	✓
12	YYR 2015	do not reconstruct catch from foreign fleets	✗
13	YYR 2015	exclude data from the experimental Langara Spit POP fishery	✗
14	POP 2017	expand 5C to include southern 5E (Anthony Island)	✗
15	RSR 2018	calculate gamma and delta using geometric means	✓
16	RSR 2018	replace observed landings with estimated ones	✗
17	RSR 2018	specify years by fishery for discard regimes	✓
18	WWR 2019	allocate post-EEZ foreign catch to fisheries by gear type	✓
19	BOR 2019	specify flexible reference years to calculate gamma	✓
20	BOR 2019	reconcile catches from GFM and PH3	✓
21	BOR 2019	use historical SBF and LIN to calculate discards for FIDs 3 & 4	✓
22	BOR 2019	reallocate PH3 records to five fisheries	✓
23	POP 2023	adjust the 5C boundary to include areas from 5B and 5E	✗
24	POP 2023	adjust the 3D-5A boundary for POP south to Brooks Peninsula	✗
25	YTR 2024	keep derived and reported catch periods separate	✓
26	SGR 2025	add supplementary SGR catch to 'rrfhistory' data object	✓

The accuracy and precision of reconstructed catch series inherently reflect the problems associated with the development of a commercial fishery:

- trips offloading catch with no area information,
- unreported discarding,
- recording catch of one species as another to avoid quota violations,
- developing expertise in monitoring systems,
- shifting regulations,
- changing data storage technologies, etc.

Many of these problems have been eliminated through the introduction of:

- observer programs – at-sea observers (ASO) starting in 1996 for the offshore trawl fleet, electronic monitoring (EM) starting in 2006 for the H&L fleets, and EM replacing ASO in the trawl fleet starting in 2020 during the COVID pandemic;

- dockside [shoreside] monitoring, and
- tradeable individual vessel quotas (IVQs starting in 1997) that confer ownership of the resource to the fishing sector.

The catch reconstruction procedure does not currently rebuild catch by gear type (e.g., bottom trawl vs. midwater trawl, trap vs. longline). While adding this dimension is possible, it would mean splitting catches back in time using ratios observed in the modern fishery, which likely would not accurately represent historical activity by gear type (see similar caveats above regarding the use of modern catch ratios to reconstruct the catch of one species from a total rockfish catch).

Note that the catch reconstruction allocates catch of an RRF from unknown areas to PMFC areas proportionally by known catch in PMFC areas to reflect all potential removals of biomass from BC waters. Consequently, reported catches by area are often less than the reconstructed catches by area.

The catch for any assessment year is usually incomplete and so the previous year's catch is often adopted. Sometimes extrapolated catch is calculated based on monthly totals-to-date compared to previous catch metrics (e.g., 5-y mean monthly catches). Regardless, advice from industry should be sought, either through direct communication or via Technical Working Group participation.

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