

A new approach to quantifying non-commercial deep snapper catches in Hawai‘i based on the bottomfish vessel registry

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Executive Summary

We present a new method to estimate non-commercial (NC) catch of the main Hawaiian Islands deep 7 bottomfish complex (Deep 7) that is independent of Marine Recreational Information Program (MRIP) estimates. We used the bottomfish vessel registry (BFVR) to identify fishers without a commercial marine license (CML), adjusted these counts for inactivity and under-registration, and estimated an average of ~327 active NC fishers annually from 2011–2024. To represent their catch, we drew on low catch volume CML fishers in the Fisher Reporting System (FRS), applying filters based on Lamson et al. (2007) mail survey data and MRIP interviews of fishers who reported “never selling” their catch. We then combined fisher counts with catch-per-fisher distributions through Monte Carlo simulations to generate twelve NC catch scenarios.

Across these scenarios, mean annual NC catch ranged from 15,000 to 41,500 lb, with a central estimate of 34,000 lb/year. This represents about 10% of total Deep 7 removals. For comparison, the previous assessment estimated Deep 7 catch to be roughly 240,000 lb commercial reported and 250,000 lb for NC catch and unreported commercial catch. For the new approach proposed here—assuming 30% of commercial catch goes unreported—total Deep 7 removals declined from ~490,000 lb/year to ~359,000 lb/year. ‘Ōpakapaka *Pristipomoides filamentosus* and ehu *Etelis carbunculus* accounted for most NC catch, while lehi *Aphareus rutilans*, hapu‘upu‘u *Hyporthodus quernus*, and gindai *Pristipomoides zonatus* contributed relatively little.

Our BFVR-based method improves precision (CV ~7% vs. ~30% for MRIP) and separates NC and commercial fleet dynamics, addressing long-standing concerns about MRIP estimates. Fishers who participated in our workshops agreed that NC catch is small (roughly 8–12% of total) and should be considered independently of the commercial sector. We recommend that future Deep 7 assessments explore replacing MRIP-based NC catch estimates with this approach, which provides a more realistic and stable framework for stock assessment which is embraced by participating fishers.

Section I: Introduction

Background

The deep bottomfish fishery in the main Hawaiian Islands harvests six deep-slope snappers and a grouper that inhabit offshore habitats at depths between 50 and 200 fathoms. These species include the snappers onaga *Etelis coruscans*, ehu *Etelis carbunculus*, 'ōpakapaka *Pristipomoides filamentosus*, kalekale *Pristipomoides sieboldii*, gindai *Pristipomoides zonatus*, and lehi *Aphareus rutilans*; and the grouper hapu'upu'u *Hyporthodus quernus*. Collectively referred to as the main Hawaiian Islands deep 7 bottomfish complex (Deep 7), these species are integral to Hawai'i's cultural traditions, local food systems, and small-boat commercial and recreational fisheries.

Stock assessments of the Deep 7 complex are led by NOAA's Pacific Islands Fisheries Science Center (PIFSC) in collaboration with the State of Hawai'i; outputs are used by the Western Pacific Regional Fishery Management Council (WPRFMC) to set annual catch limits (ACLs). These assessments have increasingly recognized the importance of including total fishing removals—commercial, unreported, and non-commercial (NC)—to ensure accurate estimation of stock status and sustainable harvest levels (Brodziak et al., 2011; Langseth et al., 2018; Moffitt et al., 2006; Syslo, 2021).

Since 1948, the State of Hawai'i has required any fishers that intend to sell fish to obtain a low-cost commercial marine license (CML) and report all their catch—including unsold—in the Fisher Reporting System (FRS). This long-standing requirement effectively helped define the commercial and non-commercial fishery sectors, at least from a management perspective. It is worth noting that CML-holding fishers selling fish to cover trip costs may not see themselves as “commercial.” The reliance on fishers to self-report catch also introduced another category of catch—unreported commercial—which managers and stock assessment scientists struggle to estimate. A third category of catch comes from the NC sector, represented by fishers with no CML and therefore no reporting requirement.

In the past, PIFSC scientists have used one-time port sampling (Hamm & Lum, 1992) or mail surveys (Lamson et al., 2007) to provide point estimates of the ratio of non-commercial to commercial catch; however, we recently transitioned our focus to the Hawai'i Marine Recreational Fishing Survey (HMRFS), now part of the Marine Recreational Information Program (MRIP).

HMRFS started in 2003 and combines mail surveys of fishing effort (number of angler-trips in a two-month period) with port sampling of fisher catch. Combining catch-per-angler-trip with the total number of angler trips provides annual estimates of “recreational” catch. However, the use of HMRFS data has raised concerns with the Deep 7 fishing community that it overestimates the size of the non-commercial sector in addition to being highly variable.

Part of the issue is that HMRFS targets the “recreational” sector by 1) asking fishers how many “recreational” trips they conducted, and 2) only filtering out catch interviews from self-identified full-time commercial fishers. This creates a potentially significant overlap with the commercial (CML) sector, which includes part-time/subsistence fishers who are required to report their catch in the FRS (Figure 1). A recent HMRFS change to filter out catch interviews from trips with a primary commercial purpose (instead of only full-time fishers) does not eliminate this potential overlap and the problem remains.

Non-commercial catch estimates in past stock assessments

The 2011 benchmark stock assessment (Brodziak et al. 2011) was the first Deep 7 assessment to include an estimate of non-commercial catch in the assessment model, based on the work by Martell et al. (2011) and Courtney and Brodziak (2011). To do so, it split the catch time series into two periods: 1948–1999 and 2000–2010. For the first period, it used calculations by Martell et al. (2011) based on data collected by Hamm and Lum (1992)—a one-year port survey around O‘ahu. Hamm and Lum (1992) estimated that only 34% of “bottomfish” catches were sold. However, “bottomfishes” included non-Deep 7 species.

To correct for this, Martell et al. (2011) first calculated the total commercial “bottomfish” catch and multiplied it by 1.94, the ratio of non-commercial to commercial catches (0.66/0.34) from Hamm and Lum (1992). This provided the total non-commercial “bottomfish” catch, which was then split into its component species using species catch proportions from Hamm and Lum (1992). The species-specific NC catch estimates for the Deep 7 were then divided by their corresponding 1990–1991 commercial catch to obtain per-species non-commercial-to-commercial catch ratios. It is important to note that an error in Martell et al. (2011)—where the total FRS catch used in the above calculation also included Northwest Hawaiian Islands data—led to an overestimation of these catch ratios. Correcting this mistake brought the mean 1948–1999 NC-to-commercial catch ratio from around 1.7:1 to 1:1 (see Figure B3 in Syslo et al., 2024). For the 2000–2010 period, Brodziak et al. (2011), following Courtney and Brodziak (2011), combined catch ratios obtained from Lamson et al. (2007) and the first two years of HMRFS.

Lamson et al. (2007) conducted a one-time mail survey of fishers on the bottomfish vessel registry that asked questions related to species-specific annual catch, catch disposition, and fisher type (e.g., “Do you ever sell your catch?”). This allowed for a fairly straightforward calculation of species-specific NC-to-commercial catch ratios for the Deep 7, averaging only 0.2:1.

At the time, HMRFS provided two years (2004–2005) of species-specific catch estimates that likely included a significant amount of FRS-reported catch, given that these surveys only excluded full-time commercial fishers, and likely included many CML holders. This is likely the reason why the mean Deep 7 ratios for these two years were unexpectedly high (around 4:1 for ‘ōpakapaka) and very different from the Lamson et al. (2007) study (0.2:1). Despite this, the mean ratio for these two sources were combined and averaged around 1.1:1 for the 2000–2010 period. Finally, for both the 1948–1999 and 2000–2010 periods, Brodziak et al. (2011) simply

multiplied the per-species annual commercial catch with the species-specific ratios and summed the 7 species together to get annual total Deep 7 catch. This general approach to generate non-commercial catch was used mostly unchanged until the 2024 benchmark assessment (Langseth et al., 2018; Syslo, 2021).

For the 2024 benchmark assessment, Syslo et al. (2024)—based on the work by Ma et al. (2023)—used a significantly different approach to estimate non-commercial Deep 7 catch for the post 2004 period. It focused entirely on the HMRFS data, which included almost 20 years of data. To do so, they modified the HMRFS annual catch estimates by removing the catch flagged “to be sold” and smoothed catch rate estimates using a Kalman filter. They calculated the ratios of NC-to-commercial catch by species and year from 2003–2022. However, given the high variability associated with HMRFS Deep 7 catch estimates (percent standard errors—or PSE—around 30%–50%)—and, thus, the high annual variability in the NC-to-commercial catch ratios—Syslo et al. (2024) elected to average those 19 years together to obtain a global ratio for each species. These species-specific ratios were used to multiply the species’ annual commercial catches to obtain total catch by species and total Deep 7 catch by year by summing the seven species together (Syslo et al., 2024).

It is important to point out that the various approaches to obtain non-commercial catches described above did not resolve the issue of the potentially significant overlap with the commercial sector catch as reported in the FRS. These approaches attempt to separate commercial catches from various data products by filtering out sold catches. However, this does not remove the unsold catch by CML holders from these data products, thus creating an unclear estimate of non-commercial (i.e., non-CML) catch. This likely introduces a positive bias on total Deep 7 catch estimates. PIFSC researchers have long recognized this issue, and we have often suggested that these estimates not only contain non-commercial catch, but also include unreported and even reported commercial catch (Figure 1). For example, Courtney and Brodziak (2011) states:

Estimates of “nonsold” catch from Hamm and Lum (1992) may overestimate the recreational catch component because they probably include both recreational catch and unreported commercial catch (Hamm and Lum 1992). As a result, we also interpreted the ratio 1.94 from Martell et al. (2006) as the ratio of total unreported catch to reported commercial catch (i.e., $U_r = 1.94$).

This has led to some confusion regarding Deep 7 catch terminology, with “non-commercial”, “recreational”, and “unreported” terms be used to describe non-CML catch estimates in various reports, sometimes without specifying whether catch included unreported commercial catch estimates. In addition to this confusion, the aforementioned approaches present two important issues: 1) the high variability associated with these non-commercial/unreported catch estimates forces the use of multi-year average NC-to-commercial ratios, and 2) the use of these ratios in combination with reported commercial catch ties the non-commercial sector to the commercial sector, despite clear suggestions from fishers that these sectors do not evolve following the same dynamic. Given these issues, it is clear that a new approach is needed.

An alternative approach to estimating non-commercial catch

One important and under-utilized data set pertaining to the Deep 7 fishery is the bottomfish vessel registry (BFVR). First established in 1998, the Hawai'i Administrative Rule Chapter 13-94 requires that any vessel catching a Deep 7 species must obtain a bottomfish registration number (at no cost), and must clearly identify their boat with "BF" letters. The original BFVR list was open-ended, and vessels were continuously added to it with no renewal requirement. This led to a consistently increasing list of vessels that were potentially no longer in use. In late 2011, the BFVR system was updated to require annual registrations forcing Deep 7 fishers to renew their BFVR every year. This change ultimately made the BFVR useful to track the number of registered Deep 7 fishers by year.

Recently, Helyer (2024) explored a new way of estimating non-commercial Deep 7 catch using this registry. This approach uses the number of vessels on the BFVR in a given year and removes those associated with a CML to generate an estimate of the number of non-commercial Deep 7 fishers by year. Helyer (2024) then explored multiple approaches to identify CML fishers whose reported catch compositions were representative of non-commercial fishers. Multiplying the number of non-commercial BFVR vessels by average annual catches from CMLs identified as representative of non-commercial fishers provides an alternate estimate of the non-commercial Deep 7 catch. Helyer (2024) explored further scenarios, such as doubling the number of non-commercial BFVR vessels to account for potential under-reporting of the BFRV. The resulting NC catches were much smaller than values derived from methods used previously in stock assessments, supporting the contention that Deep 7 NC catches have been over-estimated in the past.

The primary objective of the current report is to build on the work done by Helyer (2024) and develop an alternative approach to estimating non-commercial (NC) Deep 7 bottomfish catch that is independent of estimates derived from HMRFS. This approach is intended to be transparent, reproducible, and suitable for review by stakeholders, and to potentially replace the current HMRFS-based approach. This work contributes to a broader effort to improve understanding of the main Hawaiian Islands Deep 7 fishery, particularly regarding the magnitude of non-commercial fishing activity.

To achieve this objective, the report first examines the bottomfish vessel registry (BFVR) as a tool for identifying the potential universe of NC Deep 7 fishers. Then, it uses the commercial fishing report database to identify CML fishers whose fishing behavior may approximate that of non-commercial fishers under different hypotheses. A method is presented for generating annual fishing effort and catch distributions based on these groups, simulating plausible NC catch scenarios. The resulting simulations are evaluated for realism by comparing descriptive statistics with historical data from prior surveys of small-boat bottomfishing in Hawai'i. Finally, the alternative NC catch scenarios developed here are compared with reported commercial catch and with the two MRIP/HMRFS-based NC estimates.

Section II: Methods

As explained above, the BFVR non-commercial catch approach consists of two major steps: 1) obtaining the number of active non-commercial bottomfish-registered fishers by year, and 2) selecting fishers from the FRS that are representative of non-commercial fishers and summarizing their annual Deep 7 catch. Multiplying these two estimates together provide an estimate of annual non-commercial Deep 7 catch for the fishery. These steps are described sequentially in the following sections. The full script, formatted in Quarto R markdown, is available on GitHub upon request.

Number of active non-commercial bottomfish fishers

A transaction list of vessel registration activity associated with the BFVR going back to 2011 was obtained through Western Pacific Fisheries Information Network (WPacFin). This list contains fisher name, address, phone number, CML number (if any), State of Hawai'i or Coast Guard vessel identification number, transaction action (renewal, new, etc.), and transaction date, among other fields.

As a first step, we cleaned this list and re-organized it in order to merge it with the CML fisher list. To do so, we cleaned and standardized data fields such as vessel registration number, CML number, fisher name, and address to remove whitespace, harmonize formatting, and resolve inconsistencies. For all vessel registration numbers, a transaction activity within a given year was used to determine the years a vessel was registered, using the *transaction date* and *transaction expiration date* fields. Then, the cleaned dataset was reshaped to a “wide” format by spreading vessel registration numbers into columns, with each row representing a unique fisher-year combination. This transformation facilitated identification of fishers associated with multiple vessels across different years and changed the BFVR “vessel” list into a “fisher” list, which was necessary to cleanly merge it with the CML fisher list.

The CML fisher list is needed to remove commercial fishers from the BFVR list obtained from the above steps. We decided to use the FRS data itself to derive this list instead of the CML license transaction list since it contained fewer mistyped names and addresses. Instead, the name and addresses can be obtained from the licensee table, which is also available from WPacFin. One issue with this approach is that the licensee table only contains a fisher's most recent address, which can complicate assigning fishers to specific counties if they moved between counties in previous years (note: this issue could be resolved by looking at fishing grid or landing port information).

After downloading the FRS data from the WPacFin database and merging it with the licensee information, we selected records from 2011 to present and from the “BF”, “FR” and “DNF” (i.e., did not fish) record types (thus excluding aku, bait, and aquarium reports). We also removed charter vessels and shore-based reports (i.e., reports with no associated vessel ID). As with the

BFVR list, we cleaned and standardized the various fields (name, address, vessel ID, etc.) and harmonized their formatting. We also pivoted “wide” the vessel ID field into columns, since certain fishers reported catch from multiple boats in a given year.

At this point, the CML and BFVR lists were both formatted as “fisher x year” lists, with the BFVR list containing information about fishers with BF-registered boat(s) and the CML list containing information about the possession of a CML, by year between 2011 and present.

In a final step, we merged the cleaned BFVR and CML fisher lists by year and multiple fisher identifiers (e.g., CML number, name + vessel ID, name + address, phone number) to create a master list of all registered small boat fishers in Hawai‘i, with yearly information regarding their BFVR and CML registration status. From this list, we were able to calculate the number of fishers with BF-registered boats—but no CML—for each of the four counties in Hawai‘i (i.e., the number of non-commercial registered Deep 7 fishers by county). The few fishers who only had BFVR or CML addresses from the continental U.S. were randomly assigned to one of the counties, proportionally to the number of registered fishers in each county.

The number of non-CML *BF-registered* fishers provided us with a starting point to estimate the number of *active* non-commercial Deep 7 fishers. Not all BF-registered fishers are actively fishing for Deep 7 bottomfish and, conversely, it is possible that some fishers are catching Deep 7 without being on the BFVR. For example, some fishers may be renewing their BF registration as a routine, even if they have not targeted Deep 7 in years, or some new Deep 7 fishers may not be aware that a BF registration is legally required for their boat. Therefore, the initial non-CML BF-registered count should be adjusted downward to exclude inactive fishers, and upward to account for fishers that are actively fishing for Deep 7 but are not BF-registered.

These two adjustments would then result in an annual estimate of the number of *active* non-commercial bottomfish fishers (i.e., fishers that will catch at least one Deep 7 throughout the year). There are currently no immediate ways to estimate these two adjustment factors. For example, the State’s enforcement officers do not often check BF registration status for fishers with Deep 7 catches (Division of Conservation and Resources Enforcement, DOCARE, 2025 [personal communication]). We asked experienced Deep 7 fishers during a workshop what their estimate of these two adjustment factors might be, which we used as a starting point. These are discussed later in the Results section.

Annual catch per fisher

The second major step was to obtain estimates of average annual catch from the FRS associated with commercial fishers with fishing activity profiles representative of non-commercial Deep 7 fishers. In other words, casual or low-volume CML holders whose fishing behavior is assumed to reflect that of true non-commercial participants. Helyer (2024) explored three different approaches in selecting these more casual fishers: 1) non-highliner fishers (<1,000 lb per year), 2) no-sales non-highliner fishers (same as previous, but never sell catch), and 3) an unsupervised cluster analysis based on species-specific nominal catch per unit effort

(CPUE). The 1,000 lb per year limit defining highliner was somewhat subjective, following the definition used by Hospital & Beavers (2012). To move towards a more objective limit, we reviewed all available literature and data products containing some quantitative information on the Hawai'i non-commercial bottomfish fishery.

In short, we determined that the one-time port sampling effort from Hamm and Lum (1992), identifying catch disposition (sell vs. keep) for “bottomfish” to be of limited usefulness, given the lack of taxonomic resolution allowing us to isolate Deep 7 catches and the lack of fisher profile information allowing us to isolate non-commercial fishers. Additionally, this sampling effort is dated and less relevant, since it occurred 35 years ago.

The series of reports by Zeller, culminating with Zeller et al. (2007), mainly contained broad comparisons of one-time market and shoreline surveys with reported FRS catches and aggregated coral-reef and bottomfish species. This made these studies heavily dependent on assumptions and of limited relevance to non-commercial Deep7 fishers. In a more recent study, Hospital et al. (2011) surveyed fishers at port around Hawai'i regarding their fishing activity and catch. However, they classified fishers based on the sale of any fish in the last year, with full-time commercial fishers defined as those depending on selling fish for more than 50% of their income. This definition does not align with the CML-based definition of commercial fishing that is needed to cleanly separate FRS catches from the rest and this limits its usefulness for our purpose. Hospital and Beavers (2012) mailed 1,012 questionnaires to bottomfishers across the state, but only sent mail to CML holders and holders of the federal non-commercial bottomfish permit. A limited number of bottom fishers obtained these federal permits, mainly O'ahu-based fishers that fish on Penguin Bank. The lack of information about general non-commercial fishers limited the use of this study for our needs.

Overall, we settled on two sources of quantitative information to help characterize non-commercial Deep 7 fishers: a mail survey based on the BFVR from Lamson et al. (2007) and the 2003–2022 HMFERS boat-based creel interviews conducted across ports in Hawai'i. Both of these sources report catches at the species level and asked a few key questions to fishers, including “Do you ever sell fish?”, which allowed us to filter for exclusively non-commercial fishers (i.e., those likely without a CML and no reporting requirements).

Lamson et al. (2007) conducted a mail survey of Hawai'i bottomfish fishermen during 2005–2006 to quantify fishing activity and catch. They mailed questionnaires to all 3,678 individuals listed on the state's bottomfish vessel registry and received 802 responses (22%), which covered the period July 2004 – June 2005. After re-entering and screening the data, they retained approximately 292 active fishermen for analysis. They asked respondents whether they sold any bottomfish in order to classify commercial status and collected self-reported catch in both pounds and numbers of fish for each of the Deep 7 species and uku.

We obtained the Lamson et al. (2007) dataset and used it to generate annual catch distributions for the self-identified “never sell their catch” (i.e., non-commercial) fishers, for both aggregated Deep 7 catches and individual species. In a similar fashion, we used the 2003–2022 creel interviews conducted by HMRFS to generate distribution of Deep 7 catch-per-trip, at

both the aggregate and species-level. We only selected fishers that responded that they “never sell their catch” for this analysis. We had to limit our data to pre-2023 interviews given that HMRFS no longer conducts a full fisher profile during interviews following the implementation of electronic tablets for data entry.

The annual non-commercial catch distributions from Lamson et al. (2007) and the per-trip non-commercial catch distributions from HMRFS can both be used to generate filters to select non-commercial proxy fishers from the FRS. We tested using the 95th and 99th percentile of these distributions to classify all fishers in the FRS within a given year. For the per-trip HMRFS filter, we classified all fishers in a given year that reported a single trip with higher Deep 7 catches than the above percentiles as “commercial” and identified the remaining fishers as “non-commercial.” For the annual Lamson filter, we calculated the annual Deep 7 catch-per-fisher in the FRS and classified fishers as commercial and non-commercial following the annual percentile limit described above. Finally, we applied these filters either for Deep 7 aggregated catch or aggregated catch in addition to species-level catch. This gave us 12 different ways to filter the FRS for annual catch per fisher (95th or 99th percentile, Lamson and/or HMRFS filters, Deep 7-only or additional species-level filters).

Total non-commercial catch estimation

The final step in generating an archipelago-wide estimate of non-commercial Deep 7 catch was to combine the number of active non-commercial fishers derived previously with these per-fisher annual catch estimates by year. To do so, we ran a Monte Carlo simulation sampling from the distribution of the number of active Deep 7 fisher by county and multiplied these values with annual catch-per-fisher values sampled (with replacement) from the county-specific distributions. This provided us with a distribution of Deep 7 non-commercial catch by county, which were then combined to generate a final distribution of non-commercial catch by year.

Section III: Results

Number of active non-commercial fishers

The first step in our non-commercial catch estimation was to identify the number of active NC fishers using the BFVR. We began by cleaning both the BFVR transaction list and the CML fisher list, then merged them using CML number, name, address, and other identifiers. This produced a yearly list of “registered” fishers (those appearing in either the BFVR or CML) from 2011–2024.

On average, about 3,100 fishers were registered each year, of which roughly 1,300 appeared in the BFVR. Among these BFVR fishers, approximately 420 per year did not hold a CML and, thus, represent potential non-commercial Deep 7 fishers (Table 1). Figure 2 presents the number of registered commercial and non-commercial fishers by year and county.

As previously explained, these values need to be adjusted to remove inactive BFVR-registered fishers and add unregistered active fishers, following this equation:

Equation 1.

$$Total\ active = Registered \times Prop\ reg\ active + Total\ active \times Prop\ unreg\ active$$

which simplifies to

Equation 2.

$$Total\ active = \frac{Registered \times Prop\ reg\ active}{1 - Prop\ unreg\ active}$$

where *Total active* is the number of active non-commercial Deep 7 fishers, *Registered* is the raw number of non-commercial fishers on the BFVR (as explained above), *Prop reg active* is the proportion of BFVR-registered fishers that are actively catching Deep 7, and *Prop unreg active* is the proportion of total active NC fishers that are not on the BFVR.

Since we lack definitive estimates for these two proportions, we consulted eight experienced Deep 7 fishers during a workshop and asked them to provide informed estimates. On average, they suggested that 52.5% of BFVR-listed fishers (range: 0–80%) actively target Deep 7, and that 32.5% of active Deep 7 fishers (range: 10–60%) are not listed on the BFVR. Combining these proportions yielded a global correction factor of 0.778, which we applied to the registered values described above. As a result, the average of 420 BFVR-registered non-commercial fishers per year corresponds to an estimated 327 active non-commercial Deep 7 fishers (Figure 3). This correction factor was applied in all subsequent analyses.

Annual catch per fisher

The second step in our approach to estimating non-commercial Deep 7 catch was to identify representative fishers from the FRS dataset. As described in the Methods section, we focused on two sources: the annual catch mail survey conducted by Lamson et al. (2007) and MRIP trip-level catch interviews from 2003–2022, selecting only those fishers who reported “never selling” their catch.

Between 2003 and 2022, MRIP trip interviews asked fishers whether they “never sell” their catch, allowing us to identify non-commercial proxy fishers. Of roughly 30,000 total interviews, 3,408 were from bottomfish trips, and only 571 involved fishers who caught uku or Deep 7 and reported “never selling” (reduced to 233 when excluding uku). Due to this small sample size, we pooled all years for analysis. Figure 4 shows the distribution of per-trip Deep 7 catch for these fishers (both aggregated and by species), including the 95th and 99th percentiles. For aggregated Deep 7 catch, the 95th and 99th percentiles were 70 and 101 pounds per trip, respectively.

The Lamson et al. (2007) mail survey of annual catch provided another way to filter the FRS dataset. Of the 802 responses received, 292 active fishers were retained for analysis. We further narrowed the sample to 244 fishers who reported catching uku or Deep 7 species, and then to 107 who reported “never selling” their catch. Figure 5 shows the distribution of annual Deep 7 catch for these fishers, both aggregated and by species with the 95th and 99th percentiles indicated. For aggregated Deep 7 catch, the 95th and 99th percentiles were 445 and 491 pounds per year, respectively.

We note here that there were not enough observations in either the MRIP trip interviews or Lamson mail survey for two Deep 7 species, the grouper hapu’upu’u and the snapper lehi. These were excluded from the species-specific filters, while included in the Deep 7 filter.

Figure 6 and Figure 7 compare the distributions of per-trip and annual Deep 7 catch for NC fishers with those of all CML fishers in the 2023 FRS dataset. As expected, NC fishers caught substantially less Deep 7 than commercial fishers, both on a per-trip and yearly basis.

Total non-commercial catch estimation

In the final step, we estimated annual non-commercial Deep 7 catch using Monte Carlo simulations. For each run, we multiplied the number of active fishers in each county by county-specific estimates of annual catch per fisher, then combined these results to produce yearly catch distributions for the main Hawaiian Islands. We applied this approach across:

- **Three FRS filter levels:** Lamson (annual catch), MRIP (per-trip catch), and both (L+M)
- **Two taxonomic levels:** Deep 7 only (D7) and Deep 7 plus species-specific (D7+Spp)
- **Two percentiles:** 95th and 99th

Throughout the text, we refer to scenarios by filter level (Lamson, MRIP, or L+M), taxonomic level (D7 or D7+Spp), and percentile (95th or 99th). For example, *MRIP D7 99th* denotes the MRIP-only per-trip filter applied to Deep 7 catch at the 99th percentile of the distribution.

The combination of filters produced 12 NC catch scenarios, with average annual catch (2012–2024) ranging from 15,000 to 41,500 lb (Table 2). As expected, scenarios using the 99th percentile filter, the Lamson-only annual catch filter, and the Deep 7-only filter generated the highest estimates. Specifically, the *Lamson D7 99th* scenario produced the largest catch, while the *L+M D7+Spp 95th* scenario produced the smallest. Despite differences in scale, temporal trends were broadly similar across four representative scenarios (Figure 8).

These scenarios were discussed with bottomfish fishers during two workshops. The first workshop discussed most of these decision points, while the second workshop was focused on the proportion of inactive and unregistered fishers and exploring per-trip MRIP filters applied to Deep 7 only. An interactive tool using the “R Shiny application” platform was developed to help these discussions and exploration (see Appendix A). Following these meetings, we decided to focus further explorations on the *MRIP D7 99th* scenario, which represents a middle-of-the-road catch estimate (Table 2) and is one of the more parsimonious ones (i.e., a single filter source applied only to total Deep 7 catch).

Focusing on the *MRIP D7 99th* scenario, Figure 9 shows annual distributions of Deep 7 non-commercial catch by county. Average catches were lowest in Kauaʻi and Maui counties (≈5,000 lb/year), followed by Hawaiʻi County (≈10,000 lb/year) and Honolulu County (≈15,000 lb/year). Species-specific results (Table 3) indicate the smallest catches for lehi, hapuʻupuʻu, and gindai (≈1,000 lb/year each), with higher averages for kalekale (≈2,000 lb/year), onaga (≈3,800 lb/year), ehu (≈6,600 lb/year), and ʻōpaka (≈7,400 lb/year).

The 2024 Deep 7 stock assessment estimated NC catch from MRIP by excluding trips where fish were reported “to be sold,” yielding an average of about 250,000 lb/year. An alternative approach is to restrict MRIP to fishers who reported “never selling” their catch, then expand their CPUE after removing roughly 30% of effort attributable to commercial trips. Applying a 0.75 multiplier to correct for known bias in MRIP effort estimates (Ma, 2026 [personal communication]) reduced this estimate to an average of about 100,000 lb/year for 2012–2022. For comparison, our *MRIP D7 99th* scenario produced a mean of 34,000 lb/year, while the highest of our scenarios reached 41,500 lb/year. Temporal trends for these three sources are shown in Figure 10.

If the *MRIP D7 99th* scenario is used as a base case and it is assumed that 30% of total commercial catch is not reported in the FRS—as roughly suggested by fishers during workshops—NC catch represented about 10% of the total, while the highest scenario tested (*Lamson D7 99th*) increased this share to 12% (Figure 11). The coefficient of variation (CV) around these estimates is low (at about 7%). However, this only reflects the variability in annual catches, and it does not include the uncertainty in the two adjustment factors for the number of NC vessels (go to Discussion). Overall, the estimated total Deep 7 catch declined from an average of 490,000 lb/year using methods included in the 2024 stock assessment to 359,000 lb/year using the current approach.

Section IV: Discussion

This study developed and tested a new approach for estimating NC catch of the main Hawaiian Islands Deep 7 bottomfish complex that is independent of MRIP/HMRFS. Using the bottomfish vessel registry (BFVR), we first identified the annual number of BF-registered fishers without a CML and adjusted these counts for inactivity and under-registration based on fisher input, arriving at an average of about 327 active NC fishers per year from 2011–2024. We then used FRS to identify low-volume CML fishers whose fishing behavior most closely resembled that of NC fishers, filtering their annual catch using percentile thresholds derived from Lamson et al. (2007) mail survey data and MRIP trip-level interviews of “never sell” fishers. Multiplying the distribution of active NC fishers by the catch distributions of these proxy fishers through Monte Carlo simulations produced a suite of twelve NC catch scenarios.

Across scenarios, mean annual NC Deep 7 catch from 2012–2024 ranged from 15,000 to 41,500 lb, with the *MRIP D7 99th* percentile filter providing a middle-ground estimate of about 34,000 lb/year. These values are similar to those found by Helyer (2024) using the “no sale/no highliner” filter when selecting proxy non-commercial fishers (~20,000 lb) but about half the value found when only using the “no highliner” filter.

The results of the BFVR approach contrasts sharply with the ~250,000 lb/year NC catch values used in the 2024 stock assessment, or even the ~100,000 lb/year obtained from an effort-corrected MRIP approach using only interviews from fishers who “never sell”. Under the new method, NC catch represented only ~10% of the total Deep 7 harvest (up to 12% in the highest scenario), and total catch was reduced from ~490,000 lb/year to ~359,000 lb/year depending on assumptions about unreported commercial removals. Species-specific results highlight that ‘ōpaka and ehu dominate NC catches, while lehi, hapu‘upu‘u, and gindai contribute relatively little.

It is important to note that previous Deep 7 stock assessments have usually interpreted the NC catch in a broader category of “unreported” catch, that includes both NC and unreported commercial catch (Figure 1). This interpretation was in recognition that HMRFS/MRIP catch estimates will capture a significant amount of CML-reported commercial catch while attempting to estimate non-commercial catch, and that removing “sold” catches will still leave unsold CML-reported catches in the estimate. However, the level of overlap is unclear and the high level of “unreported” catch was deemed unrealistic by fishers and SSC members. In contrast, the current estimate of ~10% of total catch associated with non-commercial fishers, combined with a rough estimate of 30% unreported commercial catch, was deemed more realistic by the bottomfish fishers involved during our workshops on this subject.

Another significant advantage of this new approach is the higher precision of the catch estimates, which has a CV around 7% compared with the high variability associated with the MRIP (CV>30%). It is important to note that this CV does not take into account the uncertainty in the adjustment factors for inactive fishers on the BFVR or Deep 7 fishers that were unregistered.

Fishers at our workshops estimated the percent of Deep7 fishers not on the BFVR to be around 33%, but this value ranged from 10% to 60%. Similarly, the percent of BFVR fishers that actually catches Deep 7 was estimated at around 52.5% with values ranging from 30-80%. If we look into the FRS data, these percent values are smaller and, therefore, have less of an impact. Only 21% of fishers reported Deep 7 catch without being listed on the BFVR, and only 15% of BFVR-listed fishers not catching any Deep 7 in a given year. Using these two correction factors, we obtain an average of 452 active Deep 7 NC fishers compared to 327 using the factors estimated by fishers. Under the *MRIP D7 99th* scenario, NC catch would increase to 46,746 lb/year from 33,826 lb/year (composing 15% of the total catch instead of 10%).

More work needs to be done to better understand these two correction factors, such as querying a larger group of fishers, collaborating with DOCARE officers, increasing the outreach to fishers explaining the BFVR, and sending a mail survey to all fishers on the BFVR. More effort is likely needed to ensure the integrity of the BFVR through a combination of outreach (e.g., emails, fishing tournaments, meetings) and verification (e.g., DOCARE officers issuing warnings for fishers with Deep 7 catches and no BFVR).

The lower CV associated with this approach would lead to an important improvement in the way we model the Deep 7 fishery by separating the temporal dynamic of the NC and commercial sectors. Currently, the high variability associated with the MRIP NC catch estimate requires recreating the NC catch using a 20-year ratio of the NC-to-commercial catch and applying this ratio to the annual commercial catch. We know that these two sectors do not operate following the same dynamic and that separating these is a more accurate representation of the Hawai'i bottomfish fishery, even if the NC sector is likely only a small component (~10% of the catch).

Another important implication is the potential change in our estimates of total Deep 7 catch and its impact on our population models and, ultimately, stock status and ACLs. As mentioned previously, using the *MRIP D7 99th* NC catch scenario and assuming 30% of commercial catch is unreported, average annual Deep 7 catch estimates would decrease to 359,000 lb/year from the 490,000 lb/year average included in the 2024 assessment. In this new catch framework, NC catch is independent of the commercial catch and could change model dynamics and outputs. However, given the stability of the NC catch between 2011–2024 and its small size compared to the commercial sector, biomass dynamic models using the BFVR approach would behave similarly to the 2024 assessment (i.e., similar stock status and population trajectories).

As seen in our R interactive application, the difference is mainly in population scale across the temporal range (1948–2024), given the smaller catch estimates. This type of change in catch data does not lead to significant changes in population dynamics and stock status; it mainly impacts the scale of the population estimate (Rudd & Branch, 2017). This was confirmed in our exploration of changes in catches through the interactive application, where we ran biomass dynamic models across a range of NC catch scenarios.

For the *MRIP D7 99th* scenario and 30% unreported commercial catch, the total ACL would go from 1,008,000 lb in the 2024 assessment to 813,885 lb. However, the proportion of the ACL

allocated to the commercially reported sector would increase from 47% to 53%, resulting in the ACL for the commercially reported sector remaining stable at 493,000 lb (Table 4). Figure 12 provides a visual representation of the total ACL by sector, between the 2024 assessment and the *MRIP D7 99th* scenario. It is important to note that the emergence of online marketplaces through social media in the early 2010s may have led to an increasing trend in unreported catches, which would bias our assessment models. This will need to be investigated further in future research track projects.

Recommendations for future research

The proposed approach to generate non-commercial catch provides estimates that seem reasonable for the Deep 7 fisheries in Hawai'i. Experienced bottomfish fishers at two workshops held in 2025 agreed with the general conclusion provided by the range of scenarios tested here (i.e., that NC/non-CML catches are small and roughly 8–12% of the total catch). Fishers also stressed that the commercial and NC sectors do not follow the same dynamics and should be evaluated separately, as this new approach does. Therefore, we encourage the next Deep 7 assessment to explore fully replacing the 2024 catch framework with the methods proposed here, using something similar to the *MRIP D7 99th* scenario or an ensemble of the scenarios presented here.

Future research on non-commercial Deep 7 catches could fully utilize the bottomfish vessel registry and conduct mail surveys to all 420 NC fishers, asking for their annual or monthly catch. A similar survey for the uku snapper using the State of Hawai'i vessel registry is currently ongoing and preliminary results are positive. A larger question is the level of unreported commercial catch (i.e., CML-registered fishers that are not completely, or at all, logging their catch). This will likely be addressed in future work within the Deep 7 research track.

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Tables

Table 1. Number of non-commercial (i.e., non-CML) fishers with vessels on the bottomfish registry by year and county.

Year	Hawai'i	Honolulu	Kaua'i	Maui	All Counties
2011	112	191	52	47	402
2012	123	248	61	64	496
2013	111	238	61	62	472
2014	114	249	56	52	471
2015	110	259	58	50	477
2016	103	234	56	54	447
2017	102	222	56	48	428
2018	106	217	51	57	431
2019	104	189	51	47	391
2020	94	179	44	50	367
2021	103	201	39	48	391
2022	126	199	44	60	429
2023	124	190	46	45	405
2024	127	180	43	39	389

Table 2. Mean annual non-commercial catch estimates (2012–2024) from scenarios with different filters (annual catch from Lamson et al. (2007), per-trip catch from MRIP, or both) applied at different taxonomic levels (Deep7-only or also including species-level filters) for two percentile values.

Filter source	Taxonomic level	Non-commercial catch (lb)	
		95 th percentile	99 th percentile
Lamson	D7	38,938	41,543
Lamson	D7 and species	28,535	31,902
MRIP	D7	22,527	33,826
MRIP	D7 and species	16,253	24,501
MRIP and Lamson	D7	20,678	28,383
MRIP and Lamson	D7 and species	15,087	20,736

Table 3. Annual non-commercial catch by Deep 7 species from the *MRIP Deep7-only 99th* scenario.

Species	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Hapu'upu'u	1007	1778	1333	932	1337	1571	1345	783	1029	413	781	641	563
Kalekale	2147	2640	1724	2756	1777	1348	1448	1496	1387	2032	1960	1430	1718
Opakapaka	8532	10403	9290	9658	8493	11208	6336	4280	4773	5196	6654	6723	4977
Ehu	6207	9125	6537	7138	6521	6760	6893	6271	6437	6448	6007	6316	5037
Onaga	4218	4903	4642	3141	3736	4156	3247	2489	2702	4127	4135	4269	3757
Lehi	546	714	562	664	738	486	471	465	578	927	1667	605	303
Gindai	1101	1015	1202	846	711	896	996	1431	1382	1018	1451	1269	1626
Deep 7	23758	30577	25289	25135	23313	26425	20737	17214	18289	20160	22656	21253	17981

Table 4. Annual Catch Limit (ACL) for the 2024 assessment which uses MRIP “not sold” catches versus a model using NC catch from the *MRIP D7 99th* scenario with an assumed 30% unreported commercial catch.

Measure	Assessment 2024	New Scenario
Total ACL	1,008,000	813,885
ACL (reported commercial catch)	493,000	493,513
Recent reported commercial catch (2018-2022)	186,360	186,360
Recent reported commercial catch relative to total catch	47%	53%
Recent reported commercial catch relative to ACL	38%	38%

Figures

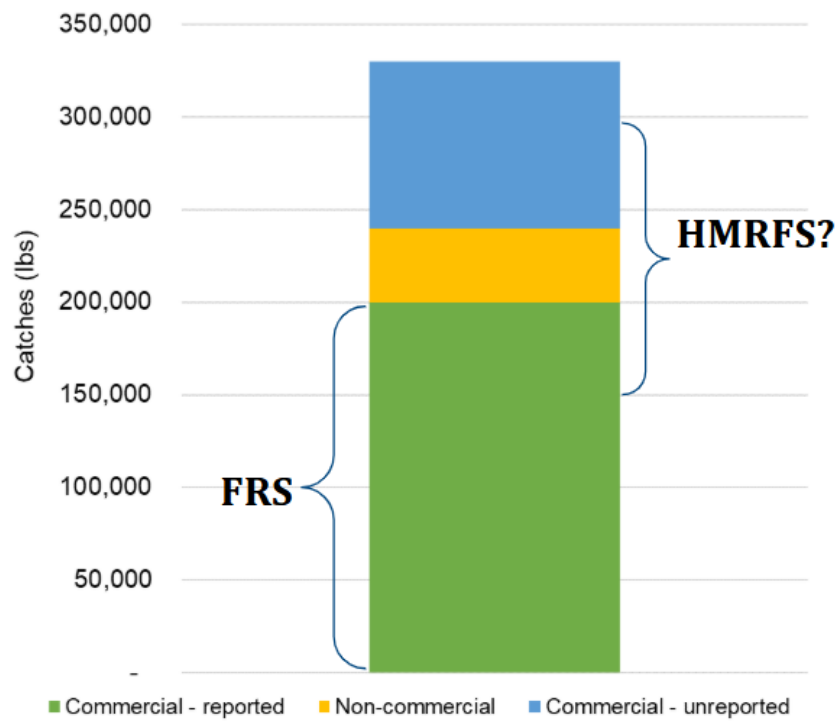


Figure 1. Theoretical representation of bottomfish catch in Hawai'i, split among the 3 fishery components and the two main catch data sources (FRS: Fishing Reporting System for CML holders, and HMRFS for “recreational” fishing).

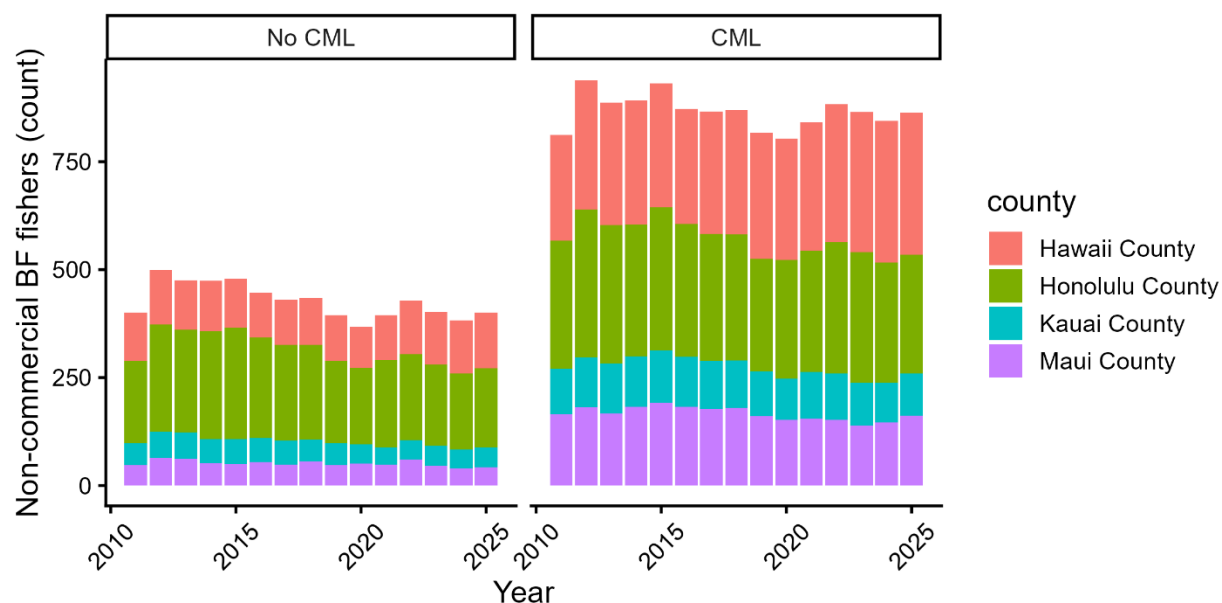


Figure 2. Number of non-CML fishers (left) and CML fishers (right) with vessels on the bottomfish vessel registry by year and county.

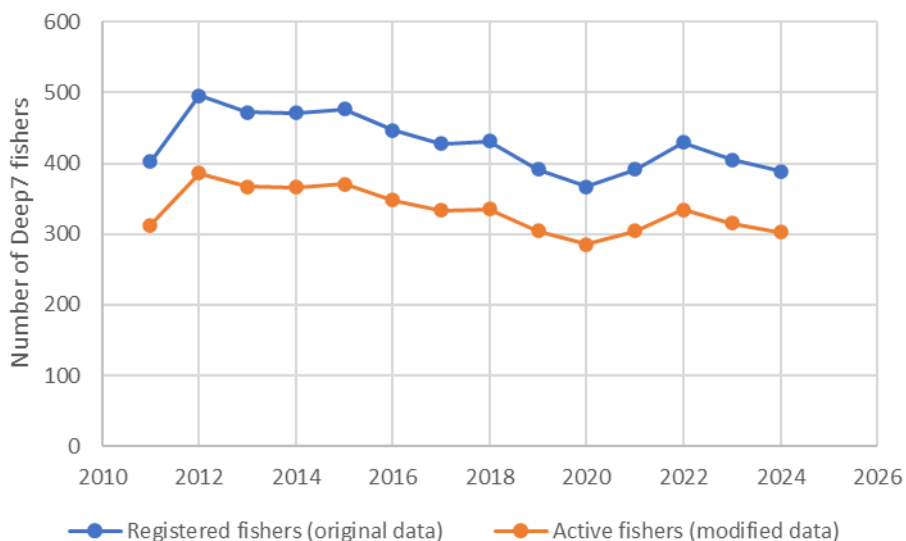


Figure 3. Number of non-commercial (i.e., no CML) fishers registered on the bottomfish registry (blue line), with the number of active non-commercial fishers determined from eq. 2 (i.e., assuming 48% of registered fishers are active and 33% of total active fishers are not registered).

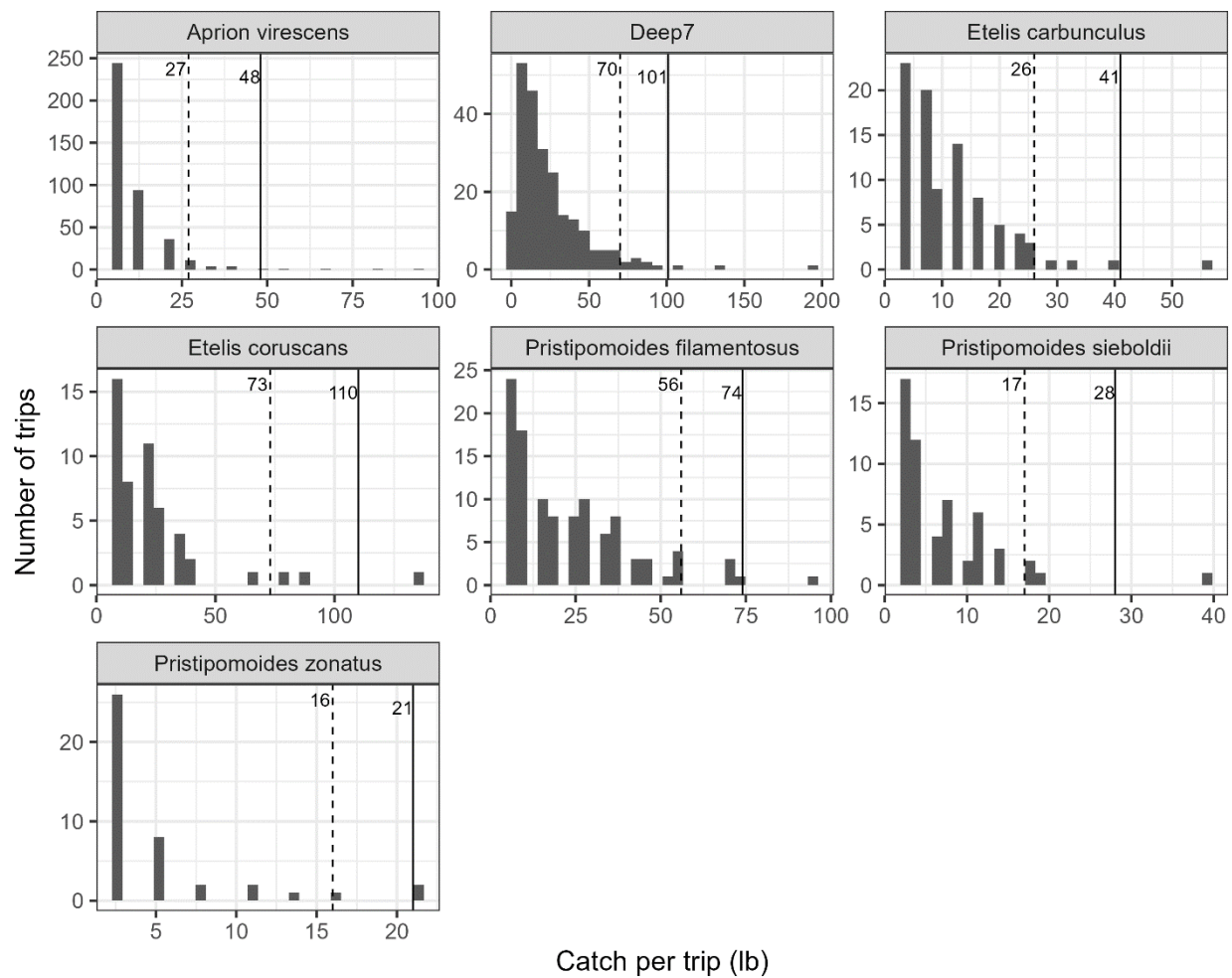


Figure 4. Distribution of catch per trip in pounds from all MRIP interviews (2003–2022) from fishers that responded they “never sell their catch”, for selected species and for all Deep7 combined. The 95th (dashed) and 99th (solid) percentiles are shown as vertical lines, with their values annotated.

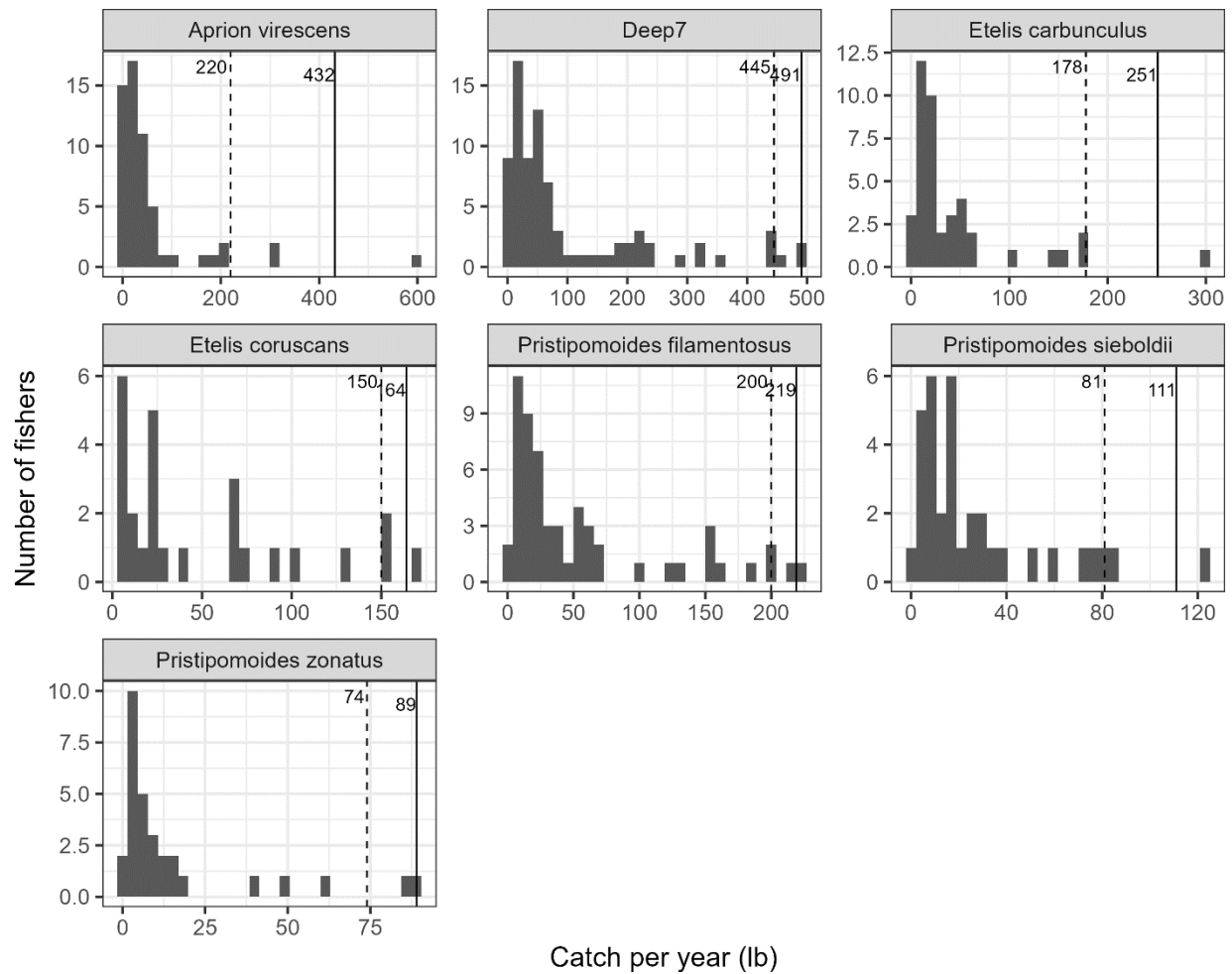


Figure 5. Distribution of catch per year in pounds from the Lamson et al. (2007) mail survey, selecting fishers that responded they “never sell their catch,” for selected species and for all Deep 7 combined. The 95th (dashed) and 99th (solid) percentiles are shown as vertical lines.

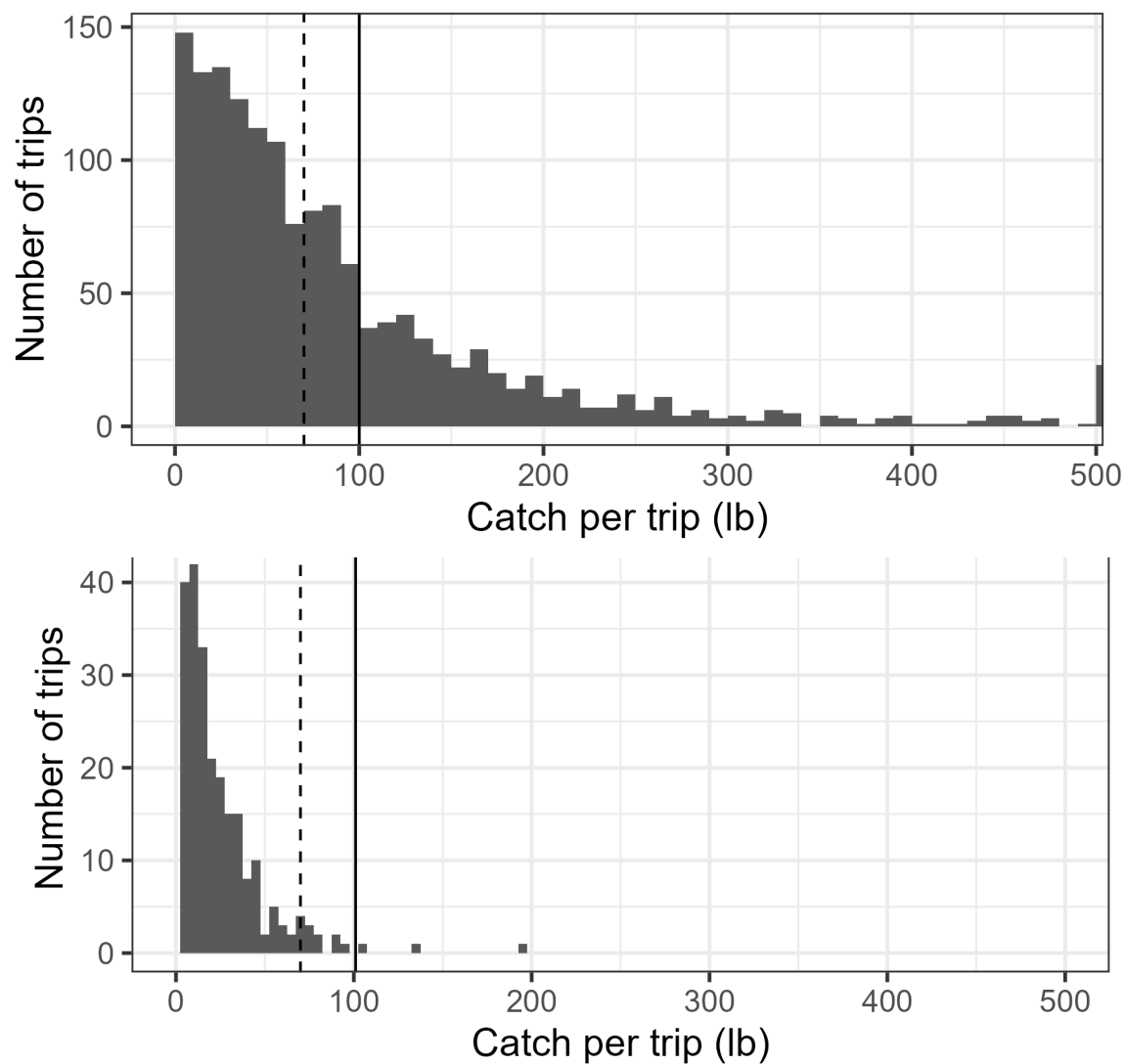


Figure 6. Distributions of catch per trip for fishers with CML, obtained from the FRS in 2023 (top panel) and for fishers that report “never selling their catch” from MRIP interviews (2003-2022; bottom panel). The 95th (dashed) and 99th (solid) percentiles of the MRIP distribution is presented on both figures.

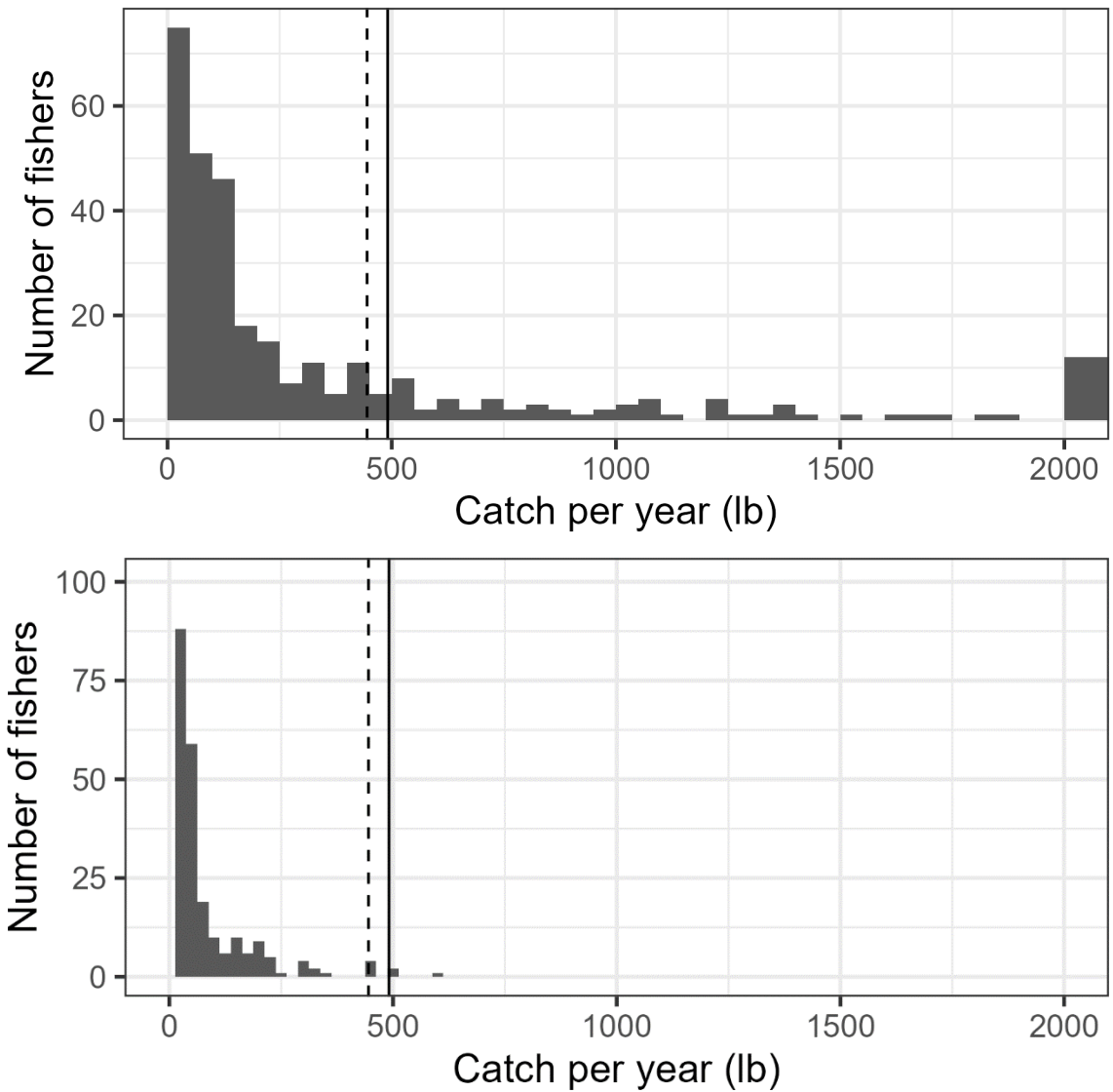


Figure 7. Distributions of catch per year for fishers with CML, obtained from the FRS in 2023 (top panel) and for fishers that report “never selling their catch” from the Lamson et al. (2007) mail survey (bottom panel). The 95th (dashed) and 99th (solid) percentiles of the MRIP distribution is presented on both figures.

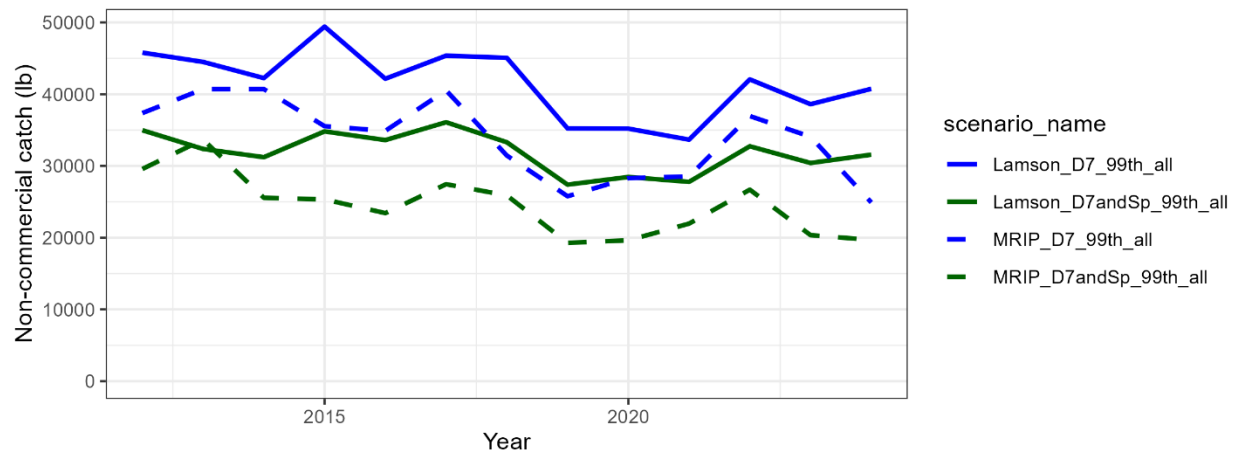


Figure 8. Non-commercial catch estimates from selected scenarios. Solid lines represent scenarios using only the Lamson et al. (2007) 99th percentile annual catch filter and dashed lines represent scenarios using only the MRIP 99th percentile per-trip catch filter, applied only for total Deep 7 catch (blue lines) or for Deep 7 and species-level catch (green lines).

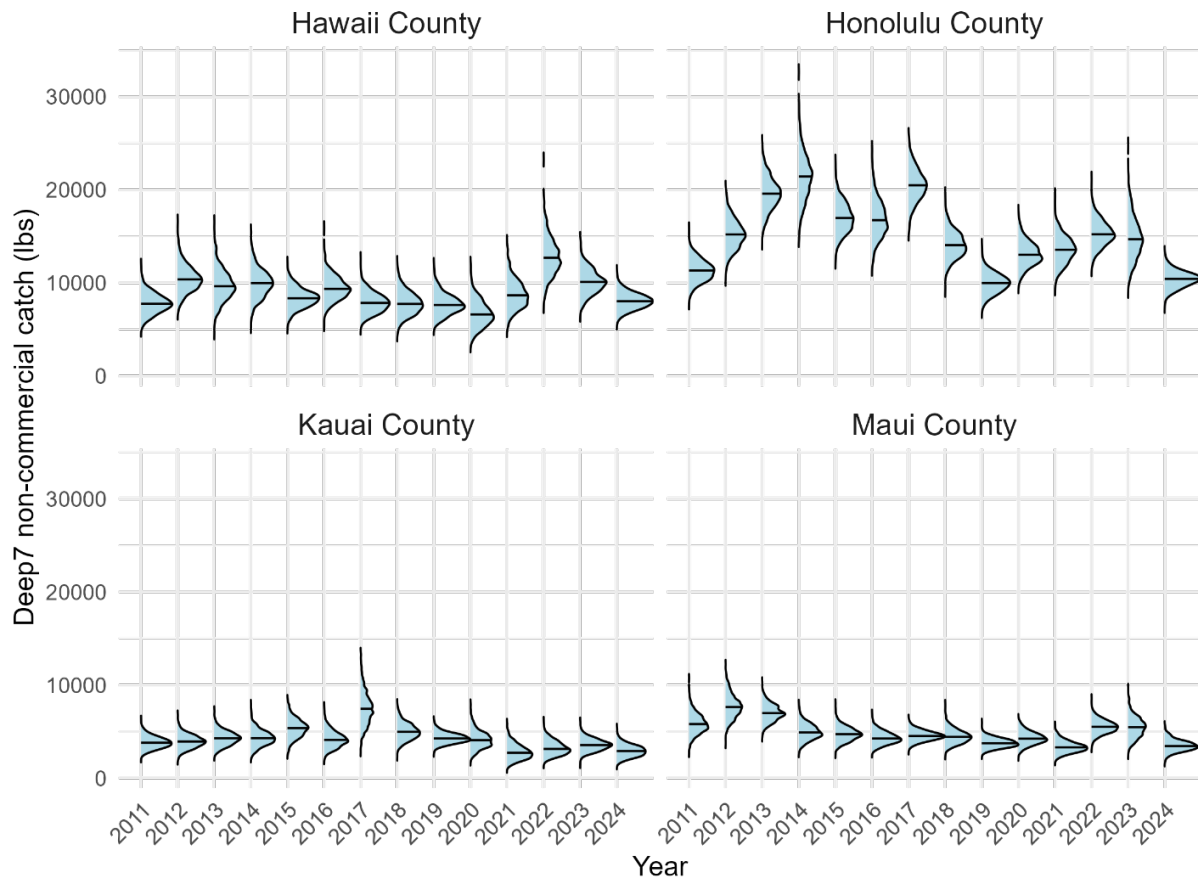


Figure 9. Deep 7 non-commercial catch by county estimated using the MRIP-only 99th percentile filter applied to aggregated Deep 7 catch only.

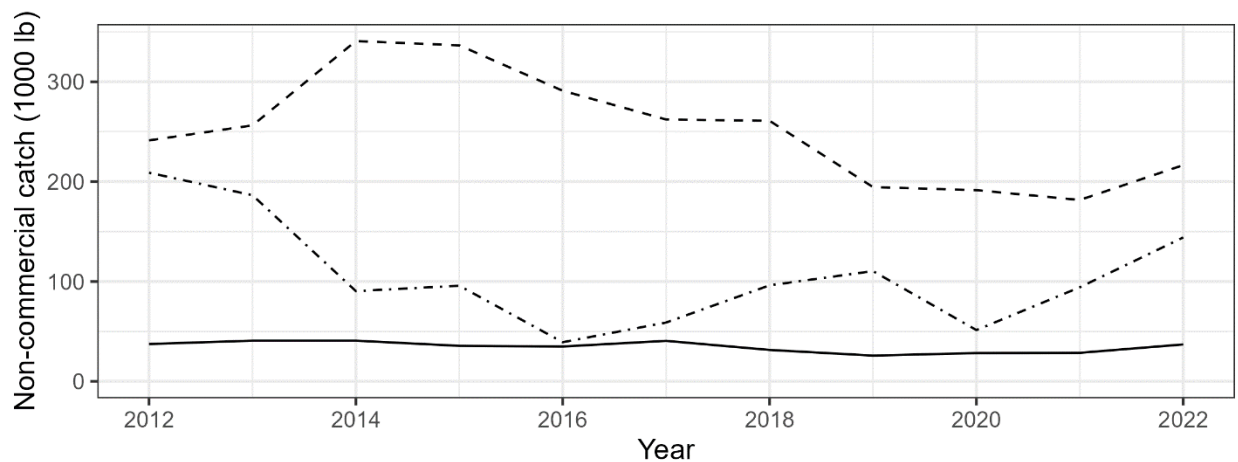


Figure 10. Comparison of Deep 7 non-commercial catch estimates from three different sources: the MRIP "not sold" (dashed line) used in the 2024 assessment, the effort-corrected MRIP "never sell" (dash-dot line), and the current approach based on the MRIP D7 99th scenario (solid line).

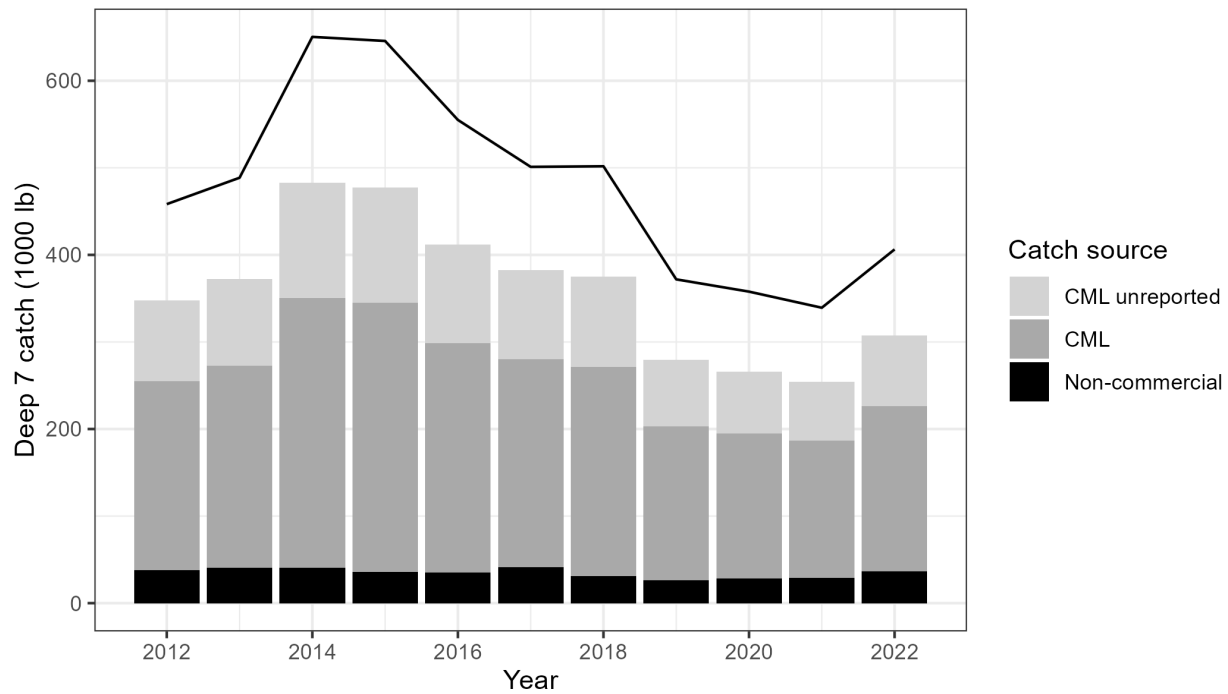
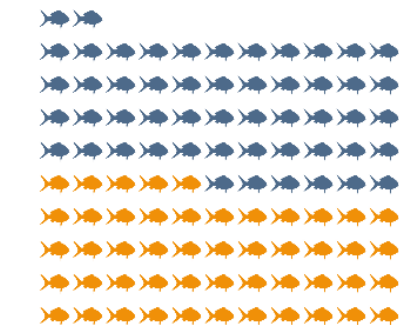


Figure 11. Total Deep 7 catch by year under the new proposed approach, broken down by sector, with a reference line showing the total catch used in the 2024 Deep 7 stock assessment. The non-commercial catch uses the *MRIP D7 99th* scenario.

Allocation of Total ACL Between Sectors (2024)

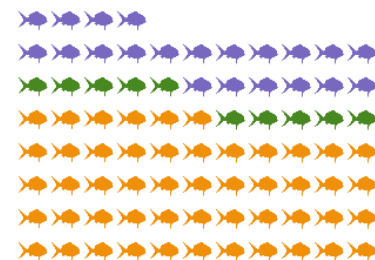
Commercial: 490 thousand lbs (49%)
Non-commercial and CML unreported: 520 thousand lbs (51%)



Sector: ● Commercial - CML reported ● MRIP (Non-commercial and CML unreported)

Allocation of Total ACL Between Sectors (BFVR)

Commercial: 500 thousand lbs (61%)
Non-commercial: 100 thousand lbs (13%)
CML unreported: 210 thousand lbs (26%)



● Commercial - CML reported ● Non-commercial - BFVR approach ● Commercial - CML unreported

Figure 12. Annual Catch Limits by sector from the 2024 assessment model versus a model using NC catch from the *MRIP D7 99th* scenario assuming 30% unreported commercial catch. Individual fish symbols represent a thousand pound of Deep 7.

Appendix A: Deep 7 bottomfish catch estimation tool: summary report

1. Executive Summary

This report introduces an interactive decision-support tool designed to foster trust between fisheries scientists and fishing communities by transforming how scientific methods and results are shared. Traditional fisheries workshops created significant knowledge gaps and trust deficits through one-way information transfer that kept scientific methodologies opaque to stakeholders who would be affected by management decisions.

The web-based tool integrates Bottomfish Vessel Registry (BFVR) and Fisher Reporting System (FRS) data through an accessible R *Shiny* interface that requires no technical expertise to operate. Users can adjust inputs for three key categories to explore how different scenarios affect annual catch estimates and Annual Catch Limits (ACL) across fishing sectors. Developed through extensive collaboration with fishing communities, the tool achieved two critical objectives: incorporating local knowledge from active fishers to improve estimation accuracy, and providing transparent, real-time demonstration of how assumptions translate into management outcomes.

This work represents a paradigm shift from traditional fisheries science communication to collaborative decision-making, providing a model that could be adapted for other data-limited fisheries facing similar challenges with stakeholder engagement and non-commercial (NC) catch estimation. The open-source tool remains publicly accessible, ensuring continued utility for fisheries scientists, managers, and fishing communities.

2. Background and Context

The traditional approach to fisheries data collection and methodology communication created significant knowledge gaps and trust deficits between constituents and scientists that necessitated a new, interactive approach. Previous data workshops with commercial fishers have yielded valuable insights into various topics. And while these workshops have been beneficial for scientists in gathering information from fishers, the explanation of methodologies and the potential impact of results on the fishers' livelihoods has been insufficient. The workshops typically spanned several days, involving a large group of fishers and facilitated by scientists presenting highly technical topics via slideshows. This communication method proved ineffective for that audience, contributing to a lack of transparency and trust regarding our work.

To be as transparent as possible and build confidence from the fishers in the new methodology for estimating non-commercial catch, we wanted to take a novel approach for how we shared our work and results. Our aim was to develop an interactive tool capable of performing real-time analysis based on user inputs and promptly displaying key metrics. These metrics include

annual non-commercial catch estimates, annual total catch estimates, and the impact on the ACL for the fishery, separated by sector.

A crucial requirement of the tool was that we wanted to incorporate input from the fishers directly into the analysis. As outlined in the previous section of this report, there are several key decision points that are crucial to characterizing the NC fishery as accurately as possible. However, these decision points are often impossible to get a true value for, for example the number of people fishing for Deep 7 that have not registered their boat. To best characterize the “true” NC Deep 7 fishery, we needed insight from active participants in the fishery.

Additionally, the tool needed to be accessible to all users, specifically requiring no coding knowledge or specialized software. For instance, executing an R script with hundreds of lines of code is no more intuitive than presenting equations on a slide. Our aim was to develop a tool that would empower anyone in the fishing community to independently adjust inputs, test assumptions, and observe the actual impact on the ACL.

The tool was designed to serve two distinct user communities, each with specific needs for understanding catch estimation impacts on fisheries management. The primary target audience for the tool was the Deep 7 fishers participating in our fisher engagement meetings. For them, we wanted the tool to be user-friendly, ask clear, direct questions, have inputs that were intuitive and realistic, and to show only key information related to catch estimates for different fishing sectors and the impacts on ACL. The secondary target audience were regional fisheries managers. Given the significant shift in catch estimation methodology, regional managers will be interested in understanding how catch advice is calculated. Specifically, they will want to compare the new catch estimates to previous ones, and see the resulting impact on the ACL.

Here we introduce an interactive tool to estimate non-commercial catch for Deep 7 species in the main Hawaiian Islands that can be used by fisheries scientists, managers, and fishers.

3. App Overview and Architecture

3.1 Technical Framework

The decision-support tool leverages the R package *shiny* (version 1.11.1) and is hosted on NMFS Posit Connect server to provide accessible, real-time analysis capabilities without requiring technical expertise from users. The benefit of hosting the tool on NMFS Posit Connect server is that anyone can access the tool and the script-based code runs without the user needing to have an R session running on their computer, Posit Connect provides the server connection. We chose to use *shiny* to build the decision-support tool because it allows users to interact with code and run analyses in a way where the user doesn’t need any coding knowledge to run the calculations; everything happens on the backend but is displayed in a user-friendly interface. The full code for the decision-support tool can be found on the [GitHub repository](#).

3.2 User Interface Design

User-centered design principles guided the development of an intuitive interface that presents complex fisheries data through interactive visualizations. When a user navigates to the decision-support tool, they are directed to a landing page that provides background text of the methodology, the inputs users can manipulate, and a short “How to Use” guide.

On the second page, the user interacts with the tool to run the analysis. In a collapsible sidebar, questions in three main categories have either a slider or select buttons for the user to choose an input value. For clarity and to reduce visual clutter, we decided to make the headings and questions as short as possible but added more detailed explanations that display only when the user hovers over the question. We utilized the reactivity capabilities of the *shiny* application so that when any of the inputs are changed, it triggers the code on the backend to run the calculations and update the plots and tables.

All of the plots in the decision-support tool were made using the R package *plotly* for interactivity. For example, data values are displayed when you hover over a point on a chart and elements of the plot can be displayed or hidden by clicking the element in the legend. Plotly’s capabilities helped us create plots that we could use to narrate a story and build up incrementally by adding elements one-at-a-time. This allowed us to fully explain each element of the plot before adding in a new one, and allowed the users to digest the information in small bits at a time.

3.3 Core Functionality

The tool's core functionality centers on three key categories that allow users to explore how different assumptions affect catch estimates and management outcomes. By adjusting the inputs for the three categories, users can quickly explore a range of scenarios and get a better understanding on how different estimates of non-commercial catch actually impacts management targets such as ACL.

Non-commercial Fisher Count Adjustments

To get the most accurate estimate of the number of BFVR boats that are fishing for Deep 7, we had two adjustable inputs. The first asks for the percentage of boats that are registered on the BFVR and are actually fishing for Deep 7. This is to remove the boats that may register but actually do not target Deep 7 species, or boats that are no longer very active in fishing. The second input is the percentage of boats that are catching Deep 7 that are registered on the BFVR. This is to account for any un-registered boats that are on the water fishing.

FRS Data Filtering Parameters

To characterize the NC catch, we used the FRS catch data as a proxy, but we wanted to set an upper limit of catch. Especially since we know the NC fishers do not have the same set of skills, time, and equipment that highliner fishers do and they also have a five-fish bag limit per person. Due to these limitations, it would be unrealistic for NC fishers to catch more than a certain poundage per trip. To capture this, we have three options for an upper cut-off, 50 lb/trip, 70 lb/trip, and 100 lb/trip. Having the three options to choose from allows the user to look at what the difference would be between the different limits and since fishers often had varying opinions of what the limit should be, we could easily show what impact each limit had on the total non-commercial catch estimate.

Unreported Catch Adjustments

To begin to get at the amount of unreported Deep 7 catch that occurs in the fishery, particularly in the commercial fishery, we also included an input that asks what percentage of the commercial catch is unreported. This percentage is not included in the non-commercial catch estimate but it is included in the total catch estimates. We included this aspect to fully capture the fishing activity within the Deep 7 fishery.

4. Scientific Applications, Limitations, and Implications

The decision support tool can be used in many ways to support the sustainable management of the Deep 7 fishery while building trust between the scientific and fishing communities. Fisheries scientists can use it to explore alternative assumptions for each component of the NC catch estimates and compare the differences each assumption has on NC and total catch estimates.

These explorations can help to narrow down potential catch estimate scenarios that seem realistic and possible, particularly for the non-commercial and unreported catch estimates. The tool also allows for immediate visualization of the catch estimates for the entire Deep 7 complex and by species, which can help to quickly identify if the same assumptions can be reasonably applied across all species and how non-commercial catch trends impact each species differently.

The tool facilitates engagement with fishers by enabling us to solicit their assumptions regarding the NC fishery and integrate them directly into the analysis. Additionally, the tool helps us to reach agreement among many opinions of possible scenarios and account for nuances such as inter-island variability in fishing behavior. While the code behind the tool is not as detailed as the final analysis may be, the tool helps to facilitate discussions that often help identify certain assumptions that may not hold true across all islands or for all species.

These discussions with fishers helped us to refine our methodology and produce the most robust NC catch estimates. Using the tool in meetings with the fishers to show them how we

can put their information directly into our analysis and coming to an agreement on the best inputs to use, helped to create a sense of transparency in our work and build trust.

The tool does have some functionality limitations. Currently, we designed it for fishers, and we did not want to overcomplicate the inputs and control options. This meant that we had to make some simplifications. For example, in the full estimation, the maximum catch limit can be determined by 99th, 95th, or 90th percentile of FRS catch data. However, because 99th versus 90th percentile may not be meaningful to our target audience, we selected pound amounts that were around those quantile values. We did test the simplifications with the full estimation code and found small differences between the two (less than 1,00 lb per year) and felt that the simplification for clarity was worth the small difference in actual catch estimates.

5. Development Process and User Feedback

The development process was very collaborative throughout the entire process. We met with small groups of diverse users throughout the process to get feedback and conduct user testing. This helped us to tailor the tool to address the needs of the users instead of just creating what we thought would be useful. When we brought the tool to the final meeting, we were confident that it would help to explain the NC catch estimation process, and that it would help address questions other fishers may have about the process. We also got feedback early and often, making sure to iterate on the development and add in features along the way. This sped up the development time and allowed us to “build up” the tool as we went.

The feedback during user testing led to some important features found in the final product, such as the capability to show or hide elements from the plot and a table and plot showing the allocation of catch among the three sectors of the fishery. As we tested the tool with other scientists, we realized that we were presenting a lot of information at one time in each plot, and that it was distracting the audience before we could finish the explanation of what the plot was showing.

To address this, designed the plots show only one element at first and then add more elements over time as we walk through the plot step-by-step. This helped keep the audience focused only on the information we wanted to talk about at the time.

Additionally, we noticed a common sticking point for many of the fishers we spoke with was how this new catch estimation would impact the commercial ACL. We wanted to reassure them that even though it may seem counter-intuitive, a decrease in NC catch would not negatively impact the commercial ACL. To show this, we created unique visualizations to compare the ACL allocated by each sector in the previous method and the new method. This showed that the commercial ACL allocation was very similar between the two methods. This plot helped to reassure many of the fishers during the process of the limited impact of the different catch estimates on the current commercially-available ACL.

6. Conclusion

The Deep 7 bottomfish catch estimation tool represents a paradigm shift in fisheries science communication, moving from traditional one-way information transfer to collaborative, transparent decision-making. The tool successfully achieved its dual objectives of improving catch estimation accuracy through stakeholder knowledge integration and building community trust through methodological transparency.

Key achievements include: (1) facilitating consensus-building among diverse stakeholder groups with varying perspectives on fishery dynamics, (2) identifying critical inter-island variations that improved the robustness of catch estimates, and (3) establishing a replicable framework for transparent fisheries assessment communication.

The collaborative development process revealed important methodological insights, particularly regarding the heterogeneity of fishing practices across the main Hawaiian Islands and the need for flexible estimation approaches. These insights directly improved the quality of the NC catch estimation by incorporating previously unquantified local knowledge.

Beyond its immediate application, this tool establishes a new standard for participatory fisheries science that could be adapted for other data-limited fisheries facing similar data. The open-source nature of the tool and its hosting on public servers ensures continued accessibility and potential for adaptation by other fisheries management organizations.

Future development will focus on expanding technical capabilities for scientific reviewers while maintaining the user-friendly interface that proved essential for stakeholder engagement. The tool's success demonstrates that complex fisheries science can be made accessible without sacrificing analytical rigor, providing a model for building trust and enhancing collaboration in fisheries management.