Length and Weight Data Analyses for Commercially Landed Pacific Bluefin Tuna in the U.S. West Coast EEZ

Huihua Lee[1], Heidi Dewar[1], Kelsey James[1], Michelle Horeczko[2], and Yuhong Gu[1]

1: Fisheries Resources Division, Southwest Fisheries Science Center,

National Marine Fisheries Service, National Oceanic and Atmospheric Administration,

8901 La Jolla Shores Dr.
La Jolla, CA 92037

2: Pelagic Fisheries and Ecosystems Data Project,

California Department of Fish and Wildlife,

2451 Signal Street, Berth 59

San Pedro, CA 90731

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Summary

This study aims to analyze the size compositions of U.S. commercial fisheries by examining the length and weight data collected by both the California Department of Fish and Wildlife for the purse seine (PS) fishery and the West Coast Region observer program for the large-mesh drift gillnet (DGN) fishery. Length frequencies of U.S. PS and DGN fisheries were compared to the recreational length samples, while the catch-at-size data of the Mexican PS was used to compare the size frequency of the U.S. commercial landings. Results show that the U.S. PS and DGN fisheries caught more similar fish sizes to each other than those caught by the Mexican PS fleet (when overlapping). Comparing U.S. commercial fisheries to the recreational fishery revealed that similar size classes were landed, but the relative importance varied over time and there was no consistent pattern. Regularly monitoring the importance of the U.S. commercial fisheries ensures the assessment model reflects the size of fish caught by the important fisheries.

Introduction

To conduct stock assessments of Pacific Bluefin Tuna (*Thynnus orientalis*, PBF), scientists compile landings data across the Pacific Basin, with most landings coming from commercial fisheries. However, in the eastern Pacific (EPO), landings from both commercial and recreational fisheries are included. Currently, these fisheries include U.S and Mexican commercial fleets and U.S.-based recreational fisheries that operate in both U.S. and Mexican waters (ISC 2022).

The relative importance of the fleets has shifted over time. Prior to the establishment of Mexico's Exclusive Economic Zone (EEZ) in 1976, the U.S. purse seine (PS) fleet caught a large number of PBF in the waters off Baja California (Figure 1a). Since 1983, the U.S. PS fishery has only opportunistically caught PBF in U.S. waters with overall landings considerably lower than those of the Mexican PS fleet. The U.S. PS vessels usually target small pelagic species, such as Pacific Mackerel, Pacific Sardine, Northern Anchovy, and Market Squid. However, they will target higher-valued, temperate water PBF when they are in the Southern California Bight. During the past 10 years, the number of vessels participating in the fishery varied between 1 in 2012 and 14 in 2018.

While the Mexican PS fleet continues to log the highest landing in the EPO, since ~2010, the relative importance of the U.S. recreational fleet has increased, and its landings are now greater than those of the U.S. PS fleet (Figure 1b). PBF are an important target of both the charter and private recreational fishing fleets, with considerable economic value to the local community. The landings from these fleets in numbers of fish landed are included in the stock assessment.

While landings are very low, there are two additional commercial fleets that land PBF in U.S. waters of the EPO, including the large-mesh drift gillnet (DGN) fishery and the hook and line fishery (Figure 1b). The DGN fishery has operated in the U.S. EEZ since the late 1970s. This fishery initially targeted sharks, but then quickly transitioned to targeting swordfish that were more lucrative (Hannan et al. 1993). PBF are a secondary target in this fishery. Since its inception, many regulations have been implemented to reduce the catch of pregnant common thresher sharks,

as well as the bycatch of protected species like turtles and marine mammals. While the number of vessels actively fishing has decreased to less than ~20 in recent years, both the State and Federal Government have passed bills to permanently close this fishery as of 2024.

Commercial hook and line fisheries also target and land a small number of PBF. Similar to recreational fishers, vessels with a commercial permit will target PBF using baited hooks. In addition to PBF, these vessels also target swordfish, small pelagic species, and rockfish. Historically, PBF has not been an important component of their landings. However, since 2020, the number of vessels that land PBF has risen, partly due to the increase in the market price, higher demand, and increased availability. Other vessels that previously targeted Market Squid and other pelagic species have switched to targeting highly migratory species.

While there have been some exceptions, typically all fisheries in the EPO land PBF that are ages 1-3 years old, and thus relatively small. Since approximately 2016, however, progressively larger fish have been landed in the recreationally fisheries. James et al. (2021) found that the lengths of PBF landed have increased over time, with some fish estimated to be up to ~6-7 years of age (James et al. 2021, Heberer and Snodgrass 2021). These ages were estimated using the length data collected by the NOAA Pacific Bluefin Port Sampling Program and the Sportfishing Association of California On-Board Sampling Program from 2014-2020. There have been no recent analyses of the size compositions of the U.S. commercial fisheries. Hence, we examine the length and weight data collected by both the California Department of Fish and Wildlife (CDFW) for the PS fishery and the West Coast Region (WCR) observer program for the DGN fishery.

Methods

The U.S. DNG fishery operates primarily in the southern California Bight from August 15 to January 31. Fishers are restricted to setting a maximum of one nautical mile (6,000 ft) of large mesh gillnet (14 inch stretched) suspended on a leader such that the top of the net sits 36 ft (11 meters) below the surface. Lengths (straight fork length, FL) for landed PBF are obtained through the WCR observer program in 1995 and from 2001 to 2022 with observer coverage varying across years.

Life history samples for landed PBF from the PS fishery have been collected by CDFW from 2015 to 2023 in southern California ports, including San Pedro, Terminal Island, and San Diego in accordance with CDFW's Highly Migratory Species Port Sampling Manual (CDFW 2020). This fishery in the southern California Bight runs from May to October and involves small coastal vessels that target tuna as part of the wetfish and Market Squid fishery operating out of the San Pedro port area. Because of the proximity, CDFW can monitor seine-caught tuna landings concurrently with their Market Squid and coastal pelagic species dockside monitoring program. This port sampling program is based on a random stratified sample of 12 sample days per month. However, in the San Diego port area, CDFW samples one to two days per week during the fishing season, with weekly calls to the docks to monitor effort throughout the year.

The CDFW sample program records the straight FL and round weight (whole fish, not gilled or gutted) of 25-50 randomly sampled individuals of each tuna species in a load from a single vessel for PS catch, except that 0-2 age PBF juveniles are prioritized when available for Close Kin genetics sampling. For the small volume landings in San Diego, samples from multiple vessels are collected in a sample day.

Length and weight data were summarized by year and quarter. Combinations of year and quarter were excluded if fewer than 25 lengths or weights were available. This excluded 4 year and quarter combinations for the PS fishery (the same 4 were excluded for both lengths and weights), and 27 year and quarter combinations for the DGN fishery. Length and weight frequencies were plotted by year and quarter using 5 cm or 5 kg bins.

Length frequencies of U.S. PS and DGN fisheries were visually compared to the recreational length samples by plotting the data (port samples from 2014 to 2019 and onboard samples from 2020 to 2022). To compare the size frequency of the U.S. commercial landings with that of the Mexican PS fleet, the catch-at-size data of the Mexican PS was obtained from the stock assessment between 2005 and 2021 (ISC 2022) and plotted alongside the length frequencies of U.S. PS and DGN fisheries using the size bin defined in the assessment.

Results

The length and weight frequencies of 25 or more PBF caught by the U.S. PS fishery are presented in Figures 2 and 3. These frequencies are based on 10 year and quarter combinations from 2015 to 2022, with most landings in quarters (Q) 2 to 4. The length frequency of 25 or more PBF caught by the U.S. DGN fishery is shown in Figure 4, based on 19 year and quarter combinations from 2002 to 2022, with most landings in Q4. After 2015, there were only 2 instances of overlap between the U.S. PS and DGN fisheries (Figure 5). During these overlapping periods in Q4 of 2019 and 2020, the length modes observed in both fisheries were similar although the relative importance of different size classes varied between fisheries and years.

Comparison of the length of fish across time within fleets:

Examining patterns within fleets and across and within years reveals a high degree of variability in the size classes of fish landed and their relative importance. Up to approximately 2012, fish under 100 cm FL were dominant across quarters for both the Mexican PS fishery and the U.S. DGN fishery with most fish landed at 1 to 2 years of age. Starting 2013, larger fish (100-150 cm) appeared in the U.S. DGN and Mexican PS fisheries across quarters. After 2014, there is a high degree of variability across fleets, and within fleets across quarters and years. For example, in 2020, the U.S. The PS fleet landed primarily fish of 150 cm FL in Q3 but fish less than 100 cm in Q4. All fleets, other than the DGN fleet, landed significant numbers of fish >150 cm at some point during the time series.

Comparison of the length of fish from the U.S. purse seine and U.S. drift gillnet fisheries to those from the Mexican purse seine fishery:

Although the landing seasons of the Mexican PS fishery (Q1 to Q3) and the U.S. DGN fishery (Q1 and Q4) have limited overlap, there is overlap in 2019 Q1. While the modes overlap, the Mexican PS fleet caught larger, older fish (3-6 years old) than the DGN fishery (1-3 years old). There are also differences in the seasonality of the Mexican PS fishery (Q1 to Q3) and U.S. PS fishery (Q2 to Q4) and only 2015 Q2 overlapped. Similar to the comparison with the DGN fishery, while the modes occur at similar sizes, the Mexican PS fishery landed larger fish with the majority of fish estimated at three years of age vs two years of age in the U.S. PS.

Comparison of the length of fish from the U.S. purse seine fishery and U.S. drift gillnet to those from the U.S. recreational fishery

Both the U.S. PS and U.S. recreational fisheries have similar landing seasons, occurring between Q2 and Q4. This has resulted in 10 instances of overlap between the two fisheries in the years 2014-2022, including 2015 Q2, 2016-2022 Q3, and 2019-2020 Q4. In three out of ten combinations, specifically during Q3 of 2016-2018, the sizes of fish caught by the U.S. recreational fishery were notably larger than those caught by the U.S. PS fishery. The PS fleet caught primarily 1 and 2 year old fish, whereas the recreational fishery landed fish up to 6 years of age. In contrast, from 2019-2022 Q3, the pattern reversed and, while both fleets landed fish across size classes, the relative importance of larger fish was much greater for the U.S. PS fisheries than those caught by the U.S. recreational fishery.

The U.S. DGN and U.S. recreational fisheries both land fish in Q4 with overlapping data sets from 2017-2021. The most notable differences were in Q4 of 2021, where the U.S. DGN landed primarily 2 and 3 year old fish whereas the U.S. recreational fishery landed primarily 1 year old fish.

Discussion

We summarize the lengths and weights of PBF landed by commercial fleets in the U.S. and compare lengths data to those for the Mexican PS fishery and the U.S. recreational fleet. While the number of overlapping year/quarters were limited, the size modes caught by the U.S. PS and U.S. DGN fisheries were more similar (when overlapping) to each other than those caught by the Mexican PS fishery, which caught larger fish. However, it should be noted that at other points in the time series, the U.S. commercial fisheries caught fish of sizes comparable to the Mexican PS fleet. The comparison of the U.S. commercial fisheries to the recreational fishery showed, again that similar size classes were landed, but the relative importance varied over time and there was no consistent pattern. The high degree of variability across fleets in a given quarter is likely due to a combination of factors, such as seasonal and annual availability of fish, gear selectivity, targeting, and sample sizes.

The current practice of combining the U.S. and Mexican commercial landings may not reflect the reality given the high degree of variability in the length data. However, separating the U.S. commercial fisheries from the Mexican commercial in the assessment model creates additional complexity, with a greatly increased number of time-varying selectivity parameters to

be estimated. Another compromise option is to share the selectivity of the U.S. commercial fishery with the U.S. recreational fishery, which may not perfectly reflect in some year and quarter combinations. Given the smaller amount of landings of the U.S. commercial compared to the other fisheries (e.g., other PS fisheries), the cost of the additional model complexity is likely to be outweighed by the benefits of more accurately estimating the selectivity of the U.S. commercial fishery. Regularly monitoring the importance of the U.S. commercial ensures the assessment model reflects the size of fish caught by the important fisheries.

Reference

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Heberer, L. N. and Snodgrass, O. E. 2021. The NOAA Pacific Bluefin Tuna Port Sampling Program, 2014-2019.

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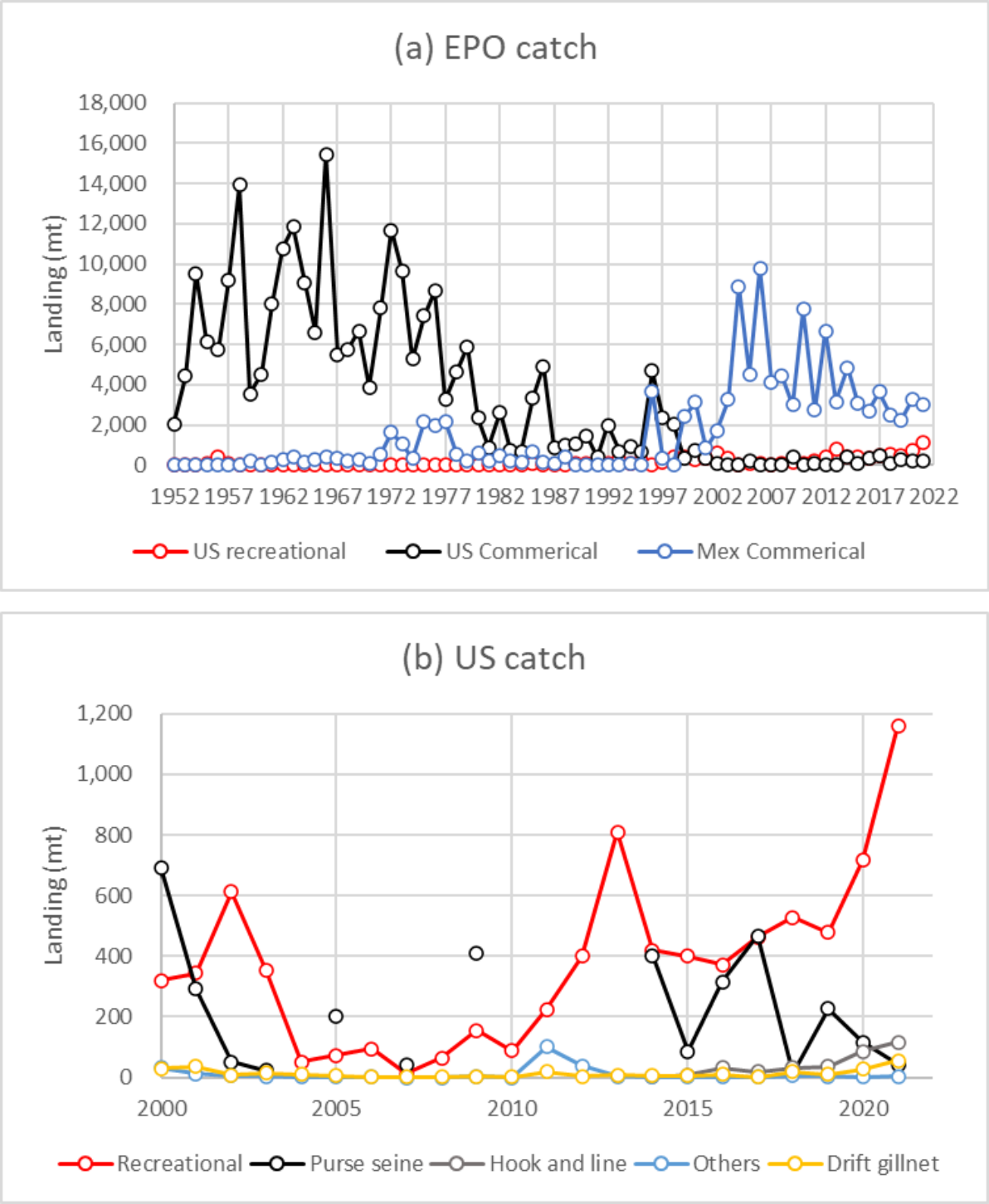

Figure 1. Landings of PBF from (a) eastern Pacific Ocean fisheries (Mexican commercial fisheries including purse seine and others, U.S. commercial fisheries including purse seine, drift gillnet, hook and line and other fisheries), and U.S. recreational fisheries from 1952 to 2021 and (b) U.S. commercial and recreational fisheries from 2000 to 2021. Data were from the ISC22 Annual Catch Table -(https://isc.fra.go.jp/pdf/ISC22/ISC22_Catchtable_202210.xlsx).

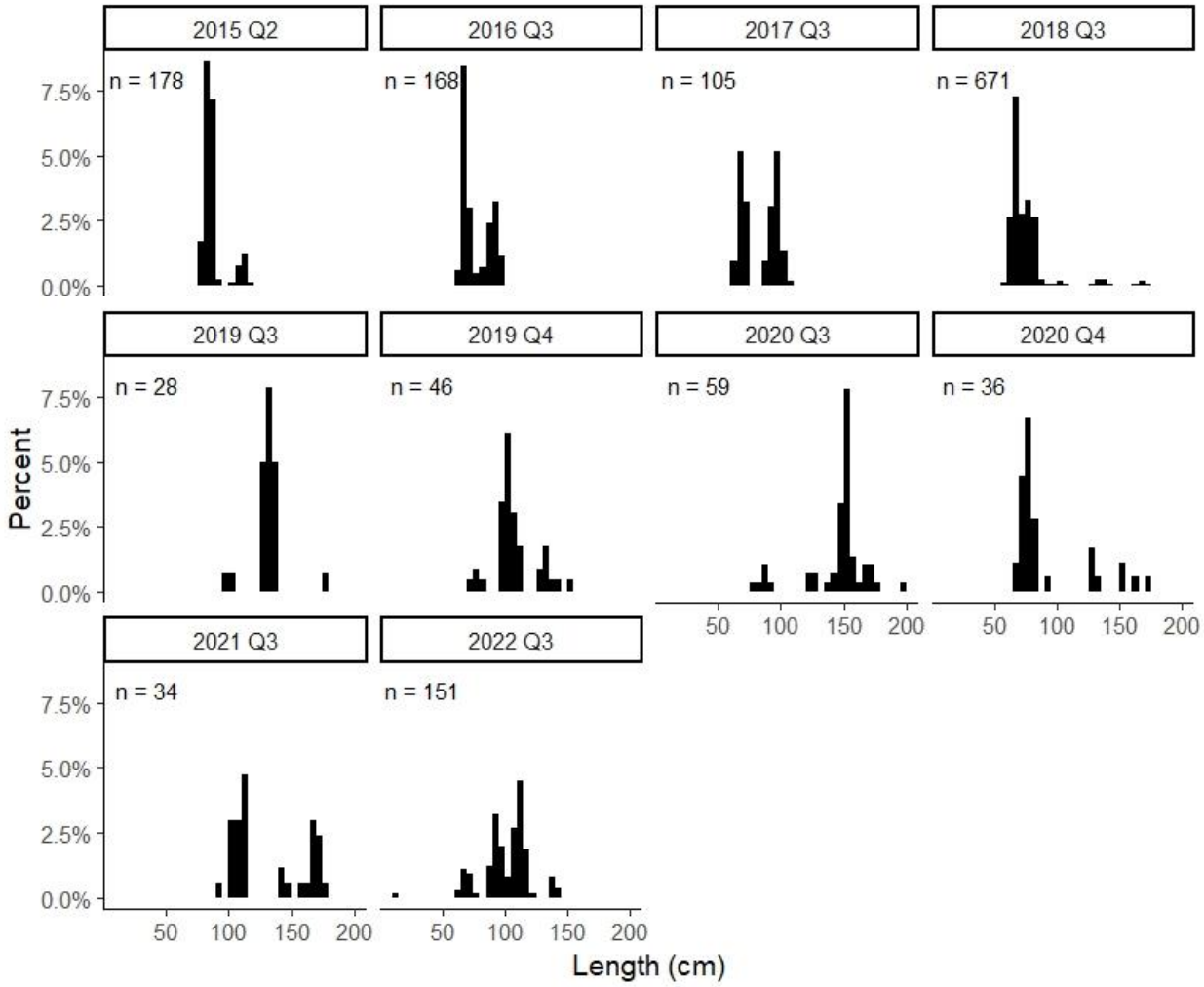

Figure 2. Length (straight fork length) frequency of PBF from U.S. commercial purse seine fishery in 5 cm bins by year and quarter. Sample sizes are listed in each panel.

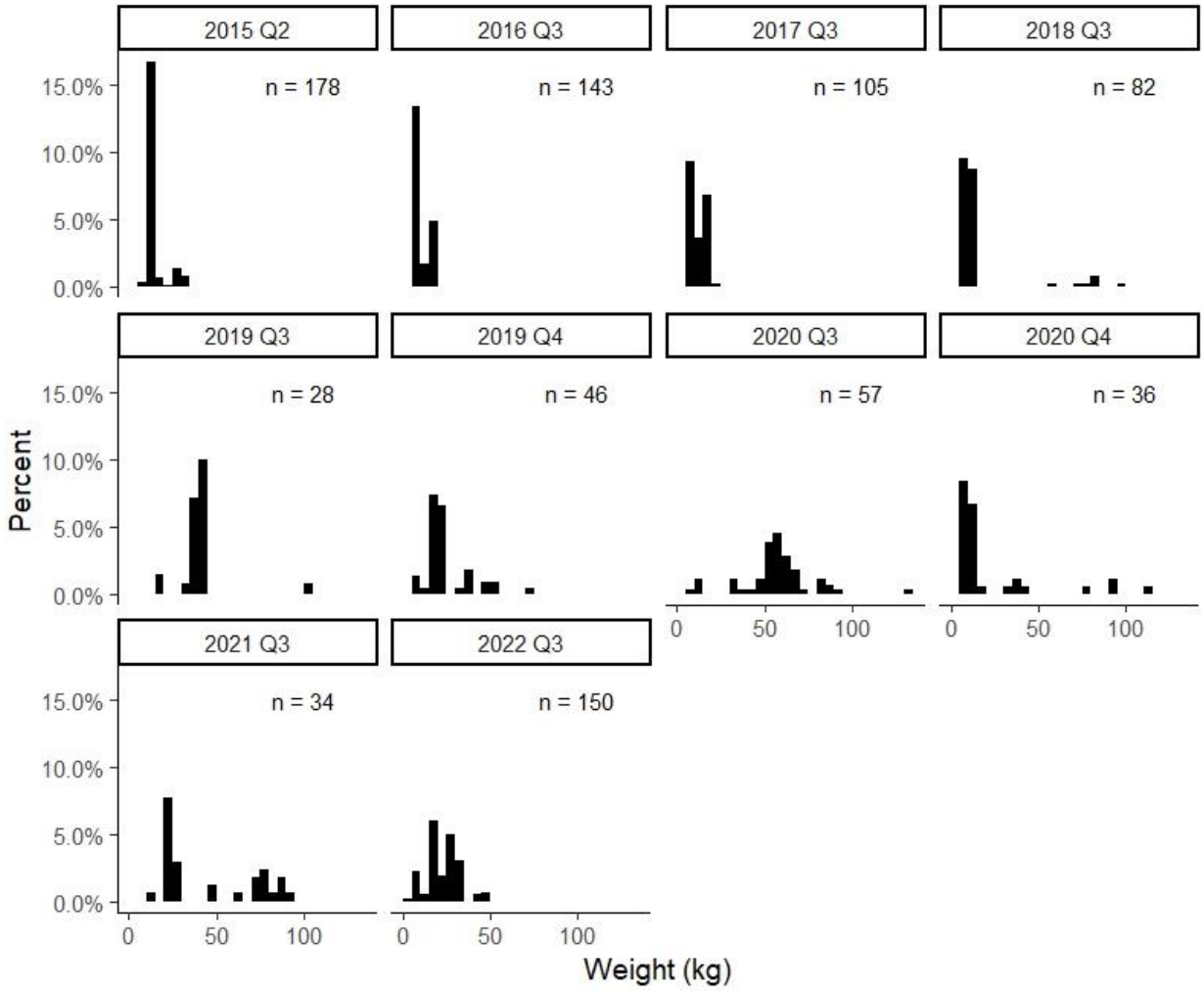

Figure 3. Weight (whole, round weight) frequency of PBF from U.S. commercial purse seine fishery in 5 kg bins by year and quarter. Sample sizes are listed in each panel.

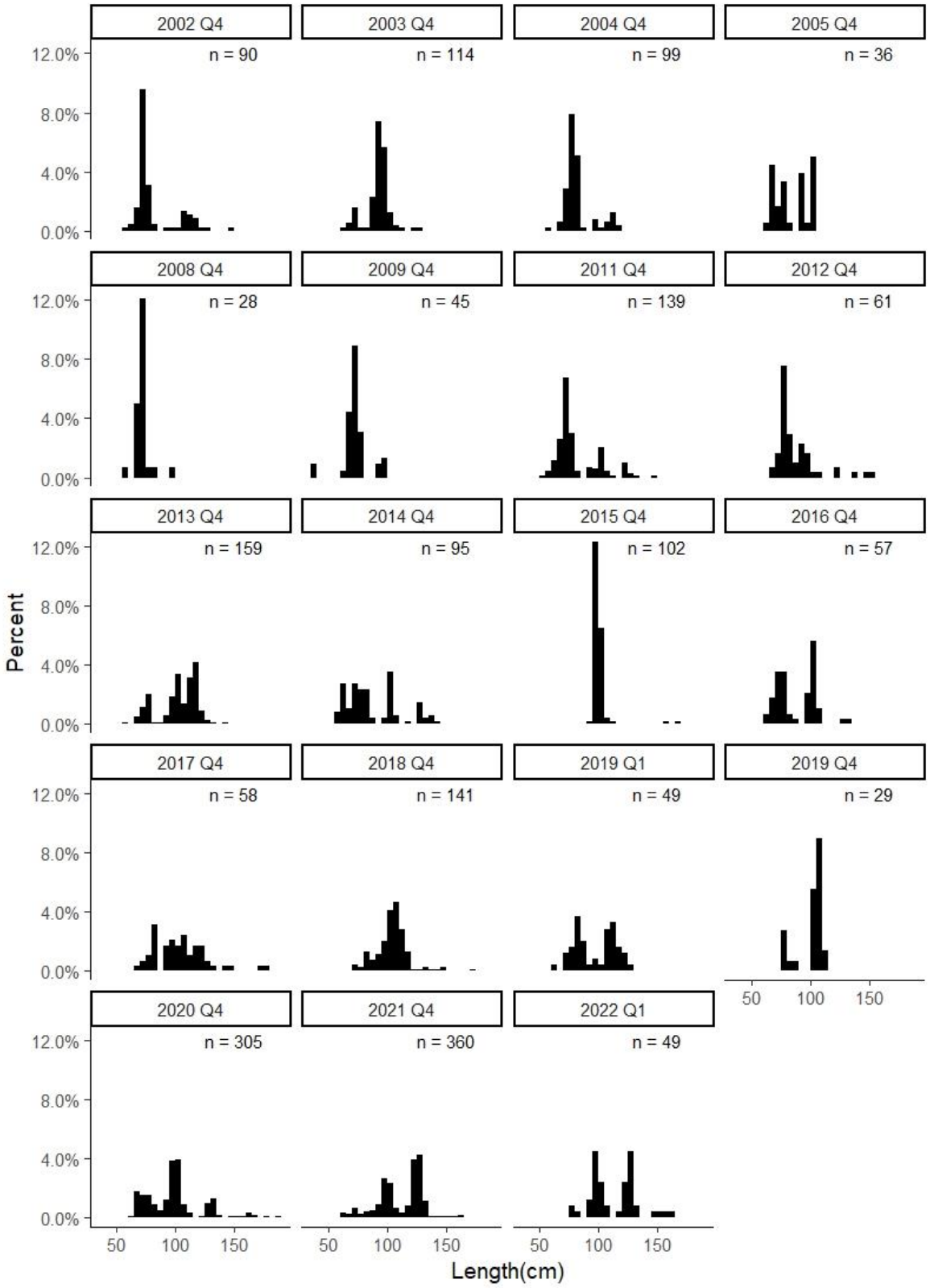

Figure 4. Length (straight fork length) frequency of PBF from U.S. commercial drift gillnet fishery in 5 cm bins by year and quarter. Sample sizes are listed in each panel.

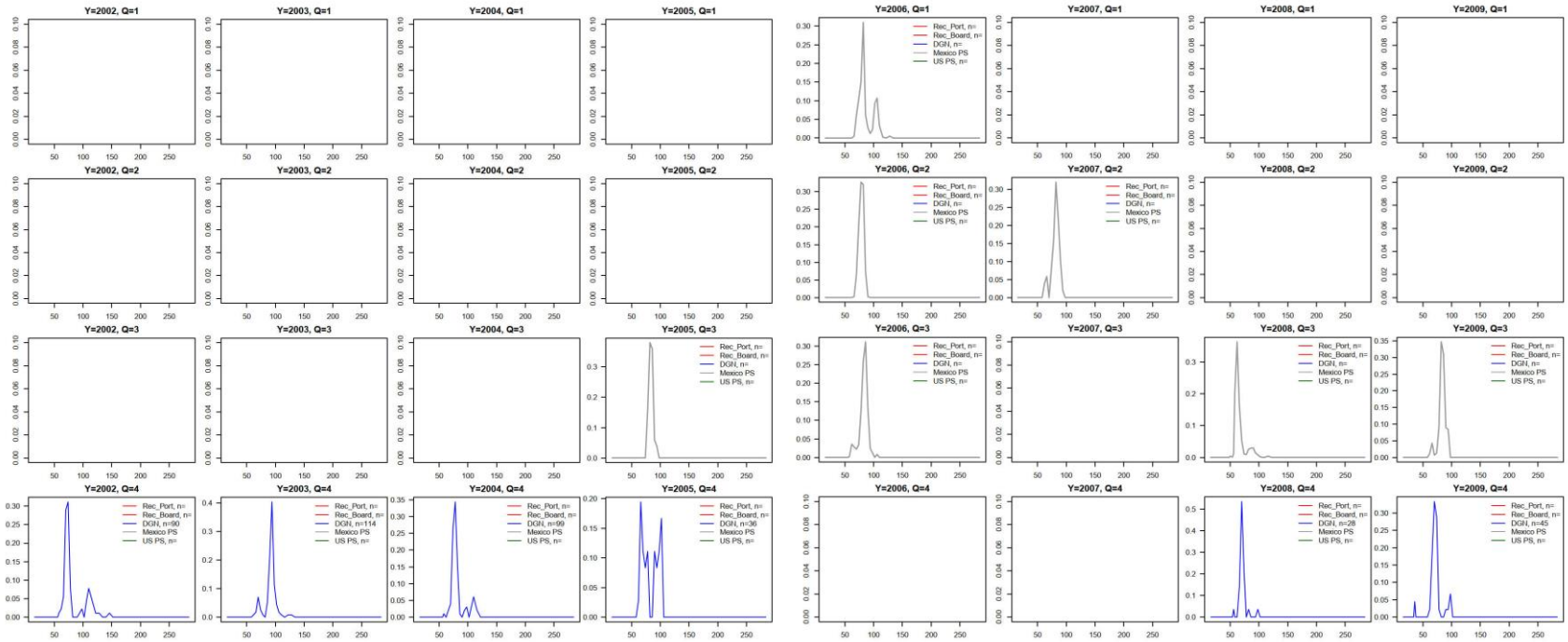

Figure 5. Length (straight fork length) frequencies of PBF from U.S. commercial purse seine fishery (U.S. PS: green curve), U.S. commercial drift gillnet fishery (U.S. DGN: blue curve), and U.S. recreational fishery (U.S. Rec_Port and Rec_onBoard: red curve) and catch-at-size from Mexican pure purse seine fishery (Mexican PS: gray curve) U.S.ing the size bins defined by the stock assessment (ISC 2022) by year and quarter. Sample sizes are listed in each panel. For the Mexican purse seine fishery, catch-at-size were obtained from the assessment without the raw sample sizes. Note that the y-axis differs across panels.

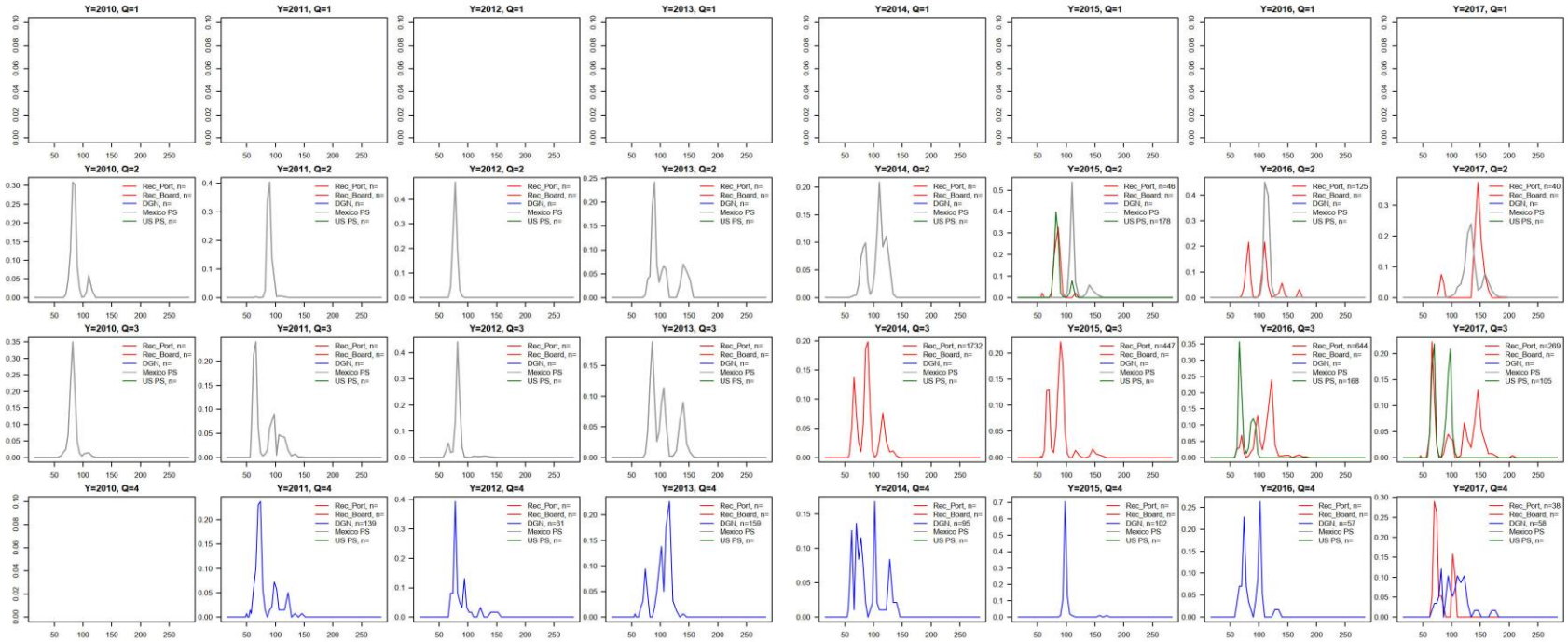

Figure 5 (cont.)

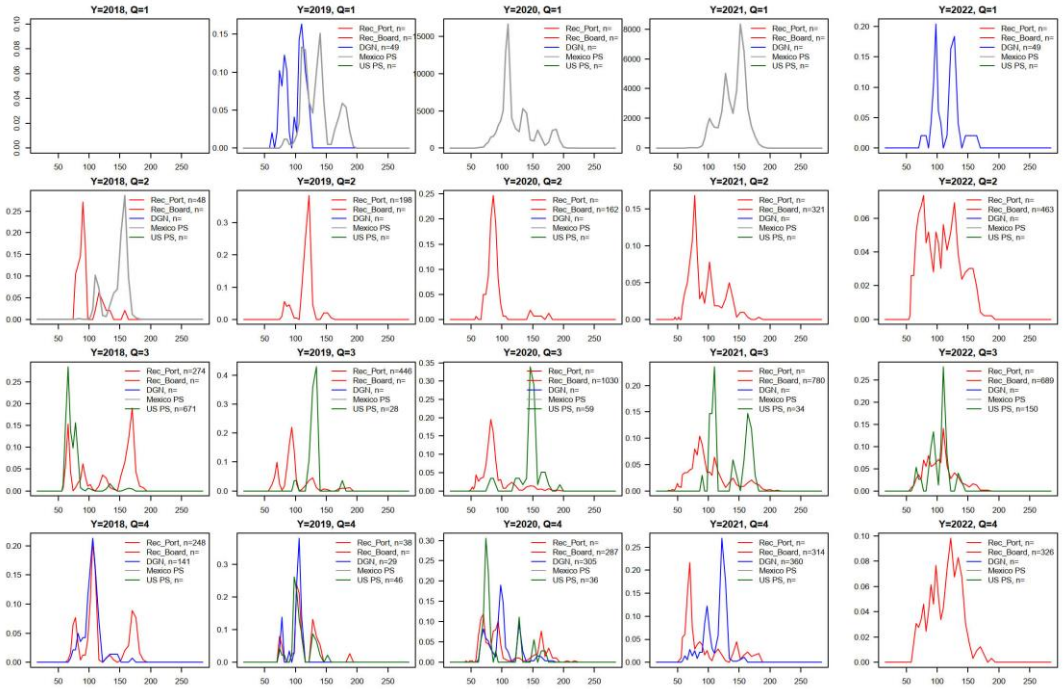

Figure 5 (cont.)