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The NOAA Pacific Bluefin Tuna Port Sampling Program, 2014-2019

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Data availability

The data presented in this Technical Memorandum are considered public and can be accessed by request from the NOAA Southwest Fisheries Science Center Fisheries Resources Division Life History Program.

Abstract

The National Oceanic and Atmospheric Administration Southwest Fisheries Science Center's Pacific Bluefin Tuna Port Sampling Program (PSP) was implemented in 2014 to collect life history data from Pacific bluefin tuna (*Thunnus orientalis*, PBF) landed at sportfishing docks, and is currently ongoing. Port sampling targets the recreational Commercial Passenger Fishing Vessels (CPFV) from the port of San Diego, California, catching PBF in United States (U.S.) and Mexico waters by hook-and-line. The program collects straight fork length (FL) measurements as useful size composition data representing the Eastern Pacific Ocean (EPO) sport fisheries, and tissue samples from EPO juveniles for genetic and close-kin mark recapture studies in collaboration with various international partners. The objective of this Technical Memorandum is to document the operations and catch of the San Diego CPFV fleet sampling frame, detail the PSP sampling design and methods, and provide summarized sampling effort and data from 2014 to 2019. Additionally, an EPO-specific operculum length-to-fork length relationship, established from PBF landed in Southern California from 2011 to 2014, is presented here for the first time. Between July 2014 and December 2019, the PSP collected 4,593 FL measurements and 3,918 fin clips from PBF landed on 338 trips from 44 unique San Diego CPFV vessels. Fish ranged between 46.1 cm FL (age 0) to 210.2 cm FL (age 9), with an average FL of 98.7 (age 2) ± 26.8 cm (SD). The San Diego CPFV fleet provided an ideal sampling frame by comprising at least 72.6% of the total recreational (private and public) catch of PBF by the California sport fleet, the most important U.S. fishery currently catching PBF in the EPO. Portside sampling paralleled peak PBF catch from San Diego CPFV vessels in summer and fall months, reflecting the seasonal availability of the species in the EPO. The PBF sampled by the PSP represented 3.9% of the total PBF catch by the California fleet, and 5.4% of the total PBF catch by the San Diego CPFV fleet between 2014 and 2019.

Introduction

The Pacific bluefin tuna (*Thunnus orientalis,* PBF) is a highly migratory pelagic scombrid inhabiting subtropical and temperate (20°-50° N) waters of the North Pacific Ocean (NPO). The species is fast growing and iteroparous (spawning more than once in a lifetime), with a potential lifespan of at least 20 years (Shimose and Takeuchi 2012, Fukuda et al., 2015, Shimose and Ishihara, 2015). The PBF spawns in the western NPO (WPO) between eastern Taiwan and the Ryukyu Islands from April to June around 5 years of age (> 150 centimeters (cm) fork length [FL]), and in the Sea of Japan from June to August around 3 years of age (>118 cm FL) (Yabe et al. 1966, Okiyama 1974, Yonemori 1989, Kitagawa et al. 1995, Chen et al., 2006, Suzuki et al., 2014, Ashida et al., 2015). Despite the presence of active spawning females (Ohshimo et al., 2018) and larvae (Tanaka et al., 2020) in the Kuroshio-Oyashio transition zone and the presence of larger adults of spawning age in other Pacific locales (Snodgrass, 2019), no spawning grounds have been confirmed outside of the WPO. Age 0 (young-of-the-year) and age 1 fish migrate seasonally along the Japanese and Korean coasts (Inagake et al., 2001, Yoon et al., 2012,), while an unknown portion of age 1-3 juveniles make a trans-Pacific migration to the eastern NPO (EPO) to forage off North America for a range of years before returning to the WPO (Bayliff et al., 1991, Itoh et al. 2003, Boustany et al., 2010, Block et al., 2011, Madigan et al., 2014, 2018a). Intra- and inter-annual variations of the timing, routes, and quantity of PBF that migrate to the EPO are likely dependent on seasonal food sources, abundance, and availability in the WPO (Polovina, 1996, ISC, 2018a), but remain poorly understood and are largely unquantified.

The PBF is an economically important species targeted heavily by commercial and recreational fisheries across the NPO. While considered a single pan-Pacific stock, the PBF spends different life history stages in various Exclusive Economic Zones (EEZ) and non-sovereign high seas, requiring international management by the Western and Central Pacific Fisheries Commission and the Inter-American Tropical Tuna Commission (IATTC). The management decisions of the commissions are largely informed by regular stock assessments conducted by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). The ISC's integrated age-structured model (Stock Synthesis v3.24f) is fitted to catch, catch-per-unit-effort (CPUE), and size composition data as far back as 1952 provided by member nations. These data are used to estimate total PBF removals and spawning stock biomass (SSB) in current and forecasted management scenarios (ISC, 2020, Nishikawa et al., 2020). The five member nations[1] of the ISC account for the majority of the retained commercial and recreational catches of PBF in the NPO: Japan (71.1% of total PBF catch since 1952), the United States (U.S. [17.5%]), Mexico (7.2%), Taiwan (2.3%), and South Korea (1.8%) (ISC, 2020). The combined Japanese, Korean, and Taiwanese fleets in the WPO typically catch two to three times the PBF caught by the combined U.S. and Mexican fleets in the EPO annually. The WPO fleets caught an average of 67.5% of the total PBF catch from 1952-1973, 82.8% from 1974-1995, and 75.1% from 1996-2018 (ISC, 2020). The most recent 2020 ISC assessment indicated the 2018 PBF stock is near historic low levels at 4.5% of unfished biomass, with the greatest fishery catches on age 0-1 fish in the WPO and on juveniles up to age 3 in the EPO (ISC, 2020).

Eastern Pacific Ocean fisheries

In the EPO, PBF typically spend spring off the Baja peninsula of Mexico (hereafter Baja), move north into warmer southern California (CA) waters in summer, migrate to central CA by fall, and then move south along the North American coast in winter (Kitagawa et al., 2007, Boustany et al., 2010). Juvenile PBF likely remain in the EPO for a range of years before returning to the WPO spawning grounds, with landings and archival tag returns indicating the presence of age 1 to age 10 fish in the EPO (Itoh et al., 2003, Kitagawa et al., 2007, Boustany et al., 2010, Madigan et al., 2014, 2018a). Three fleets target juveniles in the EPO: U.S. commercial fisheries, Mexican commercial fisheries, and the EPO sport fleet (ISC, 2018a; ISC, 2020; Nishikawa, 2020). The U.S. commercial fisheries comprise a purse seine fleet operating primarily off coastal southern CA, and “other” commercial gears defined as gillnet, troll, pole-and-line, and longline along the U.S. West Coast (Nishikawa, 2020). The Mexican commercial fisheries comprise a purse seine fleet and a very small portion of live bait gears operating off Baja (ISC, 2020). The EPO sport fleet refers to the U.S. recreational private boats and for-profit public chartered boats known as Commercial Passenger Fishing Vessels (CPFV) targeting PBF with hook-and-line methods off Baja, CA, Oregon, and Washington. While anglers from private boats also spear PBF, this catch and effort is relatively negligible and the U.S. recreational fishery is collectively regarded as hook-and-line.

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[1] The combined PBF catch reported from the non-ISC member nations of New Zealand and Australia since 1991 is less than 0.1%.

The catch of PBF in the EPO has changed dramatically since 1952, particularly the increased contribution of the sport fleet to the total U.S. PBF catch (Table 1). Historically, PBF were taken mainly by the U.S. purse seine fleet, but the fishery steadily declined in the 1980s after Mexico established its EEZ in 1976 and mandated the exclusion of U.S. vessels from PBF fishing grounds in Baja (Dreyfus et al., 2008). The U.S. purse seine fleet only caught PBF opportunistically after 1983, and by 2002, virtually disappeared as a source for high PBF catch in the EPO (Aires-da-Silva et al., 2007). In contrast, the Mexican purse seine fleet targeting yellowfin tuna (*Thunnus albacares*) only caught PBF opportunistically since 1952, but started targeting PBF in 1999 for the emerging ranching industry (fattening of PBF in offshore pens for commercial sale) (Dreyfus et al., 2008). With the steady decline of the U.S. purse seine fishery and more directed targeting of PBF by Mexico, the Mexican commercial fisheries have caught more than 80% of the total EPO PBF catch since 1996 (Table 1) (Dreyfus et al., 2008, ISC, 2020).

Table 1. Total Pacific bluefin tuna (PBF) catch in metric tons (mt), percentage of total U.S. PBF catch, and percentage of total EPO catch by the three EPO fisheries identified by the ISC. Data provided by ISC, 2020.

	U.S. purse seine and other* gears			**U.S. sport fishery**			**Mexican purse seine and other* gears**	
	Catch (mt)	% of U.S. totals	% of EPO totals	Catch (mt)	% of U.S. totals	% of EPO totals	Catch (mt)	% of EPO totals
1952-1973	171,988	99.5%	96.1%	877	0.5%	0.5%	6,097	3.4%
1974-1995	59,846	97.8%	83.2%	1361	2.2%	1.9%	10,711	14.9%
1996-2018	12,965	65.9%	12.1%	6723	34.1%	6.3%	87,431	81.6%

Catch for the U.S. sport fleet is summed as the PBF kept by private vessels and CPFV vessels, the latter dominating the catch totals and overall effort (NOAA, 2019). The U.S. sport fleet has also accounted for a growing proportion of the EPO catch in the last 20 years, and comprised nearly 35% of the U.S. catch since 1996—a huge increase from the mere 2% from two decades prior (Table 1) (Nishikawa et al., 2020). In 2018 alone, the U.S. sport fleet accounted for 88.6% of the U.S. PBF catch and 15.9% of the EPO PBF catch reported to the ISC (Nishikawa et al., 2020). The prominence of the sport fishery within U.S. operations is particularly pronounced from 2014 to 2018, where PBF comprised on average 44.5% of the species composition in the total sport catch compared to just 0.41% of the U.S. purse seine catch (NOAA, 2019). The decline of the U.S. commercial fleet and increasing catch of PBF in the sport fleet within the last decade has made the sport fleet the most important U.S. fishery currently catching PBF in the EPO (Teo et al., 2015).

Data needs

The catch-at-size from the sport fishery is important in estimating the total removal of PBF from the fleet. Despite its rising importance in the last decade, the EPO sport fleet's catch-at-size data used the ISC stock assessment has been mirrored to the U.S. purse seine fleet due to intermittent size data collection and the relatively low catch of PBF in the sport fleet's historical data (ISC 2016, 2018a). However, the U.S. purse seine fleet's size data—and thus the U.S. sport fishery's size data—has been estimated from 1952-1984 U.S. commercial size data and from Mexican commercial purse seine catch data from 2005-2006 and 2008-2016. This assumes the current U.S. sport fishery is 1) similar to the Mexican purse seine fleet operations and gear selectivity, and 2) catching PBF size classes similar to those encountered by the U.S. purse seine fleet nearly 40 years ago, both assumptions likely inaccurate for a few reasons (Lee et al., 2015, ISC 2018a, Heberer and Lee, 2019).

In the sport fisheries, target catch is driven in part by customer choice, gear and vessel operations, and PBF fish availability from port. The gross tonnage of the largest U.S. sport vessels does not exceed 150 mt and individual PBF is targeted using single rod hook-and-line methods (NOAA, 2019). Anglers generally prefer PBF of smaller catchable size that are not too big to successfully land, but big enough for food and sport (Teo et al., 2015). In contrast, commercial fishing in the U.S. and Mexico prefer larger fish for market, have a larger operational range than recreational vessels, commercial vessels have 300- 1000+ mt carrying capacities and use dedicated aerial sighting support, and schools of PBF are wrapped with purse seine nets (Dreyfus et al., 2008). Between 2005 and 2016, the Mexican purse seine fleet caught 56,978 mt of PBF compared to the U.S. sport fishery's 3,107 mt (ISC, 2020).

In addition to differences in fleet operations, the ISC PBF Working Group has noted that the U.S. sport fleet has recently caught larger sizes of PBF (over 130 kg [300 pounds]) which may not be reflected in the catch-at-size data taken from commercial fleets nearly three decades ago (Teo et al., 2015). This presents the challenges when generalizing the EPO sport fleet catch-at-size based on historical data from commercial fleets, highlighting the importance of contemporary data collection. Accurate size composition sampling from the sport fleet is essential for estimating the total removal of PBF.

A number of programs have collected size data from PBF caught by the EPO sport fleet since the early 1990s. The IATTC conducted a dockside sampling program of CPFV landings from 1993 to 2012 (Hoyle, 2006), but no data were collected in 2013 when the program ended. The NOAA Pacific Bluefin Tuna Port Sampling Program (PSP) was established in 2014 to resume dockside length sampling and is currently ongoing. In 2015, a separate but collaborative onboard sampling program was established by the Sportfishing Association of California[2] (SAC) to supplement the PSP and is currently ongoing (Siddall et al., 2019, SAC, 2020). The CDFW has also collected opportunistic length data for tuna species from onboard or dockside Primary Private Boat Survey and Party and Charter Boat Angler Surveys, but PBF size sampling is not the primary focus and data is limited (CDFW, 2017).

This report serves as the official documentation of the NOAA Pacific Bluefin Tuna Portside Sampling Program and the first formal description of the San Diego CPFV fleet from which it samples. Here, we 1) detail the at-sea and dockside activity of the San Diego CPFV fleet based on personal observations from 2014 to 2019, 2) outline the PSP design, operations, and protocols, and 3) provide summarized statistics from 2014-2019 samples. This information is intended to serve as reference for biological samples of the EPO sport fishery and provide the PSP's relative sampling to the estimated PBF catch in California.

Methods

The PSP was initiated in July 2014 to sample PBF from the EPO sport fleet and is currently ongoing. The intention of the program is to collect size composition data and biological samples from the U.S. sport fleet to be considered in the ISC stock assessment and other research. The program is run by the NOAA Southwest Fisheries Science Center (SWFSC) laboratory in La Jolla, California, by the staff of the SWFSC Fisheries Resources Division Life History Program.

[2] Many of the CPFVs and public landings in California are organized under SAC to represent their collective interests to government, research, and industry partners (SAC, 2020). It should be noted that NOAA provided scientific consultation and partially funded the SAC sampling program.

Sampling frame

The PSP is focused on the U.S. sport fleet in the EPO, which is dominated by the CPFV fleet. Within the west coast CPFV fleet, the San Diego CPFV fleet catches more PBF than any other U.S. West Coast port (NOAA, 2019) and was chosen for sampling PBF size of the EPO sport fleet due to 1) its position in the middle of the geographic range of PBF in the EPO, 2) diversified and opportunistic trip types, 3) the large number of vessels specifically targeting PBF, and 4) a near guaranteed unloading of whole fish at docks able to be sampled. To understand the sampling frame and sampling design of the PSP, the general structure and operations of the CPFV are detailed here as observed from 2014 to 2019.

Description of Commercial Passenger Fishing Vessel (CPFV) Operations

The recreational CPFV vessels fishing off Washington, Oregon, and CA attract a large base of domestic and international anglers year round. While specific operations may vary by port and state, the collective U.S. West Coast CPFV fishery is characterized by recreational anglers purchasing a ticket aboard a charter vessel with a professional captain and crew to take them fishing on day, overnight, or multi-day trips. The majority of CPFV vessels are 20-26 m in length and designed with galleys, bunks or berths, heads, and ample deck space to host 30-75 anglers at a time on multiday trips (colloquially called “party boats”). A subset of smaller vessels 10-15 m in length also host 3-6 people for day trips (colloquially called “six-packs”). Most PBF are caught in CA and Mexico waters, although in some years they can be landed as far north as the Canadian border (NOAA, 2019). When not targeting fish, many CPFV vessels offer tourism-based sightseeing and entertainment opportunities such as whale watching or shark cage diving.

While the term “CPFV” refers to the vessel itself, it also describes the larger collaborative network of public landings, fish processing companies, and auxiliary businesses like tackle shops, restaurants, and canneries located near ports supporting sport fishing. Though businesses compete for angler clientage, the success of the CPFV industry as a whole drives tourism and the industry is generally collaborative. Vessels hail from a specific port and a specific public landing, to which they pay fees to dock and receive services. The dockside landings are the physical and virtual business hubs representing a collection of vessels through dockside and online support. A landing typically consists of a main office, tackle and equipment stores, overnight parking, multiple docks, and a flat platform for unloading catch. The landing office is responsible for organizing and advertising fishing trips, vessel schedules, and catch reports through a central website, social media, and office. Fishing information is shared somewhat freely between vessels and the public via landing websites and social media to boost catches within the fleet. Online advertisement of vessel-specific catch is pivotal in garnering angler business. On-site stores outfit anglers who need rental gear, fishing licenses, and tackle prior to boarding. Vessels arrive and depart from the same dock to drop off and pick up anglers, and fish are unloaded on the landing platforms.

Most of the PBF caught by CA's CPFV fleet occurs in the waters of the Southern California Bight (SCB) and off the Pacific coast of Baja California (Baja). The SCB is a biogeographical region consisting of waters roughly south of the 34°27 N latitude line at Point Conception to the U.S.-Mexico border and generally extending out 200 nautical miles (nm) in the U.S. EEZ (Figure 1). The seasonal southward flow of cold water via the California Current interacts with offshore bathymetric features causing upwelling of nutrient-rich waters and thermal fronts ideal for feeding PBF and other large pelagic predators (Hickey et al., 2003, Block et al., 2011). A mild climate supports near year-round fishing conditions ideal for targeting PBF and other pelagic species including yellowfin tuna, California yellowtail (*Seriola lalandi*), dorado (*Coryphaena hippurus*), skipjack (*Katsuwonus pelamis*), and species of billfish and sharks. The SCB sits in the middle of the geographic range of PBF seasonally migrating between Baja and northern CA, exposing anglers to an array of size classes and availability with abundance peaking in summer. When available, PBF is typically preferentially targeted by recreational anglers and serves as a major commodity driving the CPFV industry in the SCB. During years of reduced PBF availability, the fleet adapts to target other large pelagics, particularly yellowfin tuna and yellowtail. With trips departing nearly every week of every month from the major ports in the coastal counties of Santa Barbara, Ventura, Los Angeles, Orange, and San Diego, the SCB is a popular fishing destination for a large clientele base of domestic and international anglers.

The San Diego CPFV fleet

South of the SCB, the Pacific coast extends 1,220 kilometers below the U.S. border into the Baja Peninsula and offers world-class fishing for tunas, sharks, and tropical species like wahoo (*Ancanthocybium solandri*). The close proximity of the SCB ports to the border allows for appropriately-permitted U.S. vessels to fish in Mexican waters. In 2016, U.S. CPFV trips to Mexican waters totaled to $44.7 million in expenditures and $30.1 million in wage, salary, or self-employment income to the CA economy (Hilger et al., 2019). As the closest port to the Mexican border, the San Diego CPFV fleet targets PBF in Mexican waters more than any other port along the U.S. West Coast. Fittingly, the San Diego CPFV fleet boasts a unique armada of long-range (LR) vessels capable of traveling hundreds of nautical miles south to target tropical species in winter and spring otherwise not seasonally available in the SCB.

Vessels equipped with appropriate fuel capacity, storage, and bunk space host large groups on overnight and multiday trips ranging from quarter-day to more than 16 days. Trips are advertised online by their duration (leaving and returning to the landing), which serves as a general proxy for the range of possible round-trip fishing distance from San Diego. Longer trips afford more time to travel further offshore or transit within one trip to target various species. Two general trips types are offered by the San Diego CPFV fleet: short-range (SR) trips (≤3 days; including trips less than one day), and long-range (LR) trips (>3 days). The most common SR trips are 1-day, 1.5-day and 3-day trips leaving and returning to the same landing either in the morning or at night. A smaller fleet of "day boats" typically do not have sleeping bunks to accommodate overnight travel and thus run quarter day, half day, three-quarter day, or full day trips leaving and returning on the same day. Given the allotted time, day trips typically target available species within a 50-100 nm range from port (Figure 1). The maximum practical distance for a 3-day trip is about 200 nm from San Diego, which is generally to the northern extent of the SCB or into northern Baja (Figure 1).

Instantaneous at-sea communication between CPFV captains—and the sheer amount of vessels that congregate near PBF bites—allow vessels to be in a productive area in both U.S. and Mexican waters within hours. The SR trips are characterized by their ability to change course to opportunistically target PBF, however, it should be noted that many SR trips will not always have access to PBF if fish are beyond a 1-3 day range. Long-range trips vary in duration from 3 days to more than 16 days, with distinct operations between shorter LR trips (<6 days) and longer LR trips (6≥ days). Shorter LR trips operate similarly to SR trips by opportunistically targeting PBF in northern Baja or staying in U.S. waters. In contrast, the longer LR trips usually set a destination off Baja, as far as 650 nautical miles away to Cabo San Lucas to target tropical

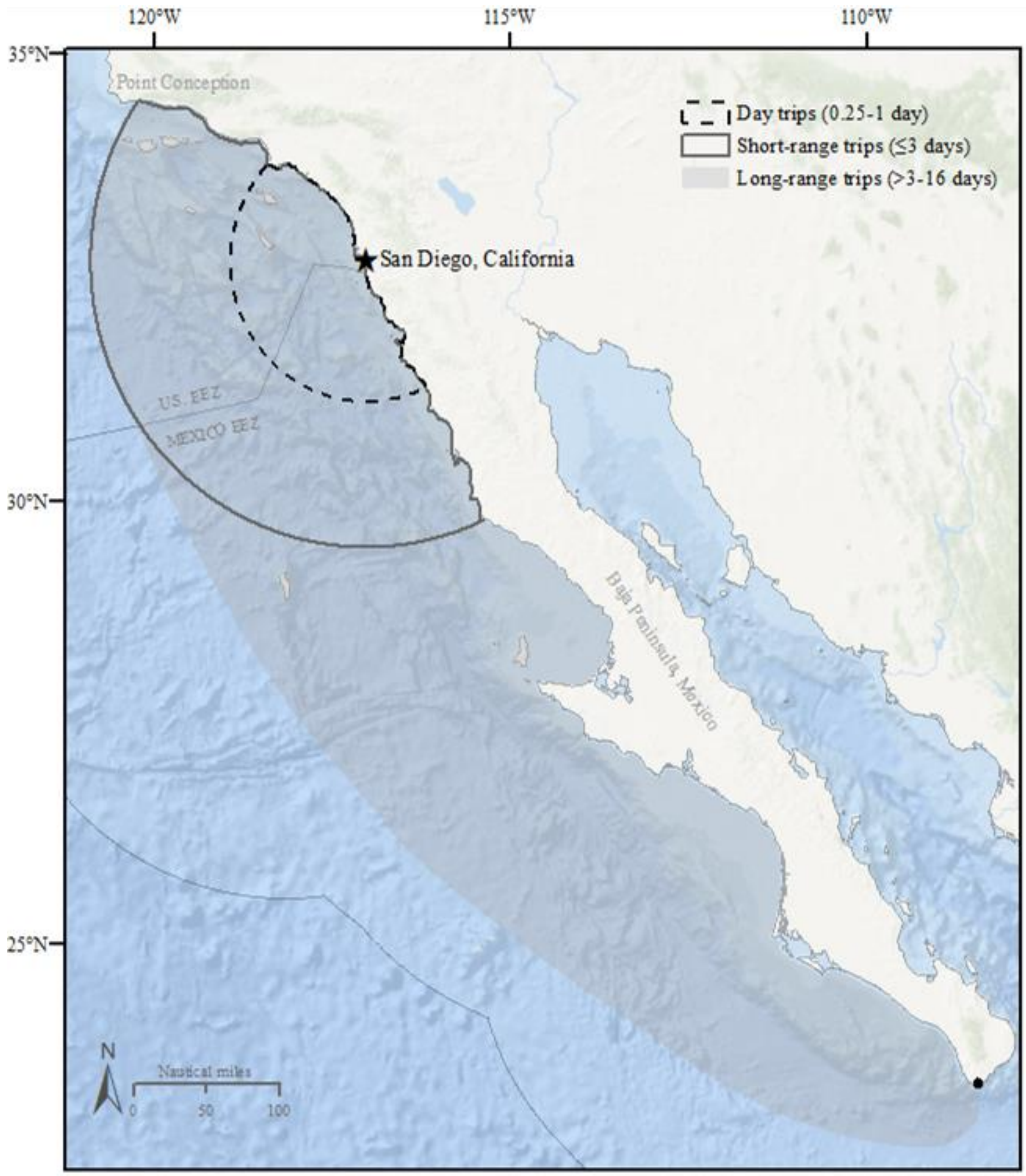

Figure 1. Theoretical fishing ranges for day, short-range, and long-range trips by the U.S. sport fleet operating out of the port San Diego and targeting Pacific bluefin tuna in the Southern California Bight and Baja.

species like wahoo and yellowfin tuna (Figure 1). Traveling to these distant locations takes more than two days of at-sea travel, so long LR trips typically follow pre-determined schedules and generally do not deviate from their set travel routes to preferentially target PBF. However, LR vessels are able to target PBF during transit into and out of northern Baja and the SCB.

Depending on the available range of PBF, many LR trips will fish for PBF in the same areas as SR trips (Figure 1).

At-sea operations

The CPFV operations prioritize getting as many anglers their limits of PBF and other species. Prior to 2015, the recreational bag limit was 10 PBF per angler per day, or 30 PBF for trips three days or longer. In July 2015, the recreational bag limit was reduced to two PBF per angler per day with a maximum of six PBF for a multi-day trip (80 FR 44887, July 28, 2015) by a new federal ruling also applying to anglers fishing in Mexican waters that land their catch in the U.S. Catch of PBF varies temporally and with size, so captains use a range of targeting strategies while balancing trip time and angler success. Communication between CPFV captains and real-time online public reporting of catch can create a positive feedback loop driving angler interest and fleet-wide targeting of available PBF size classes. Smaller (<150 cm fork length, FL) PBF generally school in mixed-size classes and bite more readily, presenting an opportunity for more anglers to simultaneously hook up and land a PBF within an hour or two. The increased numbers of larger PBF in the EPO since 2014, particularly those over 90 kilograms (200 pounds), has driven interest in targeting a larger-size class. Targeting larger fish, however, presents drawbacks for the public charter group dynamic: specific trolling methods for large PBF may limit the number of anglers able to simultaneously fish for many hours to avoid line interference; and even with appropriate gear, the success rate to land a bigger tuna is reduced by the long fight times, gear strain, and angler fatigue. Both captains and anglers consider these advantages and disadvantages of targeting larger fish when planning a trip or booking a trip, respectively.

Once at optimal fishing grounds, CPFV anglers use hook-and-line methods with a single rod and a manual reel. Reels are fitted with monofilament, fluorocarbon, or braided fiber line, and variable terminal tackle or bait (Figure 2). General practice is to match the line test with the target PBF size class to reduce the chance of the line breaking (i.e. use a 30-pound test for PBF in 30-pound range). However, sometimes fish will not bite anything over 20-pound test, requiring anglers to use lighter line and reducing the odds of landing tuna of lager sizes. Anglers will modify their tackle according to the CPFV captain's advice and most recent catch reports for which PBF size classes are currently being targeted and caught. A combination of fishing methods are often employed throughout a single trip and are adapted to the hunting strategies of available PBF, fish position in the water column (schooling on the surface or below the boat) and current foraging patterns. However, even under optimal conditions, fishing is stochastic and confounded by notoriously "selective" PBF, natural bait availability, the lunar cycle, water conditions, water temperature, and many others factors. The most popular hook-and-line methods for PBF on CPFVs are:

-*Fly-lining*: hooking live bait directly to a line, allowing the baitfish to swim freely away from the boat. In some instances, a weight is used to sink the bait deeper in the water column. Fly-lining is typically employed when PBF are schooling near the surface.

-*Kite fishing*: using a conventional kite (Figure 2) and helium balloon to skim an artificial or real bait on the surface by wind and active trolling. Kite fishing is primarily used to get the bait away from the boat and is effective for all species, particularly larger individual PBF (> 90 kilograms).

-*Casting*: casting the line with an artificial lure to either skim on the surface or sink while being retrieved to the boat, typically when PBF are at the surface.

-*Jigging*: dropping and retrieving artificial lures beneath the boat, typically when individual PBF or larger schools are deeper in the water column.

Recreational anglers are not required to document their catch, however, CPFV vessels are mandated by the CDFW to document fishing effort and number of fish kept per fishing day in monthly self-reported logbooks (CDFW, 2019). To keep track of daily catch and ensure anglers are within their legal limits, the vessel assigns each angler a unique number upon boarding. Angler numbers are printed on small tags and physically stapled to the operculum of their landed PBF (Figure 2B), and these "tagged" whole fish are placed in refrigerated sea water (RSW) holds below deck until the end of the trip. Deckhands will either cut the gills or remove gills and innards prior to placing them in the RSW, which speeds up the cooling process to enhance the consumable product.

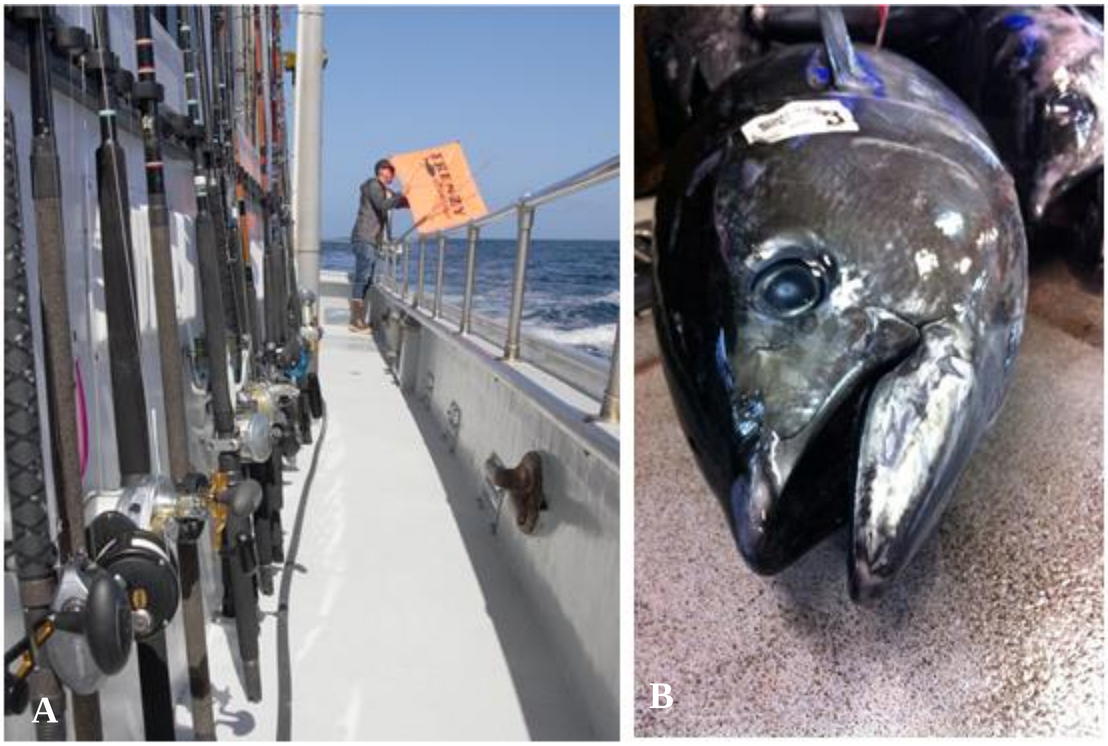

Figure 2. Recreational rods are rigged with manual reels and variable terminal tackle on a CPFV vessel, while a crewmember prepares to deploy a kite (A). The angler number is stapled to the operculum of each landed fish to track individual and vessel bag limits (B).

When vessels are underway returning to port, the crew may offer to retrieve fish from the RSW to filet and bag the edible portions and dispose of the carcass overboard. Anglers can choose to have fish fileted onboard at an additional cost, or keep their fish whole for post-trip filleting either themselves or by a fish processing company. Various processing companies set up booths at the landings coincident with known vessel arrival times where anglers can pay for filleting, canning, smoking, packaging, shipping, and other services for their catch. The booths serve as customer sign up and fish collection locations while the actual fish processing services are conducted at offsite processing facilities. At-sea filleting is typically offered by SR trips between 0.25 and 3 days, but depends on a variety of factors including fish size (larger fish tend to be saved for post-trip filleting), availability of dockside processing companies (which generally do not meet boats returning in the evening), cost, and trip operations and crew availability (longer LR trips generally do not offer at-sea filleting). New at-sea tuna filleting regulations went into effect in August 2015 to retain identifying characteristics for use by law enforcement, requiring all U.S.-landed tuna south of Point Conception to be kept whole or fileted into six pieces (two upper loins, two lower loins, the belly with pelvic fins and urogenital vent attached, and the collar with pectoral fins attached) with the skin attached and placed in its own bag labeled with the species common name (Filleting of Fish on Vessels, 27.65 C.C.R., 2015). While unquantified, the more complex filet requirements may have impacted the ability for crew to filet fish at sea.

Additionally, if a trip offers a jackpot contest (the angler catching the heaviest fish wins the charter's money pool), most fish are kept whole to be weighed on a certified scale at the landing. The number of whole PBF available for portside sampling depends on the number of fish filleted at sea instead of unloaded at the docks for post-trip filleting.

Dockside operations

Back at port, vessels dock at their respective landings to drop off anglers, gear, and catch, and prepare to board the next trip. If fish were filleted onboard, numbered bags of filets are distributed directly to anglers. Tagged fish kept whole for post-trip filleting are retrieved from the RSW onto the vessel deck to be unloaded straight to an offsite processing facility or onto the landings.

Offsite processing facility: If all or a majority of anglers on a trip request one processing company to filet their catch, the chosen processing company set up bins filled with ice water on the dock to meet the vessel upon arrival (Figure 3A). Fish are quickly weighed and inventoried on the vessel deck by processing staff and then placed into bins labeled by trip. The bins are wheeled directly to trucks for transport to an offsite processing facility (Figure 3B). As a result, no whole PBF are unloaded onto the landing, which means fish cannot be measured by the port sampler at the landing.

Onto the landings: Fish are carted from the vessel and organized next to numbered cones on the open landing platform (Figure 4A) and/or lined up to be weighed at certified landing scales for the jackpot (Figure 4B). Anglers either put their fish straight into personal coolers for at-home filleting themselves, or arrange service from their processing company of choice. Processing personnel retrieve the tagged fish from the cones, weigh them at the dockside booths, and place them into bins for transport to the offsite facility.

Figure 3. Bins of ice water are set up on the docks by a processing company prepared for vessel arrival (A). After fish are weighed on the vessel deck and loaded into bins, they are wheeled directly from the vessel to a truck for delivery to an offsite processing facility (B). Image 3B credit Paul Hillman (NOAA Fisheries).

Figure 4. Whole fish tagged with angler numbers are laid out on numbered cones (A) or lined up for jackpot weighing (B) onto the public landings to be retrieved by individual anglers for at-home filleting or by fish processing company personnel at dockside booths. Typically, fish prepared with a weighing rope in the jaw (B, yellow rope) are to be weighed in the jackpot.

Three public landings in the port of San Diego—Fisherman's Landing, Point Loma Sportfishing, and H&M Landing—are identified as sampling locations that maximize sampling efficiency (landing information provided in Appendix I). These landings collectively host around 70 vessels reporting logbook data from San Diego (James and Heberer, 2021), operate public websites advertising current catch in near-real time, and are within 200 meters of each other for one port sampler to walk to each within a sampling window. Importantly, many of San Diego's fish processing companies regularly set up dockside booths to pick up whole fish for filleting at these landings, increasing the number of fish landed whole and available for sampling. Trips are offered throughout the entire week, and the online advertisement of vessel arrival times and catch allows for an opportunistic selection of weekly sampling days.

Sampling design

Sampling days are selected conditional on at least one confirmed trip unloading at least one whole PBF at any of the three landings. This maximizes sampling efficiency for an opportunistic fleet with inherently random schedules and catch, which otherwise makes an *a priori* port sampling scheme largely unproductive. Up to three sampling days per week are selected conditional on just one whole PBF being unloaded between the three docks. Days are selected by calling Fisherman's Landing, H&M Landing, and Point Loma Sportfishing or checking their respective websites days ahead or the morning of sampling (Appendix I).

Sampling typically coincides with the 05:00-10:00 hours when fish processing company booths are set up to retrieve whole PBF. Sampling rarely occurs at night, however, this likely does not introduce bias based on vessel arrival time. Most overnight trips are afforded at least one whole cycle of morning, midday, and night fishing and the onboard RSW allows for the storage of "night caught" fish to be unloaded by a vessel returning in the morning. Sampling is conducted by one SWFSC staff member, so gaps in sampling may occur due to auxiliary work duties and scheduling, especially during months of low PBF catch.

The port sampler targets all possible vessels offloading whole PBF at all three landings within each sampling day. On a given sampling day, conditional random sampling occurs in a two-stage design, aided by the inherently random unloading of PBF off trips.

Stage 1*: Sampling of trips by vessel*

Vessels arriving and unloading PBF first are sampled first. More than 15 vessels each morning may be returning between the three landings and often three or more vessels unload catch simultaneously at one landing. In this case, the sampler measures as many trips as practically possible while prioritizing the trips with the shortest sampling window. A sampling window is the combination of the *unloading window* (time between the first and last fish being unloaded from the vessel) and the *measurement window* (time each unloaded PBF is laid prone and can be measured).

Sampling windows vary by the following unloading methods, ordered here from shortest to longest sampling window:

1. Vessel deck: *20-30 minutes vessel unloading window; 10-second measurement window*

If all or the majority of the fish from a trip are processed by the same company, vessel crew retrieve PBF randomly from the RSW and unload them on the deck to be weighed and counted by the processing crew (Figure 5). After weighing, fish are placed directly into dockside bins of ice water for transport to an offsite processing facility (Figure 3), eliminating the opportunity to measure these fish on the landings. The measurement window between PBF placement on deck and weighing is about 10 seconds per fish and the crew operates quickly to unload the RSW. The sampler works around the vessel crew and processing staff (Figure 5).

Figure 5. Sampling occurring on a CPFV vessel deck before fish are weighed for processing.

2. On the landings**:** *20-60 minutes vessel unloading window; 10 seconds-20 minutes measurement window*

The vessel crew retrieves PBF from the RSW for placement into dockside bins to be unloaded onto the public landings for a) pickup by processors and anglers, or b) given directly to the anglers. The unloading window typically ranges from 20 to 60 minutes depending on how many vessels are waiting in port to unload.

2a. <u>*For pickup by processors and anglers*</u>: PBF are placed on the ground next to their angler number cones or in distinct piles (Figure 6A). The measurement window between PBF placement on and retrieval from a numbered pile ranges from 10 seconds to 20 minutes, which includes weighing at dockside fish processing company booths (Figure 6B). The sampler works around the landing and processing personnel and the public to measure PBF on the ground.

2b. <u>*Given directly to anglers*</u>: Vessel or landing crew call out numbers for anglers to grab their whole fish from carts. The measurement window between number call out and placement in a cooler typically ranges from 10 to 30 seconds. The sampler typically asks the angler to place the PBF on the ground to be measured before placement in the cooler.

Figure 6. Measuring PBF on the landings from numbered piles (A) or at fish processor booths (B). Image B credit Paul Hillman (NOAA Fisheries).

3. Offsite processing facility: *10 minutes-48 hours bin unloading window; 10 seconds-10 minutes measurement window*

Bins loaded dockside directly from vessels (Figure 3) are taken to an offsite processing facility where fish are unloaded randomly by bin. Bins labeled by trip (vessel and date) are unloaded by the processing facility staff based on how quickly the customers of that particular trip requested their orders filled. Although bins are typically unloaded for fillet the same day the vessel arrives (typically 1-6 hours after), some trips are scheduled for filleting the next day and bins are kept in cold storage, so the unloading window may span more 24-48 hours. All the fish from a selected

Figure 7. Fish lined up for fillet in an offsite processing facility, with PBF closest to the filet table sampled first. Image credit Paul Hillman (NOAA Fisheries).

bin are laid out at the facility before transfer to the filet table (Figure 7). The measurement window between the fish being laid on the ground and transfer to the fillet table ranges from 1 to 10 minutes. The sampler must work around the processing facility staff and the fileting staff, the latter unable to accommodate sampling on the filet table.

Each sampling day is variable and vessels may use two or three unloading methods simultaneously and with multiple processing companies. For example, 75% of a trip's catch may be loaded directly into bins destined for an offsite facility, while the remaining 25% is unloaded onto the landing for filet service by two different processing companies. To keep track of where fish are going, the sampler asks vessel crew, processing companies, and landing personnel at the time of vessel arrival as to which unloading methods a trip plans to use. Given the larger bin unloading window at offsite processing facilities, fish unloaded on vessel decks are sampled immediately, followed by those on the landings. Fish unloaded at the processors are sampled later in the day based on the processor's estimate of bin unloading.

Stage 2*: Sampling of individual PBF by angler number*

In 2014, the sampling size per trip was 40 PBF, and trip metadata included sampling date, sampling location (docks or processors), and vessel name. For the 2015-2019 seasons (and currently), the sampling size was reduced to 30 PBF per trip and metadata expanded to include sampling date and day of the week, sampling location, sampling location name (landing name or processor name), vessel name, trip type (SR or LR), trip length (number of days), trip start date, trip end date, number of PBF measured from trip, and number of PBF caught on trip (either by asking the captain or looking at online landing reports) (Appendix II). If a selected trip unloads 30 or less whole PBF, all fish are measured.

If the trip unloads more than 30 PBF, fish are measured based on the unloading method:

1. *Vessel deck*: first 30 PBF randomly unloaded from the RSW.
2. *On the landings:* all PBF from every other angler number (seeded randomly day of) until 30 are measured.
3. *Offsite processing facility*: first 30 PBF randomly unloaded from the bins selected by the processing facility staff for unloading that morning.

Sampling methods

Size composition sampling

Most trip catch contains mixed species composition, including tuna species with similar morphological characteristics as PBF. The PBF are identified by the criteria outlined in Heberer et al. (2019), primarily by pectoral fin length and urogenital pore. Body markings are rarely used due to postmortem loss of color and the likely alteration of characteristic skin markings encountered before measurement, namely by storage in the RSW and movement into bins, docks, and totes. The straight FL from the lower jaw of the closed mouth to the fork in the caudal fin is measured for each PBF to the nearest mm using a 200-cm straight caliper (Figure 5B) and recorded on physical datasheets along with metadata (Appendix II). The precision of the measurement using the centimeter-scale analog caliper is 1 millimeter.

Genetic sampling

For decades before the establishment of the PSP, the SWFSC Fisheries Resources Division Life History Program opportunistically collected PBF genetic samples from processors and private, research, commercial, and CPFV vessels within the Southern California Bight. A 1-2 cm of pectoral fin was clipped and placed in pre-numbered scintillation vials filled with 100% ethanol.

Operculum length-to-fork length sampling

However, not all these genetic samples were associated with whole PBF size because many were taken from heads with intact pectoral fins or from carcasses where the whole FL could not be measured. Instead, the operculum length (OL) was measured for these samples, as an OL-to-FL relationship has been recognized as an established length-length conversion useful in estimating whole tuna size to determine age class (Oliveira et al., 2005). The OL was measured to the nearest cm from the tip of the lower jaw to the end of the operculum with a flexible measuring tape passing just below the ventral margin of the eye (Figure 8B). The vial number and OL were recorded on datasheets and populated into an Excel file.

In anticipation of establishing an EPO-specific OL-to-FL relationship to determine age class from genetic samples lacking whole size data, in 2011 the SWFSC Fisheries Resources Division Life History Program staff started measuring both OL and FL from PBF collected opportunistically from the Southern California Bight. The paired data were used to perform a simple linear regression analysis performed in R (R Core Team, 2020).

Close-Kin Mark Recapture sampling

In 2016, based on the ISC's request for EPO juvenile PBF (<140 cm FL) samples for use in a Pacific-wide close-kin mark recapture (CKMR) project (Anon, 2015), genetic sampling commenced in conjunction with the PSP's size composition sampling from the San Diego CPFV fleet. This concurrent genetic and size sampling produces fin clip samples with directly measured FL and supplements the existing opportunistic genetic sampling, which is currently ongoing.

A 1-2 cm of pectoral fin is clipped and placed in pre-numbered scintillation vials filled with 100% ethanol (Figure 8A). The straight FL is measured directly and recorded on the hardcopy PSP datasheet (Appendix II). PSP length and genetic data are manually populated into the PSP relational database housed at the NOAA SWFSC (Appendix III), on a daily or weekly basis during active sampling. Trips are identified by the vessel name, sampling date, and trip start and end date, and assigned a unique and sequential numeric primary key index, *TripID* (Appendix III). The *TripID* is used to identify individual PBF in a separate table of length data and genetic inventory.

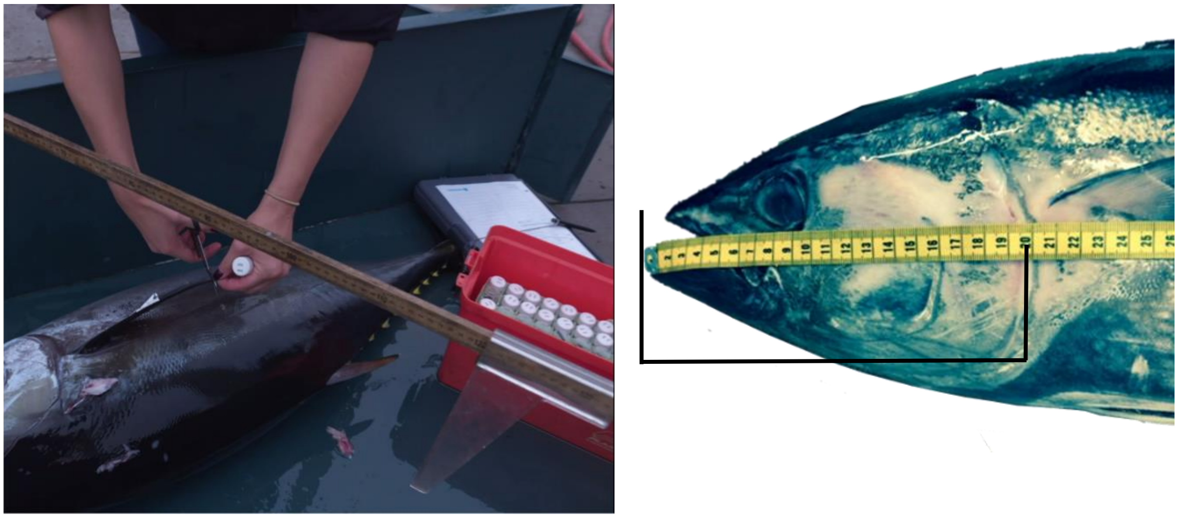

Figure 8. Clippings from PBF pectoral fins are taken at the time of FL measurement and stored in ethanol in numbered vials (A), or from PBF heads with attached fins and intact operculum from which operculum length is measured (B). Image 8A credit Paul Hillman (NOAA Fisheries).

The opportunistic and PSP genetic sampling occurs by separate staff members often at the same location on the same day, which could lead to double sampling. If sampling occurs on the same day, the staff members communicate about which vessel is being sampled and both avoid taking a fin clip from any PBF already missing a piece of the pectoral fin (indicating the fish was already sampled for genetic material).

Data analyses

The CDFW provided summarized monthly totals of PBF caught recreationally by CPFV and private vessels in CA from January 2014 to 2019, queried as of April 2021[3]. Total CPFV catch was calculated from CPFV logbook data and private catch from the integrated state and federal California Recreational Fisheries Survey (CRFS). The CRFS extrapolates private catch as the sum of PBF directly counted by port samplers at private and public landings, and PBF indirectly counted from angler phone surveys of private access marinas and night fishing. The CRFS total catch is described as "*total angler trips x mean catch per trip = total catch*" (CDFW, 2017). Comprehensive information and methods for the CRFS program are further detailed in CDFW

[3] The CPFV logbook data is continuously updated by the CDFW, even months after logbook data is originally submitted by participating vessels. As such, catch totals may vary based on the data request date.

(2017) and for the CPFV logbooks in CDFW (2019), including estimation methods and the definition of blocks and districts.

The PBF catch from public vessels was summed from the CPFV logbook data, and then grouped by year, month, port code, port name, port county, target species, and fishing block. Fishing blocks reported in logbooks corresponded to “where the majority of the fish were caught” (CDFW, 2019) as either U.S., Mexico, or U.S./Mexico blocks (those straddling the international border). Data from CPFV vessels hailing from ports in the county of San Diego (Imperial Beach, Mission Bay, San Ysidro, San Diego, Point Loma, National City, Oceanside, Coronado, La Jolla, Chula Vista) were subset to assess catch and effort of the San Diego CPFV fleet relative to the CA CPFV fleet and the total CA recreational fleet. The PBF catch from private boats was summed from the CRFS data and grouped by month, year, and district as unrounded estimates. The total CA recreational PBF catch by month and year was calculated as the sum of the CPFV catch and the private boat catch.

For the sampling period between July 2014 and December 2019, size and genetic sampling effort, unique vessels and trips sampled, and PBF measured by trip type were summarized by month and year. The average FL was calculated by year, month, and trip, and length frequency distributions (LFD) were grouped by 1-cm bins. Prominent modes were visually estimated and assigned age classes based on the minimum FL per age presented in Table 2 (e.g. age 1 PBF range from 58.6 cm to 91.3 cm FL). A focused statistical analysis of the LFD between and within years was outside the aim of this report.

Table 2. Pacific bluefin tuna age-length relation as used in the ISC stock assessment (Table 2-1 in ISC, 2020).

Age (years)	Fork length (cm)
0	19.1
1	58.6
2	91.4
3	118.6
4	141.1
5	159.7
6	175.2
7	188.0
8	198.6
9	207.4
10	214.7

The total sampled PBF relative to the total CA recreational catch, the total CA CPFV catch, and the San Diego CPFV catch was calculated by month and year. As the PSP was established in July 2014, CPFV logbook data used to calculate relative sampling excluded catch from February 2014 through June 2014.

Results

Recreational PBF catch in California

Between January 2014 and December 2019, the CA recreational fleet caught an estimated 117,759 PBF (Table 3), 98.3% of which were caught by the combined CPFV and private vessels hailing from the Southern California counties of Los Angeles, Orange, and San Diego. The CPFV fleet accounted for 88.2% of the total PBF caught in CA, with the San Diego CPFV fleet alone comprising at least 72.6% of the total PBF caught in CA total (Table 3).

Table 3. Total California (CA) recreational PBF catch as reported from CPFV logbooks and as estimated from CRFS surveys, and representative size composition sampling from the San Diego CPFV fleet by the NOAA Sampling Program between 2014 and 2019. Omitted months reflect zero PBF catches as reported in both logbooks and in CRFS surveying. *The NOAA Port Sampling Program was established in July 2014, so representative sampling for this time period excludes catch data from February 2014 through June 2014.

		CA Recreational PBF Catch (fish)			NOAA Sampling Program				
Year	Month	CPFV logbooks	CRFS estimation	Total CA catch	PBF measured	PBF measured relative to CA PBF catch	PBF measured relative to San Diego PBF catch	Vessels sampled	Trips sampled
2014	2	16	0	16	--	--	--	--	--
	3	3	0	3	--	--	--	--	--
	5	822	0	822	--	--	--	--	--
	6	599	0	599	--	--	--	--	--
	7	12930	1199.61	14129.61	631	4.47%	5.19%	16	29
	8	7331	645.14	7976.14	649	8.14%	9.77%	13	29
	9	2941	34.84	2975.84	452	15.19%	15.93%	10	16
	10	1182	0	1182	0	0	0	0	0
	11	426	55.67	481.67	0	0	0	0	0
	12	39	0	39	0	0	0	0	0
2014 Total		26289	1935.26	28224.26	1,732	6.47%*	7.66%*	20	74
2015	1	420	20.43	440.43	0	0	0	0	0
	2	268	0	268	0	0	0	0	0
	3	20	0	20	0	0	0	0	0
	4	11	0	11	0	0	0	0	0
	5	716	93.99	809.99	0	0	0	0	0
	6	866	562.52	1428.52	46	3.22%	5.86%	2	3
	7	4436	4701.91	9137.91	132	1.44%	3.74%	9	13
	8	9539	902.88	10441.88	234	2.24%	3.20%	10	11
	9	5730	201.50	5931.50	81	1.37%	2.28%	5	5
	10	96	77.37	173.37	0	0	0	0	0
	11	37	15.96	52.96	0	0	0	0	0
	12	2	0	2	0	0	0	0	0
2015 Total		22141	6576.57	28717.57	493	1.72%	3.03%	16	32
2016	4	663	159.41	822.41	7	0.85%	1.06%	3	3
	5	296	166.68	462.68	57	12.32%	19.93%	7	7
	6	473	602.52	1075.52	61	5.67%	13.01%	9	10
	7	548	630.27	1178.27	72	6.11%	14.91%	6	9
	8	3391	221.32	3612.32	355	9.83%	12.12%	19	23
	9	3183	82.96	3265.96	217	6.64%	7.68%	13	14
	10	469	88.15	557.15	0	0	0	0	0
	11	1195	92.99	1287.99	0	0	0	0	0

	12	176	0	176	0	0	0	0	0
2016 Total		10394	2044.29	12438.29	769	6.18%	9.24%	31	66
2017	2	1	0	1	0	0	0	0	0
	3	52	0	52	0	0	0	0	0
	4	472	18.74	490.74	0	0	0	0	0
	5	762	28.60	790.60	30	3.79%	3.94%	1	1
	6	340	39.16	379.16	10	2.64%	2.95%	5	5
	7	462	133.81	595.81	3	0.50%	0.92%	2	2
	8	4827	399.20	5214.20	139	2.66%	3.48%	14	14
	9	3396	356.85	3752.85	127	3.38%	4.51%	15	18
	10	1622	101.87	1723.87	0	0	0	0	0
	11	1976	83.85	2059.85	18	0.87%	1.52%	2	2
	12	1371	70.84	1441.84	20	1.39%	1.73%	3	3
2017 Total		15281	1232.91	16513.91	347	2.10%	2.89%	27	45
2018	1	415	0	415	0	0	0	0	0
	2	25	25.40	50.40	0	0	0	0	0
	3	86	0	86	0	0	0	0	0
	4	225	0	225	0	0	0	0	0
	5	224	34.65	258.65	0	0	0	0	0
	6	1293	149.13	1442.13	48	3.33%	3.73%	9	9
	7	1612	240.67	1832.67	82	4.43%	5.48%	11	12
	8	2565	64.86	2564.86	192	7.30%	12.44%	14	20
	9	1756	337.01	2003.01	0	0	0	0	0
	10	1401	25.16	1389.16	30	2.10%	3.41%	1	1
	11	3267	10.05	3277.05	218	6.65%	11.68%	7	11
	12	93	0	93	0	0	0	0	0
2018 Total		12962	886.94	13848.94	570	4.12%	6.03%	25	53
2019	1	3	11.53	14.53	0	0	0	0	0
	4	1143	0	1143	0	0	0	0	0
	5	1221	40.88	1261.88	9	0.71%	0.74%	3	3
	6	2633	140.99	2773.99	189	6.81%	7.27%	14	20
	7	2083	301.64	2384.64	92	3.86%	4.47%	8	11
	8	3074	378.85	3452.85	293	8.49%	10.28%	16	27
	9	3961	187.15	4148.15	61	1.47%	1.89%	4	4
	10	1472	61.28	1533.28	38	2.48%	3.00%	3	3
	11	1114	67.26	1181.26	0	0	0	0	0
	12	122	0	122	0	0	0	0	0
2019 Total		16826	1189.59	18015.59	682	3.79%	4.44%	26	68
2014-2019 Total		**103893**	**13865.57**	**117758.57**	**4593**	**3.90%**	**5.37%**	**44**	**338**

Within the CPFV fleet, logbook data indicated that 98.3% of the 103,893 PBF caught in CA between 2014 and 2019 were on vessels hailing out of the counties of San Diego (82.3% of CPFV totals), Los Angeles (9.3%), and Orange (6.7%) (Table 3, Figure 9). The CPFV fleet landed 65.8% of PBF in U.S. fishing blocks, 7.5% in U.S./Mexico blocks, and 26.7% in Mexico blocks (Figure 9), the latter nearly all (97.7%) by the San Diego CPFV fleet. The San Diego CPFV fleet caught 31.8% of their PBF in Mexican waters, compared to the less than 1% and 8% by the Los Angeles County and Orange County CPFV fleets, respectively (Figure 9).

Among the CA CRFS catch, the South District—defined as the counties of San Diego, Los Angeles, and Orange—caught 98.3% of the total PBF estimated caught between January 2014 and December 2019 (Figure 9). Additionally, only vessels from the South District caught PBF in

Mexico fishing blocks, which accounted for 15.9% of the district's total catch (Figure 9). Counties not mentioned did not report any PBF landings from January 2014 to December 2019.

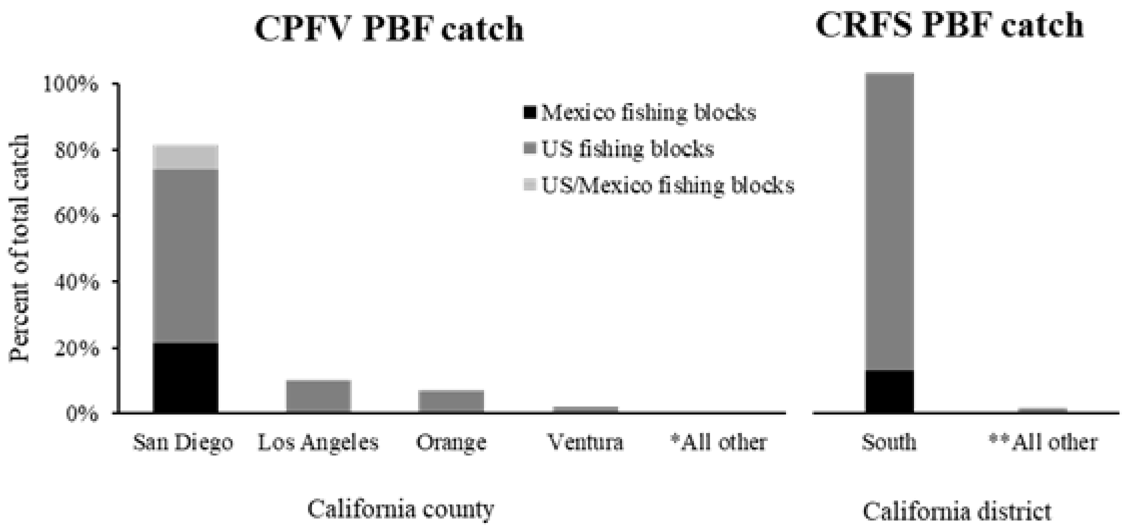

Figure 9. Total California recreational PBF catch by California county and fishing block as reported from CPFV logbooks (*left*) and by California district and fishing block as estimated from CRFS surveys (*right*) between January 2014 and December 2019. *All other California counties for CPFV catch include: Humboldt, Santa Barbara, Santa Cruz, San Luis Obispo, San Mateo, and, and Sonoma, amounting to 0.05% of the total.**All other California districts for CRFS catch include: Central, Channel, Redwood, San Francisco, and Wine districts, amounting to 1.4% of the total. Counties not mentioned did not report any PBF landings from January 2014 to December 2019.

Size composition sampling

Between July 2014 and December 2019, a total of 4,593 PBF were measured by the PSP from 338 trips on 44 unique CPFV vessels in San Diego (Tables 3 and 4). Over 90% of PBF were measured by portside methods (on the vessel decks or on the landings) from Fisherman's Landing (35.9%), Point Loma Sportfishing (33.0%), and H&M Landing (21.5%) ports, while the remaining 9.5% were measured at fish processing facilities away from the docks. A single PBF was measured dockside from a CPFV vessel hailing out of Seaforth Landing, also in the port of San Diego. The sampled PBF represented 3.9% of the total CA PBF catch (yearly range 1.72-6.47%) and 5.37% of the total San Diego CPFV catch (yearly range 3.03- 9.24%) (Table 3).

The PSP actively sampled in 31 months between July 2014 and December 2019, representing a 51.7% coverage of the 60 months where PBF were reported caught in CA and a 54.4% coverage of the 57 total months where PBF were reported caught in San Diego County (Table 3). During these 31 sampling months, 87.4% of the total CA PBF catch and 89.7% of the total San Diego County PBF catch were landed (Table 3), representing periods of high catch volume and sampling availability.

Peaks in relative monthly sampling effort corresponded to peaks in relative monthly catch, namely during the summer months of June, July, August, and September (Figure 10). Based on aggregate monthly totals for 2014-2019, 78.5% the CA PBF catch and 77.9% of the San Diego CPFV PBF were caught between June and September, while 90.7% of the PSP samples were collected. No sampling took place in the months of January, February, or March for all years, which accounted for a combined 1.3% of the CA catch and 1.3% of the San Diego CPFV catch.

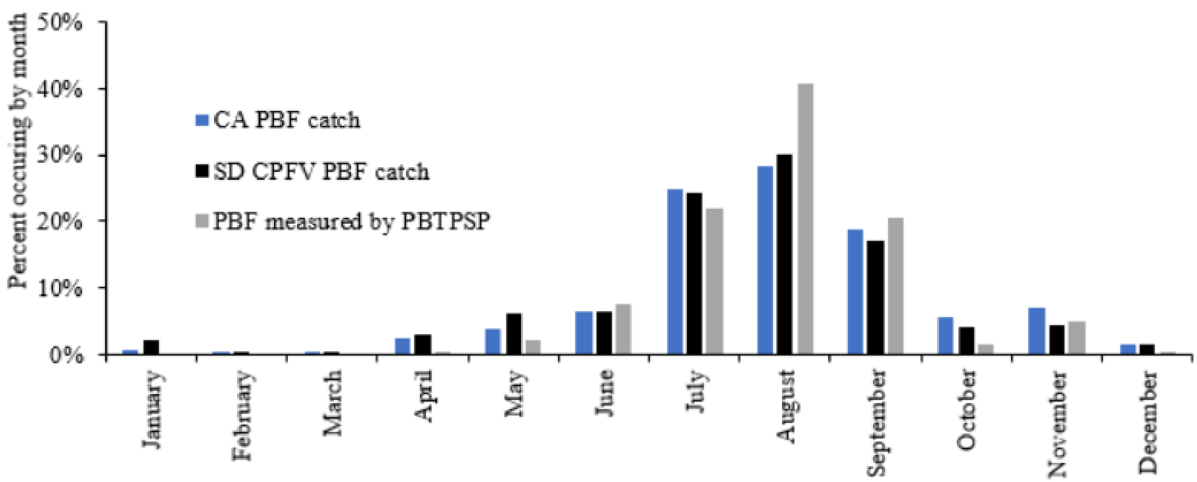

Figure 10. Proportion of the total CA recreational PBF catch, San Diego CPFV PBF catch, and PBF measured by the NOAA Pacific Bluefin Tuna Port Sampling Program occurring by month, between July 2014 and December 2019.

Table 4 summarizes the number of PBF measured and average FL and its variance by year, month, and types of trips. The number of PBF measured declined after 2015 due to the change of sample size per trip from 40 fish to 30 fish. The majority of PBF measured during the 2016-2019 seasons were from SR trips, while 52% of PBF in 2015 were from LR trips (Table 4). As trip length was not recorded in the metadata for the 2014 sampling season, more than 80% of the PBF sampled in 2014 were from trips of an unknown duration, while only a small amount of PBF (ranging from 0% to 3.3% of PBF) were measured annually from trips of unknown duration beyond the 2014 season.

Table 4. Length data by month, year, and trip type for the 4,593 PBF measured by the PSP between July 2014 and December 2019. Omitted months reflect those where no sampling occurred, however, PBF may have been reported caught in CPFV logbooks or CRFS surveying. Trips of unknown duration are due to gaps in metadata collection.

		NOAA Sampling Program Totals		Long-range trips (> 3 days)		Short-range trips (≤ 3 days)		Unknown trip duration	
Year	**Month**	**Total PBF measured**	**Avg. FL ± SD (cm)**	**PBF measured (% of total)**	**Avg. FL ± SD (cm)**	**PBF measured (% of total)**	**Avg. FL ± SD (cm)**	**PBF measured (% of total)**	**Avg. FL ± SD (cm)**
2014	7	631	86.3 ± 15.2	170 (26.9%)	86.1 ± 18.8	10 (1.6%)	80.7 ± 10.6	451 (71.5%)	86.5 ± 13.7
2014	8	649	93.4 ± 20.9	59 (9.1%)	106.8 ± 15.1	0	--	590 (90.9%)	92.0 ± 20.9
2014	9	452	83.8 ± 12.0	59 (13.1%)	87.9 ± 10.2	0	--	393 (86.9%)	83.2 ± 12.2
2014 Total		1,732	88.3 ± 17.4	288 (16.6%)	90.7 ± 18.5	10 (0.6%)	80.7 ± 10.6	1,434 (82.8%)	87.9 ± 17.1
2015	6	46	86.0 ± 7.2	6 (13.0%)	85.8 ± 2.9	40 (87.0%)	86.0 ± 7.7	0	--
2015	7	132	95.9 ± 21.1	81 (61.4%)	94.7 ± 16.2	51 (38.6%)	97.8 ± 27.1	0	--
2015	8	234	86.5 ± 12.0	106 (45.3%)	88.7 ± 12.3	128 (54.7%)	84.8 ± 11.4	0	--
2015	9	81	77.2 ± 11.4	66 (81.5%)	79.0 ± 11.8	15 (18.5%)	69.4 ± 4.3	0	--
2015 Total		493	87.5 ± 15.8	259 (52.5%)	88.0 ± 14.6	234 (47.5%)	86.8 ± 17.0	0	--
2016	4	7	77.6 ± 3.0	0	--	7 (100%)	77.6 ± 3.0	0	--
2016	5	57	85.8 ± 12.0	0	--	57 (100%)	85.8 ± 12.0	0	--
2016	6	61	119.5 ± 17.7	27 (44.3%)	110.7 ± 3.6	34 (55.7%)	126.5 ± 21.1	0	--
2016	7	72	116.8 ± 20.8	0	--	72 (100%)	116.8 ± 20.8	0	--
2016	8	355	98.7 ± 21.7	164 (46.2%)	104.6 ± 176	191 (53.8%)	93.6 ± 23.5	0	--
2016	9	217	119.2 ± 11.9	97 (44.7%)	116.5 ± 13.6	120 (55.3%)	121.4 ± 9.8	0	--
2016 Total		769	106.7 ± 21.6	288 (37.5%)	109.2 ± 16.4	481 (62.5%)	105.2 ± 24.1	0	
2017	5	30	150.7 ± 6.5	0	--	30 (100%)	150.7 ± 6.5	0	--
2017	6	10	108.2 ± 30.8	7 (70.0%)	110.1 ± 31.7	3 (30.0%)	103.6 ± 34.7	0	--
2017	7	3	146.8 ± 20.9	0	--	3 (100%)	146.8 ± 20.9	0	--
2017	8	139	89.0 ± 33.5	80 (57.6%)	78.1 ± 21.7	59 (42.8%)	103.7 ± 40.6	0	--
2017	9	127	121.8 ± 31.6	79 (62.2%)	122.9 ± 29.6	46 (36.2%)	122.0 ± 34.4	2 (1.6%)	74.6 ± 3.4
2017	11	18	92.4 ± 14.9	0	--	18 (100%)	92.4 ± 14.9	0	--
2017	12	20	73.9 ± 4.2	0	--	20 (100%)	73.9 ± 4.2	0	--
2017 Total		347	106.7 ± 36.3	166 (47.8%)	100.7 ± 34.1	179 (51.6%)	112.5 ± 37.5	2 (0.6%)	74.6 ± 3.4
2018	6	48	96.2 ± 17.2	4 (8.3%)	103.6 ± 40.4	44 (91.7%)	95.5 ± 14.3	0	--
2018	7	82	119.9 ± 36.8	22 (26.8%)	104.7 ± 28.2	41 (50%)	119.7 ± 36.7	19 (23.2%)	137.8 ± 39.6
2018	8	192	126.7 ± 48.2	49 (25.5%)	130.7 ± 47.8	143 (74.5%)	125.3 ± 48.4	0	--
2018	10	30	106.1 ± 13.3	30 (100%)	106.1 ± 13.3	0	--	0	--
2018	11	218	119.0 ± 35.5	53 (24.3%)	151.4 ± 34.9	165 (75.7%)	108.6 ± 28.8	0	--
2018 Total		570	119.1 ± 39.5	158 (27.7%)	128.7 ± 40.5	393 (68.9%)	114.3 ± 38.2	19 (3.3%)	137.8 ± 39.6
2019	5	9	116.2 ± 3.1	0	--	9 (100%)	116.2 ± 3.1	0	--
2019	6	189	116.7 ± 16.0	37 (19.6%)	107.4 ± 17.0	152 (80.4%)	118.9 ± 14.9	0	--
2019	7	92	100.8 ± 19.2	59 (64.1%)	100.2 ± 21.1	33 (35.9%)	101.8 ± 15.7	0	--
2019	8	293	95.2 ± 26.0	38 (13.0%)	88.9 ± 13.3	237 (80.9%)	96.1 ± 27.6	18 (6.1%)	97.3 ± 22.6
2019	9	61	98.6 ± 19.8	41 (67.2%)	102.0 ± 21.8	20 (32.8%)	91.4 ± 12.4	0	--
2019	10	38	111.3 ± 22.4	36 (94.7%)	108.6 ± 18.5	0	--	2 (5.3%)	159.4 ± 41.2
2019 Total		682	103.4 ± 23.6	211 (30.9%)	101.2 ± 19.9	451 (66.1%)	104.4 ± 24.9	20 (2.9%)	103.5 ± 30.2
2014-2019 total		**4593**	**98.7 ± 26.8**	**1,370 (29.8%)**	**101.3 ± 26.7**	**1,748 (38.1%)**	**105.2 ± 30.0**	**1,475 (32.1%)**	**88.7 ± 18.7**

Length compositions

The PBF measured during the 2014-2019 seasons ranged from 46.1 cm (age 0) to 210.2 cm FL (age 9), with an average FL of 98.7 ± 26.8 cm (age 2) (Table 4). The length frequency distribution for all PBF measured from the San Diego CPFV fleet was multimodal, with five prominent modes visually identified as 68 cm FL (age 1), 92 cm FL (age 2), 122 cm FL (age 3), 151 cm FL (age 4), and 173 cm FL (age 5) (Figure 11).

The mean size of all PBF measured by year was 88.3 cm in 2014, 87.5 cm in 2015, 106.7 cm in 2016 and 2017, 119.1 cm in 2018, and 103.4 cm in 2019 (Table 4 and Figure 11). The length frequency distribution was more variable in 2017 and 2018 given the higher standard deviation of the mean FL than the other years. Larger adult PBF (> 150 cm FL, > age 4) were found in the 2017, 2018, and 2019 years, reflected by a general shift in size over time. The largest FL sampled each year gradually increased from age 5 (165.1 cm FL) in 2015 (Figure 13) to age 6 (184.3 cm FL) in 2016 (Figure 14) and age 9 (210.2 cm FL) in 2017 (Figure 15). The mean PBF size from LR trips were larger in 2014, 2015, 2016, and 2018 than that from SR trips indicating that mean size did not have a relationship with the type of trips for every year. The average PBF sampled from the San Diego CPFV fleet was age 2, but the PBF in the EPO ranged from ages 0 to 9 between 2014 and 2019. Five distinct cohorts at ages 1, 2, 3, 4 and 5 in the sampling data reflected the primarily juvenile PBF in the EPO (Figure 11), where distinct modes of ages 1-3 were present in all years (Figures 12-17). Young-of-the-year (age 0) PBF were present in just three years without a distinct mode, indicating that the age-0 fish were not always available in EPO, or at least to portside sampling by the PSP. The LFD within each calendar year also appeared multimodal (Figures 11-17).

The 2017 sampling year is notable, as it contains 1) both the smallest PBF (46.1 cm FL, age 0) and the largest PBF (210.2 cm FL, age 9) measured from the entire dataset, 2) prominent age 1 and age 4 size classes, and 3) the most sampling months within a single season (7), over the largest range (May-December) (Figure 13). With the exception of the November samples from 2018, the summer months of July, August, and September typically accounted for the majority of the samples each year.

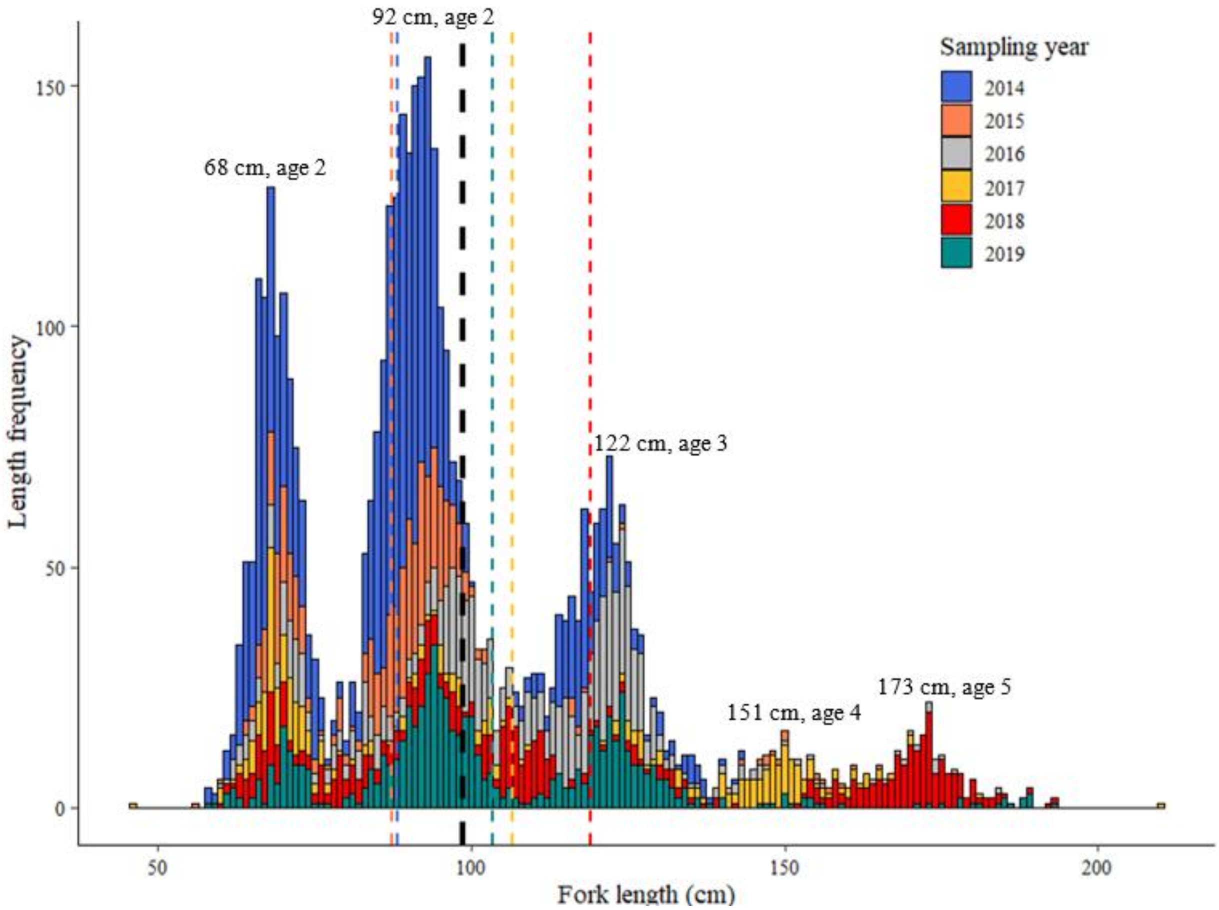

Figure 11. Length frequency distribution, aggregate five-year mean FL (black dashed line), yearly mean FL (dashed lines), and estimated modes and ages of the 4,593 PBF lengths measured in 2014 (n= 1,732), 2015 (n= 493), 2016 (n= 769), 2017 (n= 347), 2018 (n=570), and 2019 (n= 684). The mean FL for 2016 and 2017 were both 106.7 cm.

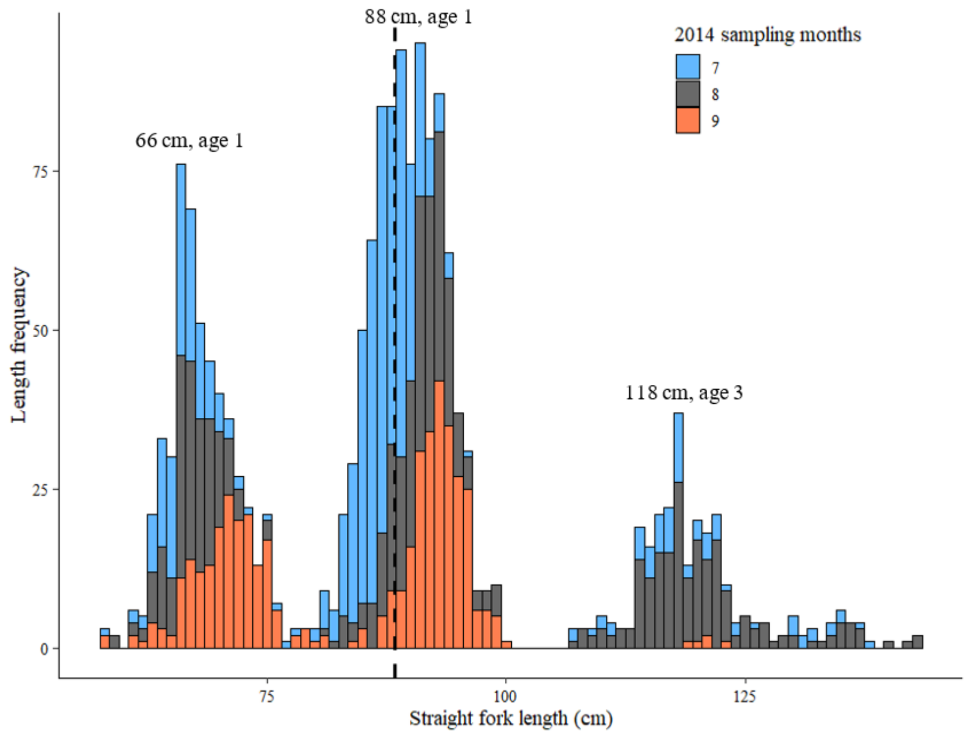

Figure 12. Length frequency distribution, average FL (dashed line), and estimated modes and ages of the 1,732 PBF measured in 2014, by month.

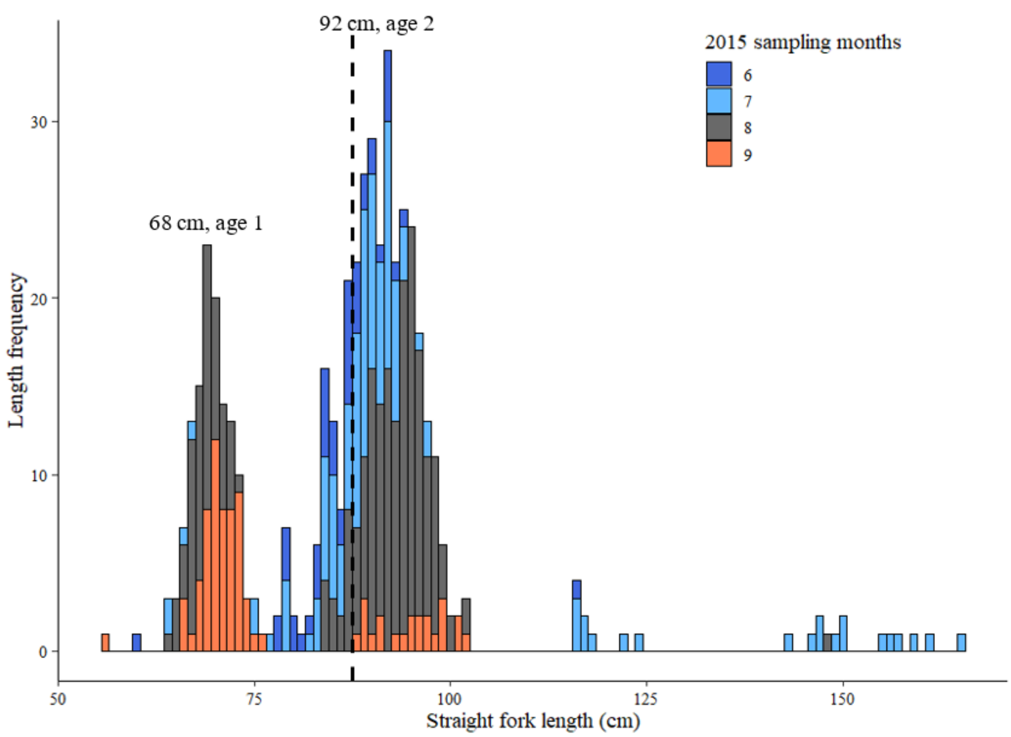

Figure 13. Length frequency distribution, average FL (dashed line), and estimated modes and ages of the 493 PBF measured in 2015, by month.

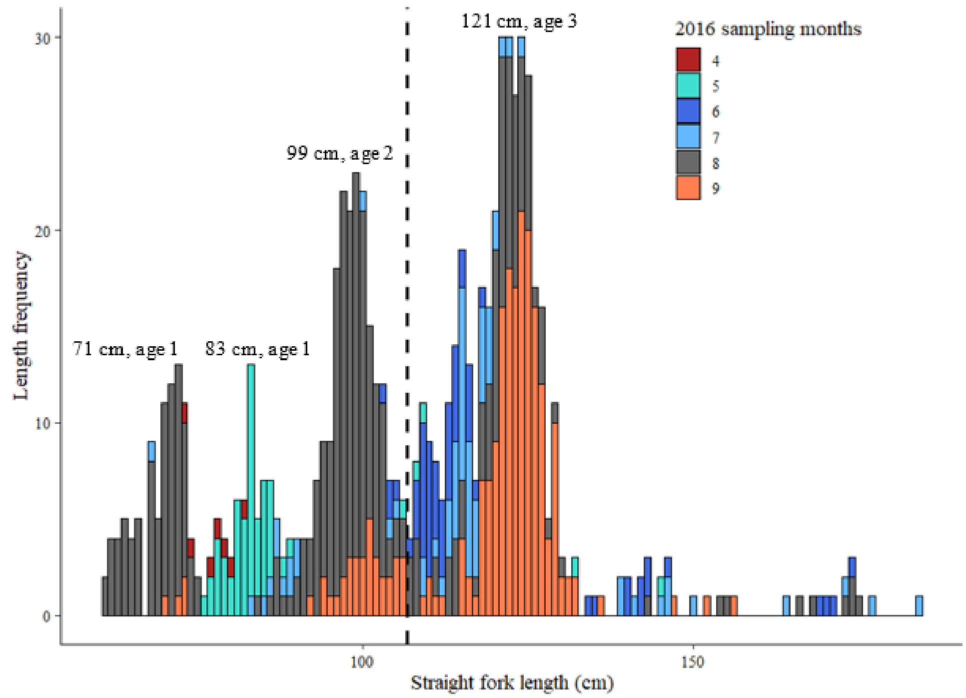

Figure 14. Length frequency distribution, average FL (dashed line), and estimated modes and ages of the 769 PBF measured in 2016, by month.

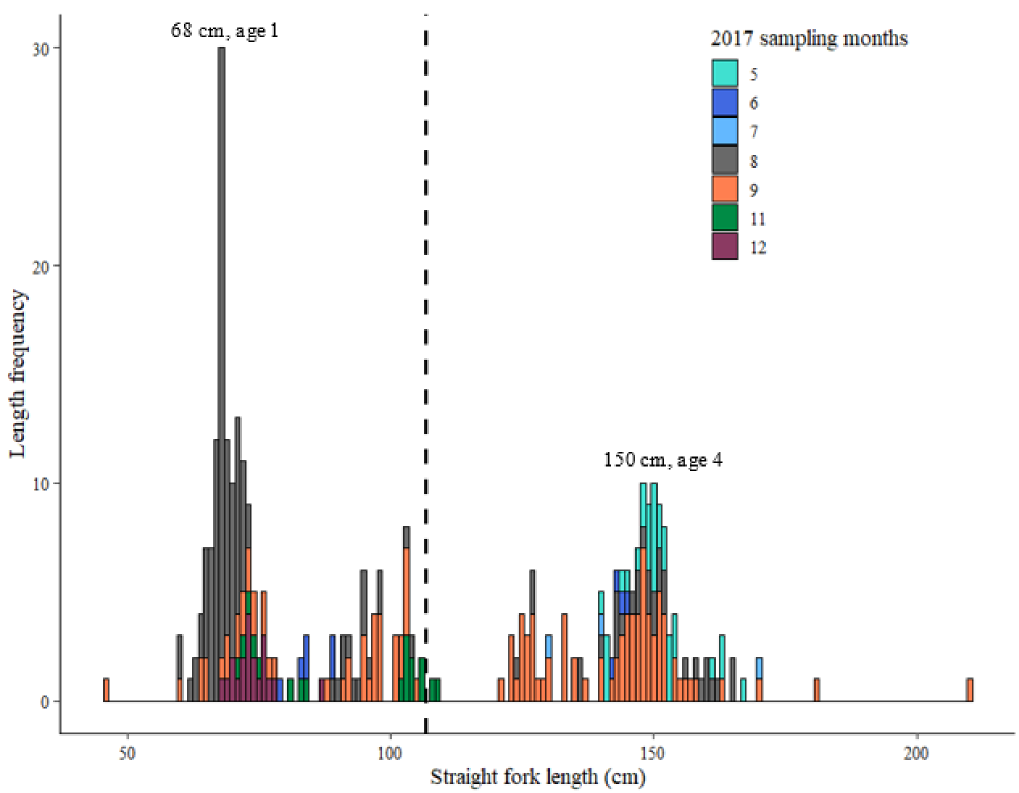

Figure 15. Length frequency distribution, average FL (dashed line), and estimated modes and ages of the 347 PBF measured in 2017, by month.

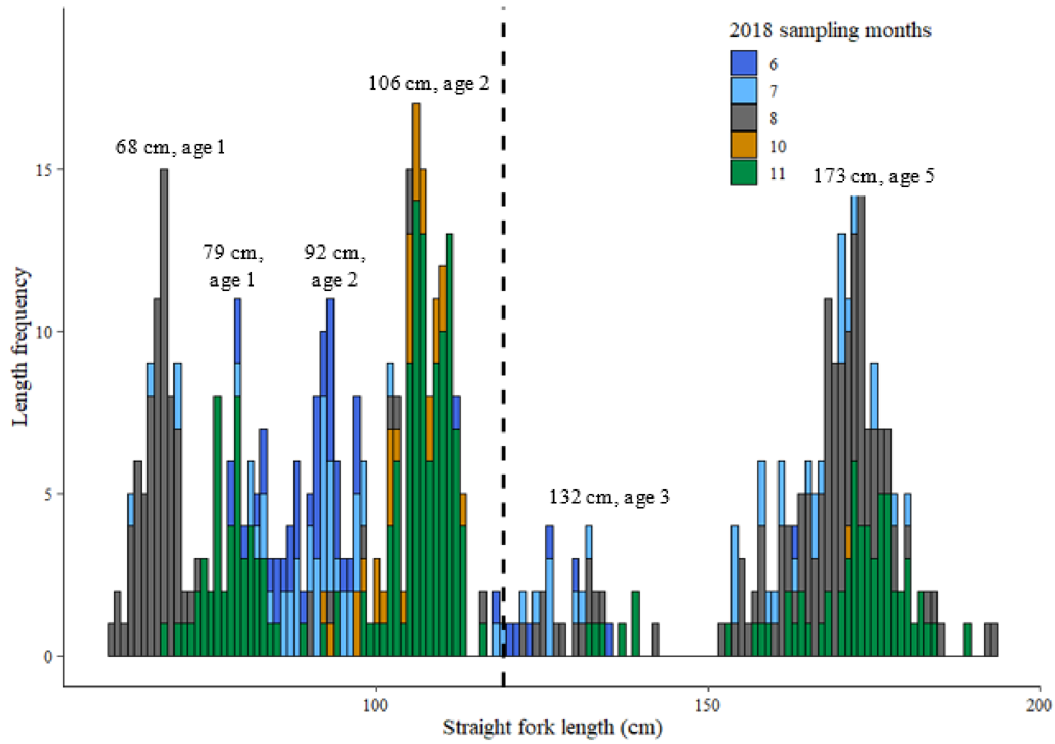

Figure 16. Length frequency distribution, average FL (dashed line), and estimated modes and ages of the 570 PBF measured in 2018, by month.

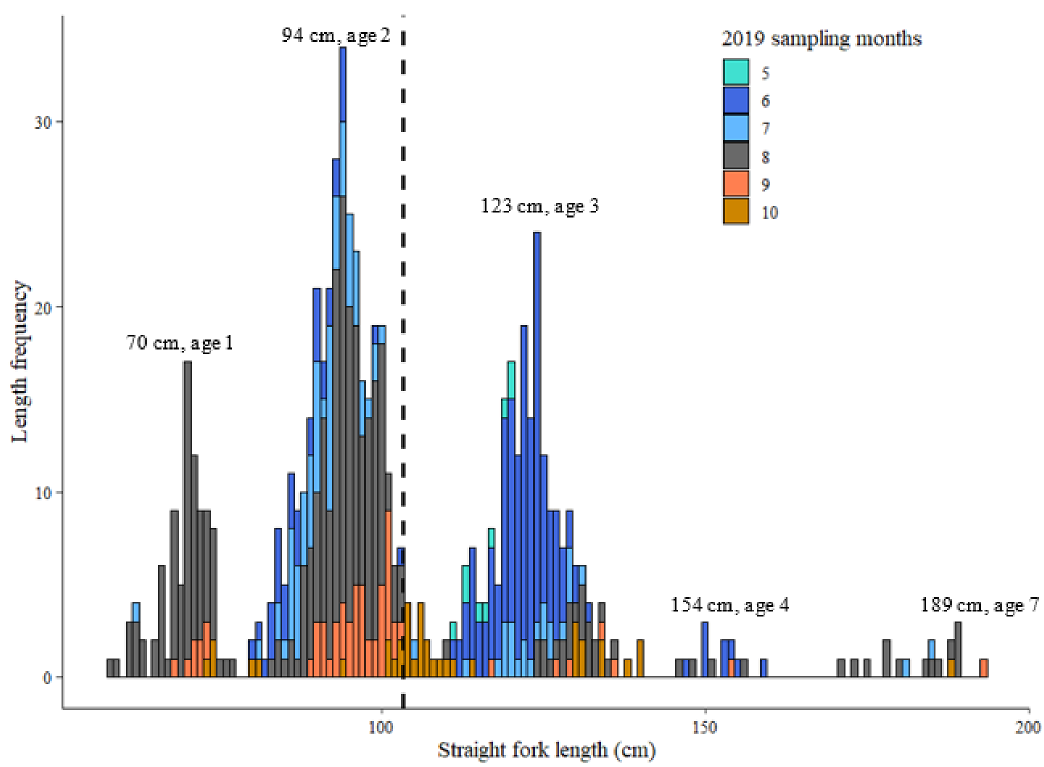

Figure 17. Length frequency distribution, average FL (dashed line), and estimated modes and ages of the 684 PBF measured in 2019, by month.

Genetic sampling

Operculum length-to-fork length regression

Between 2011 and 2014, 235 whole PBF were collected through opportunistic sampling and measured for both OL and FL. A significant log-transformed regression was found to predict FL from OL (Eq. 1),

$$\text{FL (cm)} = 2.685 * \text{OL}^{1.065} \qquad \textbf{(1)}$$

with an R^2 of 0.99 (Figure 18). This equation was used to estimate the FL of genetic samples collected from 2016-2019 (Table 5) for use in CKMR research.

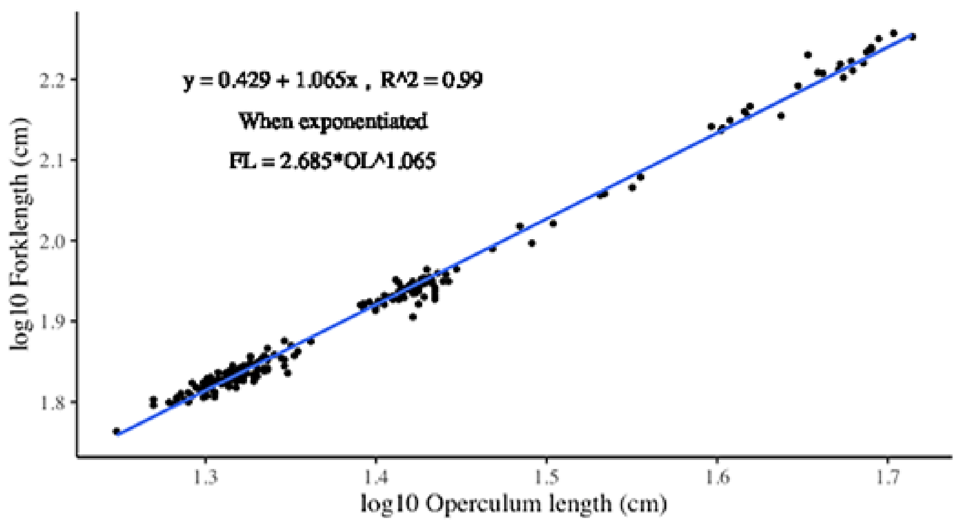

Figure 18. A simple linear regression for an operculum-length-to-fork-length (OL-FL) relationship, based on 235 PBF landed in the Southern California Bight from 2011-2014.

Close-Kin Mark Recapture genetic sampling

Between January 2016 and December 2019, a total of 3,918 fin clips were collected specifically for Close Kin Mark Recapture research from PBF of various sizes landed within the Southern California Bight. Of these, 2,142 fin clips were collected from the San Diego CPFV fleet concurrent with the PSP size composition sampling and paired with a measured straight FL (Table 5). The remaining 1,776 fin clips were collected opportunistically from PBF heads and paired with a measured OL (Table 5), from which FL were estimated using the OL-FL relationship (Eq. 1). Including the 235 fin clips collected in 2011-2014 to establish the OL-FL relationship, 4,153 total fin clips were collected from EPO PBF between 2011 and 2019 for use in genetic research (Table 5). The majority of these fin clips, 80.5%, were from juvenile PBF (<140 cm FL, age 1-3) for potential use in the CKMR project.

Table 5. Genetic samples with known fork lengths (FL) collected exclusively from the San Diego CPFV fleet, and with known operculum lengths (OL) collected from any vessel in the Southern California Bight. *The genetic sampling component of the PSP was established in 2016.

Year	Fin clips with measured OL and FL (juveniles)	Fin clips with measured FL (juveniles)	Fin clips with measured OL and estimated FL (juveniles)
2011-2014*	235 (211)	--	--
2016	--	612 (590)	477 (350)
2017	--	349 (209)	422 (357)
2018	--	558 (371)	595 (454)
2019	--	623 (590)	282 (228)
Totals	**235 (211)**	**2,142 (1,760)**	**1,776 (1,389)**

Discussion

This report is the first to describe the organization and procedures of the San Diego CPFV fleet as it operated from 2014-2019. The U.S. West Coast CPFV fleet, particularly out of Southern California, is an industry unlike any in the U.S. due to the sheer number of vessels targeting PBF, the fishing range of combined SR and LR vessels, and the unique at-sea and dockside collaboration of vessels, businesses, and customers driving high fishing volume. The geographic positioning of San Diego county in the middle of the EPO PBF migration routes, high catch totals from the county's vessels, near year-round fishing operations, and preferential targeting of PBF made the San Diego CPFV fleet the most prominent CPFV fleet catching PBF within the larger EPO sport fleet. With the ability to target PBF in U.S. and Mexican waters from a range of SR and LR vessels, the San Diego CPFV fleet alone accounted for the majority of PBF caught by the larger CA CPFV fleet and the majority of the PBF caught in the entire CA recreational fleet (private and public vessels) between 2014 and 2019. As such, it provided the ideal sampling frame for collecting length and genetic data from PBF in the EPO.

The NOAA PSP successfully sampled—and is currently continuing to sample—the size composition data and genetic materials from PBF caught by the San Diego CPFV fleet as representative of the EPO sport fleet. Despite only actively sampling in half of the months when PBF were actively caught in CA, the PSP had access to 87.4% of the total CA PBF catch and 89.7% of the total San Diego County PBF catch during peak PBF catch in summer and fall months. Overall, the PBF sampled from the San Diego CPFV fleet represented 3.9% of the CA PBF and 5.4% of the San Diego CPFV PBF catch between July 2014 and December 2019.

The shift in mean FL from 2014 to 2018 and gradual increase in the largest PBF sampled from 2015 to 2017 corroborate anecdotal accounts from San Diego's career captains and anglers seeing large schools of "jumbo PBF" reminiscent of record-setting PBF in decades past (Foreman, 1990). Further analyses of presented length and genetic data are beyond the scope of this paper, however, the multimodality and size shifts between and within the sampling years point to seasonal patterns likely attributed to changes in fishery targeting, shifting size distribution due to seasonal growth, or the arrival of new PBF recruits in the EPO. The available size composition data are publically available by request.

To our knowledge, the OL-FL relationship presented here is the first EPO-specific regression produced from PBF landed from Southern California. This length-length conversion is essential to SWFSC Fisheries Resources Division Life History Program in estimating FL for future genetic sampling while also retrospectively estimating FL for PBF biological samples since 2011. Given the short four year time span of the samples used to create the regression, the PSP may need to update this regression with samples from longer epochs spanning at least five to ten years in order to resolve or account for larger environmental events.

Notably, the 2014 and 2019 sampling seasons spanned two anomalously warm seasonal episodes when SST ranged between +0.5-2.6°C from normal 30-year averages[4] (National Weather Service, 2020). Large-scale warming occurred from 2014 to 2015 in the northeastern Pacific

[4] Five consecutive overlapping seasons. Warm and cold periods are based on a threshold of ±0.5° C for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v5 SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W)], based on centered 30-year base periods updated every 5 years.

from Alaska to Mexico (Wang et al, 2014, Bond et al., 2015), with a distinct Southern California Warm Anomaly in 2014 persisting to at least the summer of 2015 (Leising, 2015, Zaba et al., 2016). This Southern California Warm Anomaly was coupled with the 2015-2016 El Niño, which registered the highest positive SST values since the 1997-1998 El Niño (Leising, 2015). These warming events likely affected the range (Runcie et al., 2018) and activity of PBF in the EPO, warranting further investigations into current fleet selectivity compared to historical operations, recruitment timing and age, CPFV fleet operations and catch, and seasonal timing of PBF in the EPO to support assessment and management of the species in the Pacific.

Limitations and future directions

The use of one dedicated sampler for the 2014-2019 season size composition sampling presented advantages and challenges. Measurement error was reduced (or at least consistent and thus adjustable), repeat size sampling was virtually non-existent, and vessel decks and processing facilities were easier to access by just one person alone. However, it was often difficult for one sampler to navigate hectic and rapid sampling windows and unloading methods; to alternate quickly between measuring, genetic sampling, and recording data; to measure the simultaneous unloading of vessels at more than one landing; and to operate sampling gear in between crowds of anglers moving fish around. Less staffing also meant other San Diego landings, such as Seaforth Landing, was not regularly sampled due to travel and time logistics. The exclusion of other landings likely did not affect the sample population, as all vessels within the San Diego fleet fished in similar patterns and locations regardless of home landing.

A potential source of bias in this dataset was the infrequent non-random unloading of the largest jackpot fish to be piled separately from the rest of the PBF for weighing (Figure 4B). The sampler kept this potential bias in mind by measuring trips either before or after jackpot weighing, so the jackpot PBF were not separated from the rest of the catch on the cones. Samplers in future seasons could avoid this issue entirely by sampling vessels that send fish exclusively to processing companies where jackpot fish are likely to be mixed with the rest of the trip's catch and facilitate sampling randomization.

After the 2014 pilot season of the PSP, there were concerns the portside sampling design could negatively skew the average size of PBF based on two biases—targeting LR trip types, and not sampling PBF filleted at sea. The fishing conditions in 2014 were such that PBF were abundant in Mexican waters outside of the range of SR trips operating in U.S. waters, so the LR vessels able to access Mexican waters were landing mostly all the PBF in the 2014 season. It was suggested that these LR trips could be fishing a different cohort of PBF not typically available in U.S. waters, thus not accurately representing the U.S. recreational fleet of both SR and LR vessels. Additionally, it was suggested that smaller PBF were more likely to be filleted at sea by SR vessels while LR vessels did not fillet at sea at all. While the filleting presents a separate sampling issue, it also further compounds the concern of specifically targeting LR trips, which may bring in larger PBF available to portside samplers. In 2015, action was taken in response to these concerns: 1) the PSP began recording trip lengths in addition to other metadata, 2) the PSP started covering a more diverse set of SR and LR trips within a sampling day, and 3) SAC initiated an at-sea sampling program to ensure PBF from both LR and SR vessels were sampled at-sea before filleting (Siddall, 2017). A separate retrospective study conducted pairwise comparisons to show that the median FL from PSP sampling was significantly larger than the median FL from SAC sampling in 2015, 2017, and 2018 ($p < 0.001$), and that there was a significant difference in FL between PBF measured from LR and SR trips within the PSP for 2017 and 2018 (James et al. 2021a,b). The length compositions between the programs had similar multimodal distributions, but the PSP generally sampled larger PBF (median = 97.1 cm FL) while the SAC program was able to measure smaller PBF (median = 92.0 cm FL) often filleted at sea and unavailable for port sampling.

Fisheries-dependent sampling—portside or at-sea—is inherently tied to the activity of the San Diego CPFV fleet, which can be influenced by anthropogenic trends such as large-scale economic woes (e.g. the Great Recession of 2008), regulations that impact catch or fishing operations (e.g. reduction in federal bag limit), and larger environmental factors (e.g. Oceanic Niño Index). Data presented here reflect changes in CPFV operations between 2014 and 2019. The reduction in sampling totals from 1,732 lengths in 2014 to 493 lengths in 2015 was likely attributed to two factors. First, an *ad-hoc* adjustment reduced the trip sampling size from 40 fish in 2014 to 30 fish in 2015-2019 to account for the practical time limit of one sampler operating in quick dockside sampling windows. Second, the 2015 reduction in the U.S. recreational bag limit from 10 PBF to two potentially impacted the PBF caught and available to sample. The Mexican government also closed PBF fishing to U.S. commercial and recreational vessels in Mexican waters from July 2014 and to November 2015 (Secretaria de Gobernación. 2014). Together, the U.S. bag limit reduction and the Mexican closure may have prompted a reduction in the possible PBF landed by the CPFV fleet following 2014. More recently, it was not possible to conduct this sampling program during the currently ongoing global pandemic of the novel SARS-CoV-2 coronavirus (severe acute respiratory syndrome coronavirus 2) (World Health Organization, 2020) and as such, the PSP did not sample PBF from San Diego's public landings for the 2020 or 2021 seasons. Such anthropogenic factors may increase the challenges of sampling in the future and points to the advantages the complementary use of SAC sampling data to continue the time series for the fleet.

Conclusions

In 2020, for the first time, the ISC PBF WG used size composition data from the PSP to represent the EPO sport fleet. The 4,593 lengths were used to estimate an EPO sport fleet selectivity independent from commercial fisheries in the most recent 2020 ISC stock assessment (Nishikawa, 2020; ISC, 2020). The fin clips collected by the PSP also contributed to the EPO-specific genetic samples requested by the ISC CKMR project. The genetic analyses have yet to begin but are slated to include simultaneous analysis by all ISC member nations across the Pacific (Anon, 2015).

The PSP continues to collect the size composition and genetic samples from the U.S. recreational fleet. This public dataset can be used for fishery- and species-specific analyses of PBF caught recreationally in the EPO. The more than 4,000 fin clips could serve beyond CKMR research alone, as several DNA extractions can occur from just one 1-2 cm piece of tissue to be used in multiple phylogeny and population genetic studies (Wirgin and Waldman, 1994). The value of portside sampling from the San Diego CPFV fleet extends beyond just size and genetic data, as the collection of biological samples has supported life history research for the species for more than a decade. Histological analyses of ovaries collected from females larger than 140 cm FL landed by the CPFV fleet did not show any signs of previous or active spawning and were concluded to be sexually immature (Snodgrass et al., 2019). Despite the presence of potential sexually mature PBF off the U.S. West Coast, these histological findings suggest PBF are not spawning in the EPO and corroborate the lack of PBF eggs or larvae encountered during routine ichthyoplankton surveys of the California Current for over five decades (Smith, 1988). The collection of stomach, otolith and tissue samples has also supported investigations into PBF migration (Baumann et al., 2015, Madigan et al., 2014, 2018a) and foraging ecology (Madigan et al., 2012, 2018b, Snodgrass et al., unpublished), primarily.

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Appendix I. NOAA Pacific Bluefin Tuna PSP Standard Operating Procedures

Equipment

- Waterproof data sheet and pencil
- Centimeter-scale analog caliper (least count of 1 millimeter (mm))
- Waterproof storage box with pre-labeled scintillation vials filled with 100 % ethanol
- Cutting shears for genetic sampling

Procedures

Preparation

1. Plan out a tentative sampling schedule the week or day before:
   a. Access the long- and short-range boat schedules online (https://www.fishermanslanding.com/, https://www.pointlomasportfishing.com/, and https://www.hmlanding.com/) or by calling each landing to see which vessels are coming in at which time. Online sportfishing report websites also provide non-vetted records of fish reports from all local landings.
   b. Choose three to four days where vessels are arriving into port and where at least one trip has at least one PBF.
   c. Based on arrival times which can vary (generally 05:00- 05:30) and be obtained by contacting the landing or port office, plan to arrive at the docks 15 minutes before vessel ETA, as vessels sometimes unload earlier than expected.

In-field Sampling

2. Sample first trip that unloads based on the following unloading schemes:
   a. **Onboard**. Some long-range boats with multi-day permits and hundreds of fish encourage customers to use a certain fish processing company. These boats call ahead to have fish processing companies waiting with large bins of ice water on the docks for immediate transfer of fish from vessel refrigerated sea water (RSW) hold to totes to the processing facility, so fish will not be laid out on the landings for easy sampling. If possible, ask the captain or deck boss' permission to come aboard and measure PBF as the crew unload them from the RSW before transfer to the tote. As fish are both input and retrieved randomly from the RSW, sample continuously until reaching the 30-fish limit regardless of size, order, or angler number (see Figure 5 in text).
   b. **Processors**. Most anglers will request ahead of time (Figure 5) or at the landings for fish processors to filet and vacuum pack their fish by the pound. The processing companies set up their respective tables, scales, and totes at the landings and will transfer the fish from angler number cones or piles to the totes as quickly as possible to ensure freshness. At the processing facility, the fish from the labeled totes are unloaded randomly and lined up toward the filet table by order of customer-requested processing time (same day, next day, overnight, etc.). Fish will be grabbed sequentially starting closest to the filet table (Figure B), so start at the fish closest to the table and work backwards towards the end of the line to ensure you sample all possible fish before filleting. Processors may not wait for you to sample, so with their consent, make sure to work around them and as quickly as possible.

c. **Landings**. If not filleted at-sea or saved for processing ahead of time (*see 5a*), most vessels will unload whole fish onto the landings. Fish will be brought from the vessel to the landing in carts, unloaded by anglers or the landing personnel, and placed next to cone with their respective angler number (stapled to the PBF's operculum), or given directly to anglers (See Figure 6 in text). Sampling can occur before PBF are retrieved by the fish processing companies, or while the fish processing employees are weighing PBF before placement in their totes (Figure 6). Many vessels will line up the jackpot (largest fish of the trip) fish to be officially weighed at the landing. These and other big PBF may be are often unloaded separately from the other PBF, or will be selected from cones during unloading, complicating the otherwise randomized cone sampling strata (see Figure 4 in text) by removing the largest PBF that could have been measured. After weighing, these PBF will then either be integrated back into the cones or given to the fish processors. If possible, aim to sample these fish when they are still integrated with the rest of the catch.

3. **If sampling at the landings** (see 5c) and:
    a. **Vessel unloads more than 30 PBF**: choose random cone numbers to sample (e.g., every 5th number, odd numbers only) and sample all PBF at each cone until 30-fish sampling limit is reached (even if mid-way through cone).
    b. **Vessel unloads less than 30 PBF**: sample all PBF
4. With the tuna lying flat on the ground, ensure the jaw is intact, mouth closed, and body as straight as possible (sometimes tail will be frozen and curved upwards). Place the inside edge of the fixed caliper bracket at the tip of the snout and slide the inside edge of the moving bracket to touch the outside edge of the caudal fin fork. Do not allow bracket to compress caudal tail, instead bringing the caliper as close to fin's true resting position. If tuna exceeds your arm-span, ask someone to hold the fixed bracket at the snout so you can confirm the length reading.
5. With the inside edge of the moving bracket at the edge of the caudal fork, read the cm measurement to the nearest mm on the scale. If the line falls between the mm marks, round up to the nearest mm (i.e., if between 101.2 and 101.3, record 101.3 cm).
6. Record centimeter on the sampling sheet (**Appendix II**) under "Fork Length (cm)".
7. After measuring FL, use cutting shears to cut off a 2 to 3-cm portion of the tip of either pectoral fin.
8. Place fin clip in scintillation vial and record corresponding number in "Vial Number" column on datasheet next to the respective FL measurement.
9. With the cap secured, flip the vial upside down in the storage box to indicate completion and select the next vial for sampling the next fish.

Repeat steps 4-9 for each PBF.

Data Entry

10. Manually populate trip metadata information into "Trip_ID" table and sampling data into "PBF_Lengths". Assign each new trip the next available "*Trip_ID*" code (**Appendix III**) and record on datasheet.
11. Sequentially store hardcopy datasheets in designated location at SWFSC.

Appendix II. NOAA Pacific Bluefin Tuna PSP Datasheet

NOAA Pacific Bluefin Tuna Port Sampling Program

SWFSC Fisheries Resources Division- Life History Program

Contact Liana Heberer (858) 546-5626: liana.heberer@noaa.gov

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_________________ , _______ /_______ /_________

Sampling Day MM DD YYYY

Sampling Location	Vessel	Trip Type	Trip Length	Depart Date	Return Date	PBF Landed	PBF Sampled	Trip ID
		LR / SR						
		LR / SR						
		LR / SR						
		LR / SR						
		LR / SR						
		LR / SR						

Vessel		Fork length (cm)	Vial Number
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		

Vessel		Fork length (cm)	Vial Number
	16		
	17		
	18		
	19		
	20		
	21		
	22		
	23		
	24		
	25		
	26		
	27		
	28		
	29		
	30		

Sampler: _________________

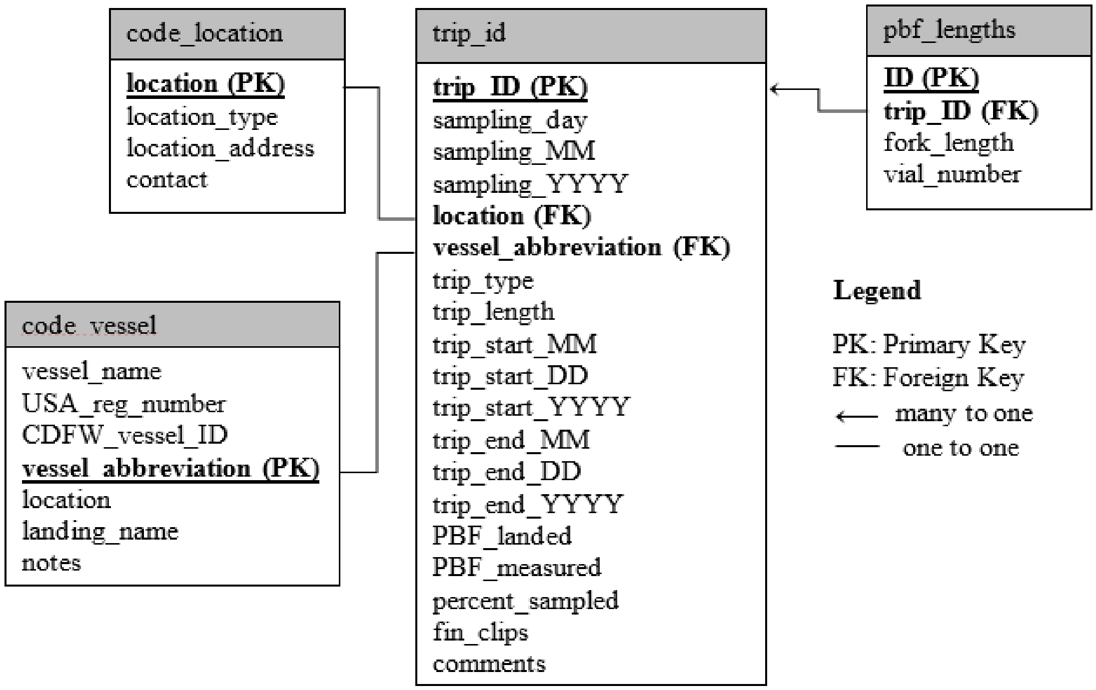
Total fish measured: ________

Total fin clips: ________

Start Time: ________ End Time: ________

NOAA FISHERIES

Appendix III. NOAA Pacific Bluefin Tuna PSP Database Structure



"code_location" table

Field Name	Data Type	Description
location (PK)	Number	Numeric code for location
location_type	Short Text	Docks or processors
location_address	Short Text	Physical street address
contact	Short Text	Telephone number

"code_vessel" table

Field Name	Data Type	Description
vessel_name	Short Text	Vessel name as written on stern and officially registered
USA_reg_number	Number	United States Coast Guard (USCG) vessel ID
CDFW_vessel_ID	Number	California Department of Fish and Wildlife Commercial Fishing ID
vessel_abbreviation (PK)	Short Text	Abbreviation of vessel name
location	Short Text	Location of sportfishing landing vessel belongs to
landing_name	Short Text	Name of sportfishing landing vessel belongs to
notes	Short Text	Ancillary notes

“trip_id” table

Field Name	Data Type	Description
<u>trip_ID (PK)</u>	Number	Unique sequential primary key index assigned by sampler
sampling_day	Short Text	Week day trip was sampled
sampling_MM	Number	Calendar month trip was sampled
sampling_DD	Number	Calendar day trip was sampled
sampling_YYYY	Number	Calendar year trip was sampled
location (FK1)	Number	Corresponding *Location* code from “code_Location” table
vessel_abbreviation FK2)	Short Text	Corresponding *VesAbrv* code from “code_vessel” table
trip_type	Short Text	Short-range (SR) or long-range (LR)
trip_length	Number	Calendar year trip was sampled
trip_start_MM	Number	Calendar month sampled trip started
trip_start_DD	Number	Calendar day sampled trip started
trip_start_YYYY	Number	Calendar year sampled trip started
trip_end_MM	Number	Calendar month sampled trip ended
trip_end_DD	Number	Calendar day sampled trip ended
trip_end_YYYY	Number	Calendar year sampled trip ended
PBF_landed	Number	Total estimated PBF landed on sampled trip
PBF_measured	Number	Total PBF measured from sampled trip
percent_sampled	Calculated	PBF_Measured/ PBF Landed
fin_clips	Yes/No	Whether at least one fin clip was collected from sampled trip
comments	Short Text	Ancillary comments

“PBF_lengths” table

Field Name	Data Type	Description
ID	AutoNumber	Unique sequential serial number for primary key index
trip_ID	Number	*Trip_ID* code from “Trip_ID” table
fork_length	Number	Straight fork length (cm) for each PBF measured in each trip
vial_number	Short Text	Alphanumeric label of scintillation vial for associated genetic sample