Fishery-at-a-Glance: Pacific Barracuda

Scientific Name: *Sphyraena argentea*

Range: Barracuda range from Cabo San Lucas, Mexico to Prince William Sound, Alaska, with the greatest abundance occurring in the southern portion of their range.

Habitat: Barracuda are a coastal pelagic, schooling fish that can be found in the open water, as well as surrounding kelp beds and rocky reefs. Juvenile Barracuda inhabit coastal lagoons, bays and harbors.

Size (length and weight): Barracuda reach a maximum size of about 48 inches (122 centimeters) in total length and 16 pounds (7.3 kilograms) in weight. Females are about 3% larger than the males.

Life span: The oldest aged Barracuda was 18 years.

Reproduction: Barracuda are broadcast spawners, releasing eggs and sperm multiple times between May and July in the nearshore waters of Baja California and southern California.

Prey: Barracuda feed upon a variety of smaller species including anchovies, sardines, young Pacific Mackerel, young Jack Mackerel, and California Grunion.

Predators: Giant Sea Bass, California Sea Lions, Harbor Seals, and porpoises are all known to feed on Barracuda when available.

Fishery: Barracuda are primarily targeted commercially by gill net and hook and line. In southern California, Barracuda also support a popular recreational fishery.

Area fished: Fishing for Barracuda generally takes place offshore in less than 100 feet of water, but also occurs near kelp beds when water is warm.

Fishing season: Barracuda are generally present off the California coast about six months of the year from April to October, and are caught seasonally with warm water events.

Fishing gear: Since purse seining for Barracuda was banned in 1940, the primary commercial fishing gear for Barracuda is small mesh drift gill nets and various types of hook and line, including trolling and jigs. Recreationally they are caught by hook and line.

Market(s): Commercially caught Barracuda is primarily sold fresh for human consumption.

Current stock status: There is no current stock assessment for Barracuda. Determining an accurate stock status of Barracuda off the California coast is challenging because they are not a resident species, they are a shared stock with Mexico, and their abundances fluctuate greatly with environmental conditions.

Management: Barracuda are currently managed by the state with a recreational bag limit and minimum size limit for both the commercial and recreational fisheries. While Barracuda are a relatively data poor stock, the continued lower landings in recent years despite warm water is of some concern and needs closer monitoring and further evaluation. In addition, to fully assess the impacts of the fishery, more information on associated bycatch is necessary.

1 The Species

1.1 Natural History

1.1.1 Species Description

Pacific Barracuda (*Sphyraena argentea*), also called California Barracuda (Barracuda), are a schooling, coastal pelagic species. They are in the Sphyraenidae family, which encompasses 21 different species of mostly tropical Barracuda. One other species of Barracuda, the Mexican Barracuda (*Sphyraena ensis),* has an overlapping range with the Pacific Barracuda, but they have only been seen in southern California during warm water events (Lea and Rosenblatt 2000). Barracuda are easily identified, as they are long and skinny with pointy teeth and silvery sides sometimes with dusky bars (Figure 1-1).

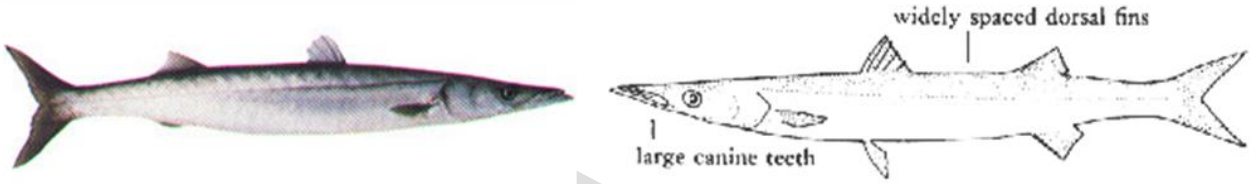

Figure 1-1. Image and diagram of Pacific Barracuda (Source: CDFW).

1.1.2 Range, Distribution, and Movement

Barracuda range from Cabo San Lucas, Mexico to Puget Sound in Washington State. Tagging studies show Barracuda annually migrate northward from Baja California to southern California in the late spring and early summer (Pinkas 1966). The timing and distance of the movement is highly correlated with sea surface temperatures, moving northward earlier in the year during warm water events. Barracuda can range from the pelagic environment to nearshore kelp beds and rocky reefs. They are commonly found from the surface to 120 feet (ft) (36 meters (m)) in depth (Schultze 1973). Juveniles also inhabit shallow habitats like coastal lagoons, bays and harbors (Pinkas 1966).

Figure 1-2. Range of Pacific Barracuda.

1.1.3 Reproduction, Fecundity, and Spawning Season

Barracuda are broadcast spawners, releasing large amounts of eggs and sperm into the water column multiple times per season. Spawning occurs between April and October in the nearshore waters of Baja California and southern California, peaking in June in southern California. Eggs drift until hatching larvae averages 0.10 inches (in) (2.5 millimeters (mm)) (Orton 1955). Multiple studies have found the mass of the female Barracuda to be the best indicator of high fecundity with the number of eggs released per spawning event increasing with the size of the fish (Walford 1932; Bottinelli and Allen 2007). The number of eggs vary from 42,000 from a 20 in (50 centimeter (cm)) female to 484,000 from a 37 in (94 cm) female (Walford 1932).

The reproductive behavior of Barracuda is unknown, but as a pelagic schooling fish they most likely spawn in large groups with no territoriality or complex mating behaviors (Bottinelli and Allen 2007).

1.1.4 Natural Mortality

Barracuda are fast growing and relatively short lived. The oldest aged Barracuda was 18 years (yr) (Bottinelli and Allen 2007). Determining the natural mortality (M) of marine species is important for understanding the health and productivity of their stocks. Natural mortality results from all causes of death not attributable to fishing such as old age, disease, predation or environmental stress. Natural mortality is generally expressed as a rate that indicates the percentage of the population dying in a year. Fish with high natural mortality rates must replace themselves more often and thus tend to be more productive. Natural mortality along with fishing mortality result in the total mortality operating on the fish stock. Estimating natural mortality is difficult and often relies on evaluation of life history traits. Using the various age and growth parameters, natural mortality for Barracuda has been estimated as M = 0.18 (Pinkas 1966); this means that about 23.7% of the Barracuda population dies from natural causes each year.

1.1.5 Individual Growth

Individual growth of fishes is quite variable, not only among different groups of species but also within the same species. Growth is often very rapid in young fish and invertebrates, but slows as adults approach their maximum size. The von Bertalanffy Growth Model is most often used in fisheries management, but other growth functions may also be appropriate. Barracuda grow quickly in length and within a year they are about 13.8 in (35.0 cm) long and weigh about 0.3 pounds (lb) (0.14 kilograms (kg)). At around 4 or 5 yr old Barracuda reach 28 in (71 cm) and weigh about 3.0 lbs (1.36 kg). Growth parameters have been calculated for Barracuda for each sex separately by fitting data to the von Bertalanffy growth function:

$$L_t = L_\infty(1 - e^{-k(t-t_0)}$$

where L_t = length at age, L_∞ = maximum asymptotic length, k = relative growth rate, t = age of fish, and t_0 = theoretical age at time when length is zero. The values of those estimated parameters are L_∞ = 777, k = 0.2618, t_0 = -2.711 for females, and L_∞ = 763.5, k = 0.2373, t_0 = -3.042 for males. Females are slightly longer than males at each age class (Bottinelli and Allen 2007).

The relationship between weight and length for Barracuda, has been modeled for both sexes combined using the exponential equation:

$$W = aL^b$$

where W is the weight in grams, L is the total length (TL) in centimeters, a is a constant indicating the intercept and b is a constant indicating the slope of the regression line (a=.007856, b=2.818) for Barracuda. This indicates a slow weight gain as length increases for fish less than 15.7 in (40.0 cm) and a much faster weight gain for larger fish, which is characteristic for slender species like Barracuda. The differences in growth rate between males and females is small until they reach about 16 to 20 in (40 to 50 cm) in length, then males begin to increase in mass at a greater rate than females, reaching a maximum difference in mass at about 35 in (90 cm) in length and weighing an additional 1.5 lbs (0.68 kg).

1.1.6 Size and Age at Maturity

Male Barracuda mature at a slightly younger age than females. During their second year at about 19 in (50 cm) all males and almost all females (75%) are mature. By the third year at about 21.6 in (55.0 cm) all females are mature (Walford 1932). The differences in growth between male and female Barracuda seems largely driven by the size at maturity, given prior to maturity there is no difference in mass between the sexes. The difference could be due to the increased energy needs of female Barracuda producing eggs for multiple spawning events per season (Bottinelli and Allen 2007).

1.2 Population Status and Dynamics

The status of Barracuda off the California coast is challenging to assess, as abundance is highly variable and dependent on environmental conditions such as ocean temperature. In some years, Barracuda are present in large numbers in California waters, and in other years, they are not. This variability is reflected in the landings and Catch Per Unit Effort (CPUE) (see section 2.3.2). Although the population status of Barracuda is unknown, the continued lower landings in recent years despite warm water is of some concern and needs closer monitoring and further evaluation.

1.2.1 Abundance Estimates

Assessing the population of Barracuda off California is challenging due to their high mobility, shifting geographic range, environmentally driven abundance levels, and the fact that it is a shared stock with Mexico. From 1963 to 1969, an aerial survey on the apparent abundance of several pelagic fish species including Barracuda was conducted (Squire 1972). Although the total abundance of Barracuda was not estimated, the average weight per school during this time was estimated at 4.5 ton (4.1 metric ton (mt)), based on observing 184 schools estimated at a total 834.5 ton (767.0 mt) (Squire 1972). There are no current abundance estimates of Barracuda populations off the California coast.

1.2.2 Age Structure of the Population

The size structure of recreational Barracuda catch can be used to assess possible changes in age classes occurring in the waters off California over time. After the minimum size limit was increased in 1971 to 28.0 in (71.1 cm), the Department sampled length frequencies of the Commercial Passenger Fishing Vessel (CPFV) catch (Maxwell 1977). From 1972 to 1974 the proportion of Barracuda under 28.0 in (71.1 cm) decreased from 88% to 74%. The majority of fish caught were 2 to 5 yr old. Since 2005, all size structures are represented in the catch with no gaps, although a shift towards smaller sizes can be seen since 2014 (Figure 1-3). The increase in smaller size classes may indicate stronger recruitment due to warmer water in southern California, as 2015-2016 and 2018-2019 were El Nino years; although, the increase in sublegal take may be cause for concern. A study assessing changes in size of trophy sized pelagic and coastal pelagic fishes found trends in trophy-sized individuals were driven by oceanographic conditions. It found that Barracuda, along with Pacific Bonito (*Sarda chiliensis*) and Chinook Salmon (*Oncorhynchus tshawytscha*), haven't displayed any long-term (about 50 yr) decreases in size (Bellquist et al. 2016).

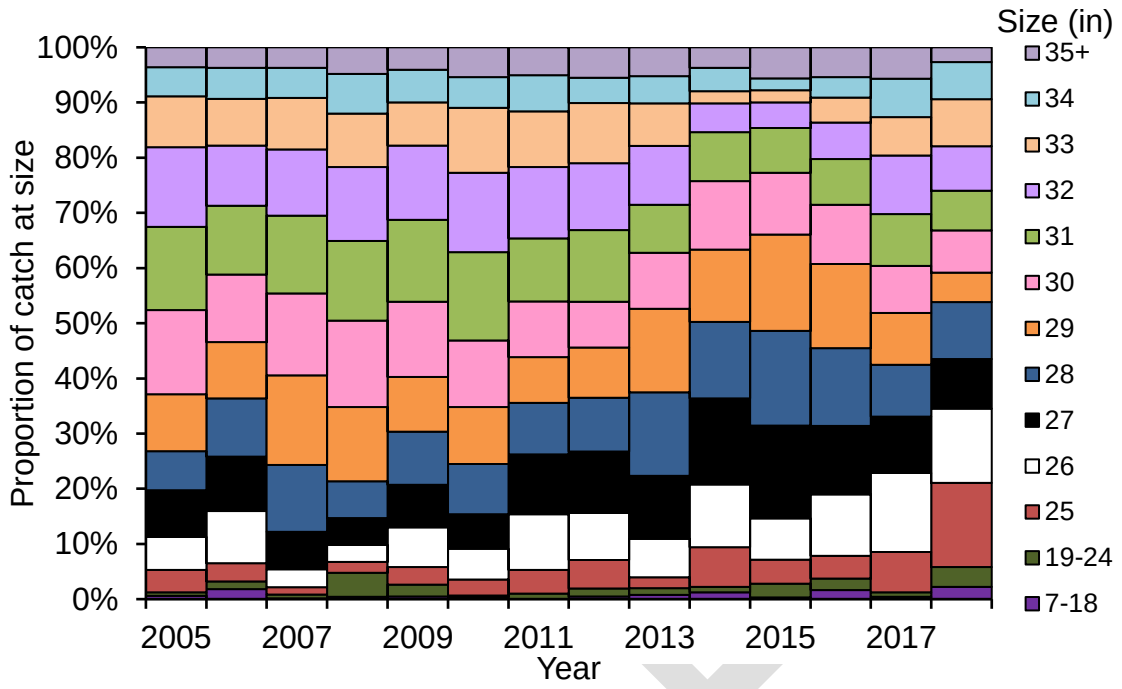

Figure 1-3. The size structure of the California Barracuda stock from 2005 to 2018 based on the recreational catch of measured Barracuda retained in California (Recreational Fisheries Information Network (RecFIN 2019)).

1.3 Habitat

Barracuda are a coastal pelagic, schooling fish that can be found in the open water, as well as kelp beds and rocky reefs to depths up to 120 ft (36.6 m) (Schultze 1973). Juvenile Barracuda also inhabit coastal lagoons, bays and harbors (Pinkas 1966).

1.4 Ecosystem Role

Little is known about the ecosystem role of Barracuda as they only spend short periods of time in the various habitats in which they reside. However, as a large schooling species they may impact their prey populations and be an important food source to the many predators that consume them.

1.4.1 Associated Species

Barracuda are most highly associated with other southern coastal pelagic species, including Chub Mackerel (*Scomber japonicas*), Jack Mackerel, and White Seabass (*Atractoscion nobilis*), that occupy the same open water habits surrounding kelp beds and rocky reefs in southern California and Baja California (Allen et al. 2006). They also commonly school with Pacific Yellowtail (*Seriola lalandi*) and Pacific Bonito (Love 2011).

1.4.2 Predator-prey Interactions

Barracuda feed upon a range of smaller species including Northern Anchovy *(Engraulis mordax*), Pacific Sardine (*Sardinops sagax caeruleus*), young Pacific Mackerel (*Scomber japonicus*), young Jack Mackerel (*Trachurus symmetricus*) and California Grunion (*Leuresthes tenuis*) (Schultze1983). Northern Anchovy is a crucial prey item for many pelagic fishes, and one study found it makes up 66.7% of Barracuda's diet (Mearns et al. 1981). Although Market Squid (*Loligo opalescens*) are eaten when offered as bait, it is not known if they are part of the Barracuda's natural diet because they were not observed in their stomach contents of the diet studies referenced above.

Giant Sea Bass (*Stereolepis gigas*), California Sea Lions (*Zalophus californianus*), Harbor Seals (*Phoca vitulina*), and porpoise are all known to feed on Barracuda.

1.5 Effects of Changing Oceanic Conditions

The geographic range of Barracuda is highly influenced by water temperature. Barracuda migrate northward from Baja California to southern California in the late spring and summer months when sea surface temperatures rise (Pinkas 1966). Additionally, Barracuda are only present in northern California, Oregon and Washington during El Niño Southern Oscillation (ENSO) periods when the water temperature increases. Barracuda may be highly affected by changing oceanic conditions given that warm water events tend to increase their apparent population size and shift their range northward and closer to the California coast. If warm water periods increase, the seasonality of Barracuda off southern California may lengthen and populations may even become resident. Additionally, changing oceanic conditions could extend the range of Mexican Barracuda that historically have only been observed off California during El Niño events (Lea and Rosenblatt 2000). Since both the Mexican and Pacific Barracuda have similar life history strategies, this might increase competition for both species.

2 The Fishery

2.1 Location of the Fishery

Both the commercial and recreational Barracuda fisheries are centered in southern California, with the highest concentration of landings occurring south of Point Conception (Figure 2-1).

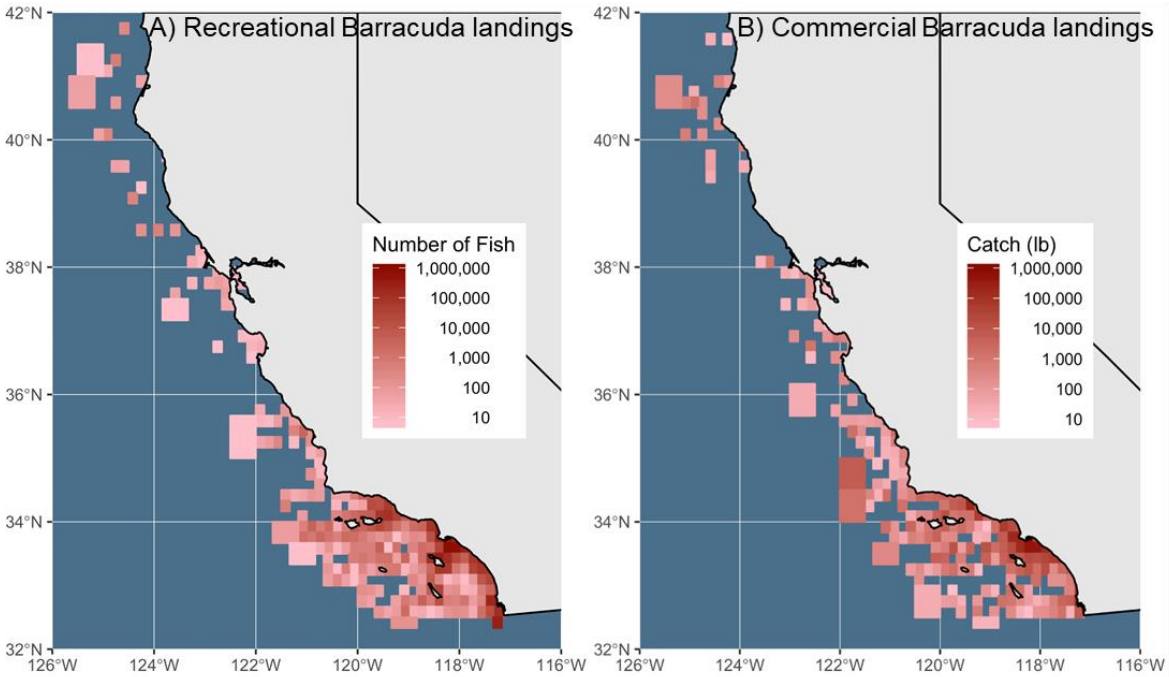

Figure 2-1. Landings of Pacific Barracuda by block from 1995 to 2018 for a) kept fish in the recreational fishery (CPFVs), and b) kept fish in all commercial fisheries (CDFW MLS 2018; CDFW MLDS 2018).

2.2 Fishing Effort

2.2.1 Number of Vessels and Participants Over Time

The commercial Barracuda fishery began in the 1800s. After World War I, the fishery developed rapidly with the introduction of purse seine vessels at the same time as the development of the White Seabass, Pacific Yellowtail, Pacific Mackerel and Bluefin Tuna (*Thunnus thynnus*) fisheries (Schultze 1983; Skosberg 1925). Since the 1980s, the number of vessels landing Barracuda tend to increase during warm water years. For example, vessel participation peaked during 1982 to 1983, 1991 to 1992, and 1997 to 1998, corresponding to strong to very strong El Niño years; however, the number of vessels landing Barracuda dropped to a low in 2016 despite being a very strong El Niño year. (Figure 2-2). We do not know if this was a due to a shift to other more desirable species or if Barracuda were not around. There is little available information on commercial fishing effort prior to 1980.

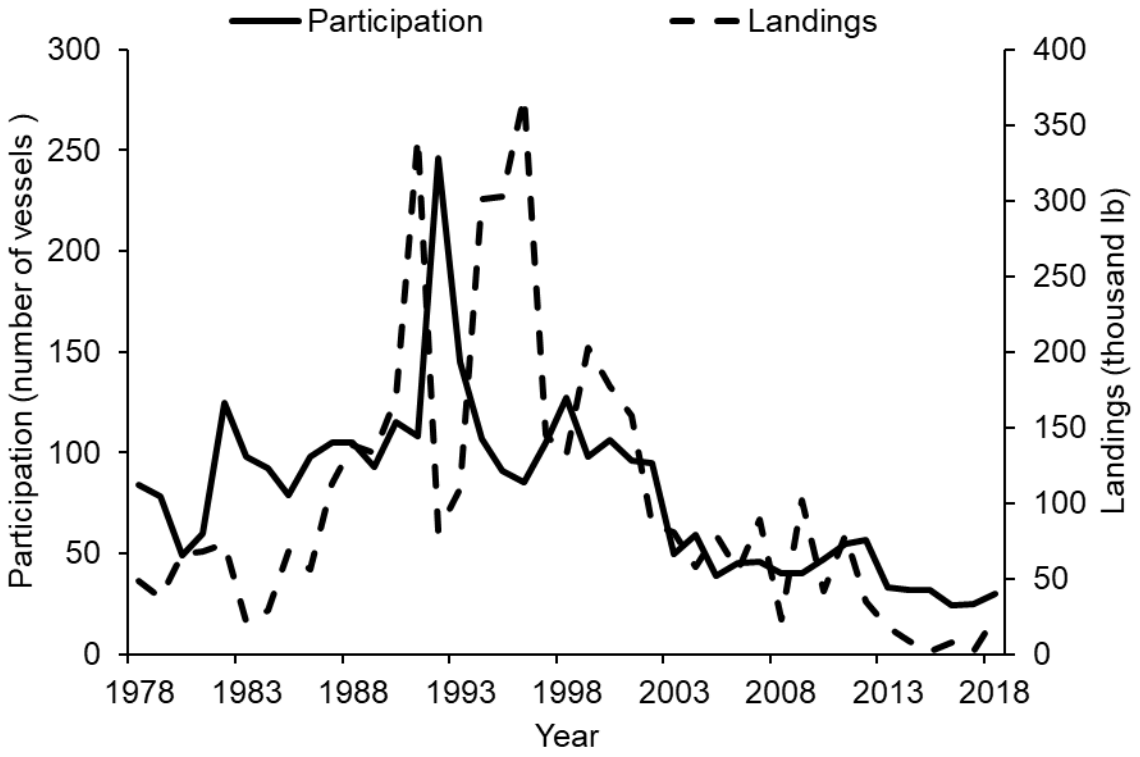

Figure 2-2. Pacific Barracuda commercial fishery participation in number of vessels and landings in thousands of lb from 1980 to 2018 (CDFW MLDS 2019).

The expansion of the CPFV fleet in the 1960s caused an increase in the number of recreational anglers targeting Barracuda. The number of CPFV trips catching Barracuda fluctuates annually with a decreasing trend since 1999 with episodic increases in effort correlating with warm water events such as the very strong El Niño of 1997 to 1998 (Figure 2-3). There is also a strong seasonal component in the Barracuda fishery with most landings occurring between May and August (Figure 2-4).

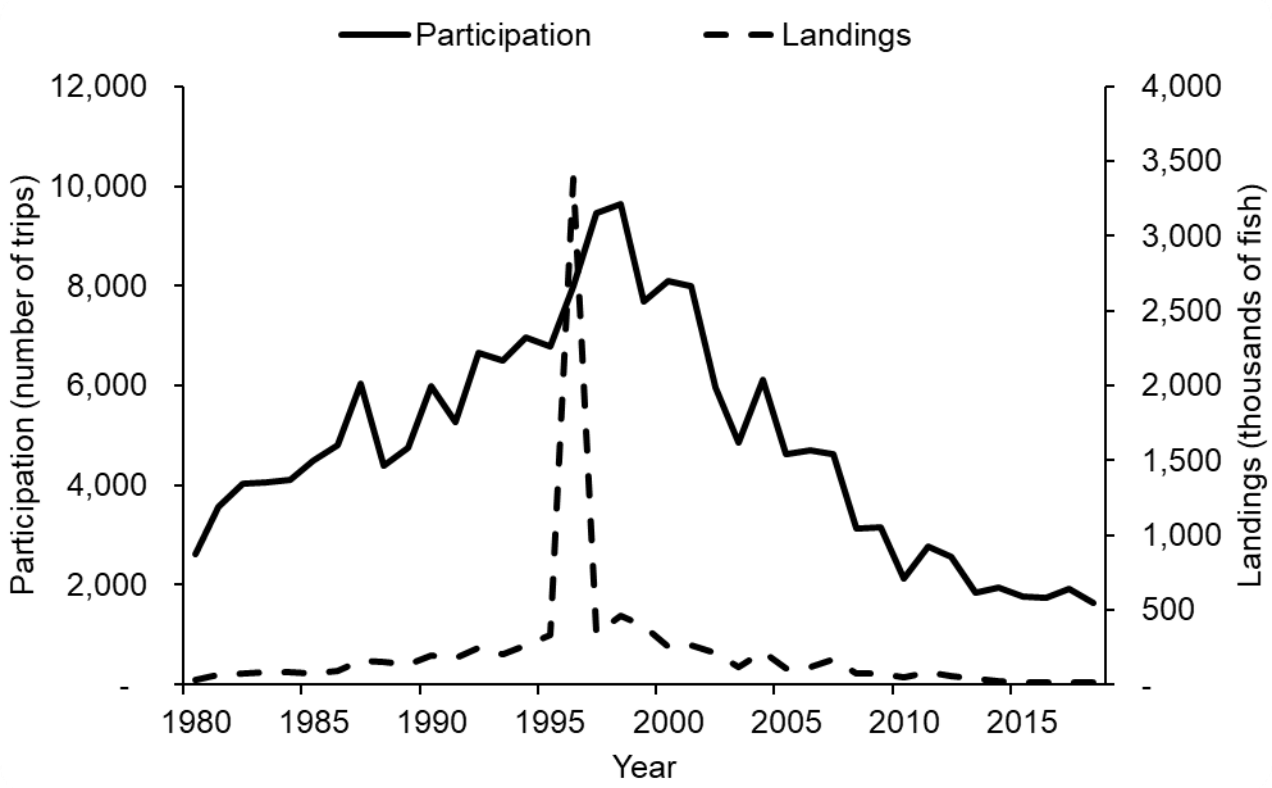

Figure 2-3. Number of CPFV trips targeting Pacific Barracuda (at least one caught) and landings in thousands of fish kept from 1980 to 2018 (CDFW MLS 2019).

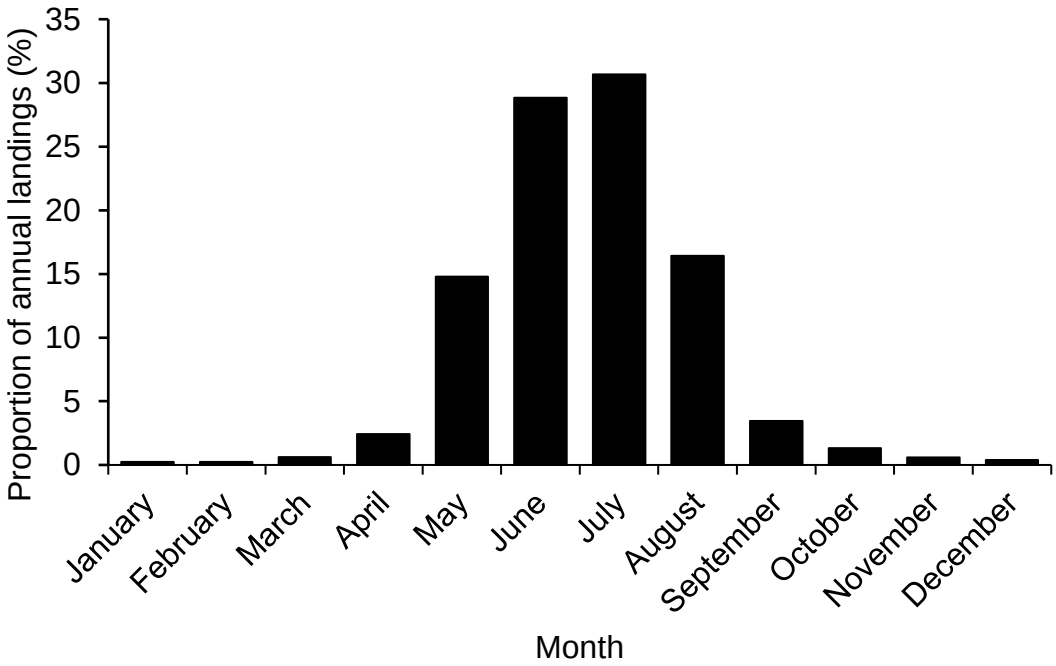

Figure 2-4. Proportion of the yearly CPFV landings of Pacific Barracuda (kept fish) by month in southern California from 1980 to 2018 (CDFW MLS 2018).

The variability of the Barracuda fishery is also reflected by the large fluctuations in the rankings of the recreational catch compared to other fisheries. From 2005 to 2018, Barracuda landings vary from being the ninth most abundant species caught in 2007, to as low as 43rd in 2013 (Figure 2-5). It is interesting that water temperature does not drive Barracuda ranking, as the highest rankings occurred during the cooler water years of 2007 and 2010. However, landings and participation in the Barracuda fishery over time may not be the best indicators of their abundance as the presence of more desirable species, that are also more abundant during warm water years such as Yellowtail and various tuna species, may reduce the number of fishers targeting Barracuda.

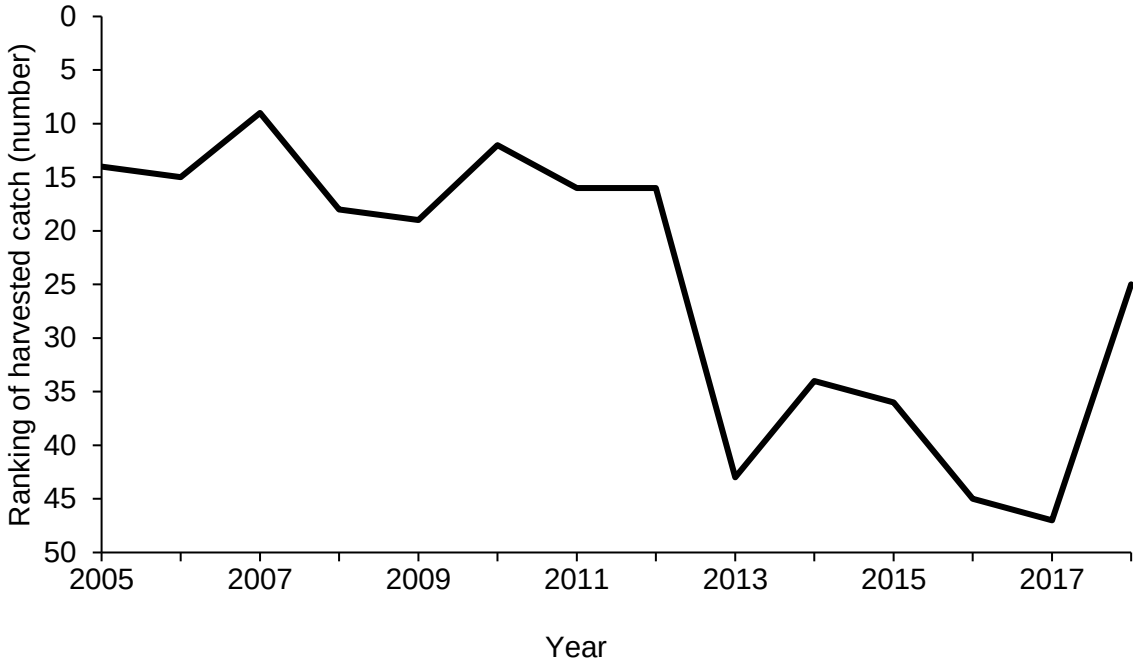

Figure 2-5. Ranking of harvested Barracuda catch relative to other finfish species in southern California from 2005 to 2018. Results are based on the estimated retained catch for all fishing modes (RecFIN 2019).

2.2.2 Type, Amount, and Selectivity of Gear

Barracuda are primarily targeted commercially using gill nets and hook and line gear. Since 1980, an average of 81% of annual Barracuda landings were caught by gill net and 12% by hook and line. Gill nets are a type of passive entangling net that are attached to buoys at the surface and either staked to the bottom (set gill net) or allowed to drift with the currents (drift gill net). Both set and drift gill nets hang like a wall vertically in the water and entangle fish by the gills as they try to swim through the mesh (Figure 2-5). Gill nets are made in a range of mesh sizes depending on the size of the target species. In general, small mesh gill nets have a mesh size under 8 in (20.3 cm) and large mesh gill nets have a mesh size of 8 in (20.3 cm) and larger. Recently legislation was passed phasing out the drift gill net shark and swordfish fishery beginning in 2019, however, this does not impact the Barracuda fishery as they are caught by small mesh drift gill nets and not by the large mesh drift gill nets that typically target sharks and swordfish. Based on logbook data (which are required to be submitted when gill nets are used; see description in section 4.2.1) from 1980 to 2016, on average 88% of annual Barracuda gill net catch is from small mesh drift gill nets, and 12% from set gill nets. Almost all of the small mesh drift gill net catch (99.7%) was from nets with a mesh size of 5 in (12.7cm) or smaller.

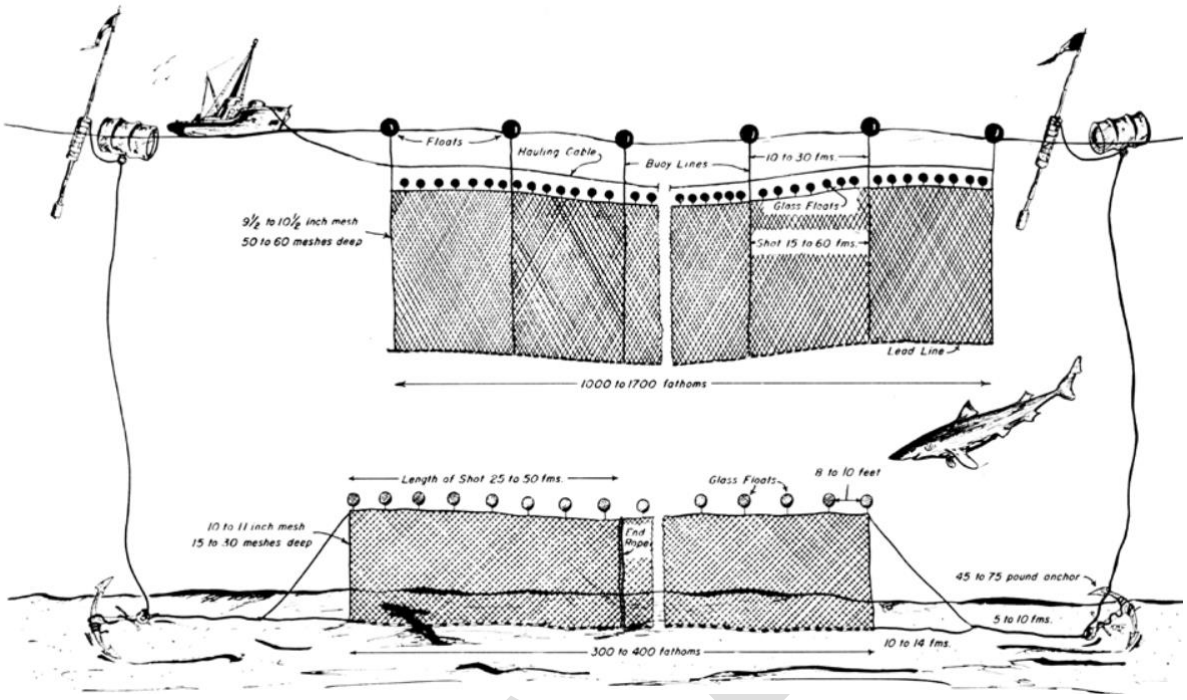

Figure 2-6. Diagram of a drift gill net (top) and set gill net (bottom) used in the Barracuda fishery (Reproduced from Roedel and Ripley 1950).

Recreationally, Barracuda are primarily caught by hook and line. Recreational anglers fishing from boat or shore may use any number of hooks and lines. On public piers, no person may use more than two rods and lines. Hook and line anglers typically use iron jigs, soft plastics, and dead or live bait. Typical baits include squid, sardines, and anchovies. The majority (67%) of Barracuda caught from 2005 to 2018 ranged in size from 27 to 32 in (68 to 81 cm) (RecFIN). It is likely smaller fish are caught as well; however, they are under sampled as fewer discarded fish are measured.

2.3 Landings in the Recreational and Commercial Sectors

2.3.1 Recreational

Catch data for the recreational fishery are available from two sources: (1) CPFV logbooks within the Department's MLS database and, (2) California Recreational Fisheries Survey (CRFS) estimates on all fishing modes available from the RecFIN website. Current CPFV logs (1980 to present) provide self-reported data on catch and effort from CPFV captains per vessel trip.

Current CRFS estimates (2004 to present) use catch and effort data collected by samplers from all fishing modes (beach/bank, man-made structures, private/rental boats, and CPFVs). From 1980 to 2003, catch and effort data on all fishing modes were collected by the federal Marine Recreational Fisheries Statistical Survey (MRFSS) conducted by the National Oceanic and Atmospheric Administration. Estimates from CRFS and MRFSS are not directly comparable due to differences in methodology, so

data from these two time periods are presented in separate figures in this ESR (See section 4.2.1 for more details on these datasets).

The recreational fishery for Barracuda primarily uses hook and line gear off party/charter and private/rental boats. Fishing off jetties and other man-made structures like piers comprise a small proportion of the catch (Figure 2-6, Figure 2-7). The total landings are highly variable, with increases in catch often related to warm water events such as the strong El Niños of 1957 to 1958 and 1965 to 1966 (Figure 2-8). Small peaks in the catch can also be seen in the El Niño years of 1982 to 1983, 1994 to 1995 and 1997 to 1998, (Figure 2-7). Although Barracuda abundances have a strong positive correlation with increased water temperature (Lea and Rosenblatt 2000; Norton and Mason 2003), Barracuda catch has also been known to increase during periods of low temperature. This is due to increased fishing effort in response to decreased availability of more desirable fishes (Jarvis et al. 2004). This may be the case in 2007 where a spike in catch is seen, although it is not during a warm water event (Figure 2-6). Additionally, a peak in the catch is not observed in 2015 to 2016, which may be cause for concern, as this was a very strong El Niño year.

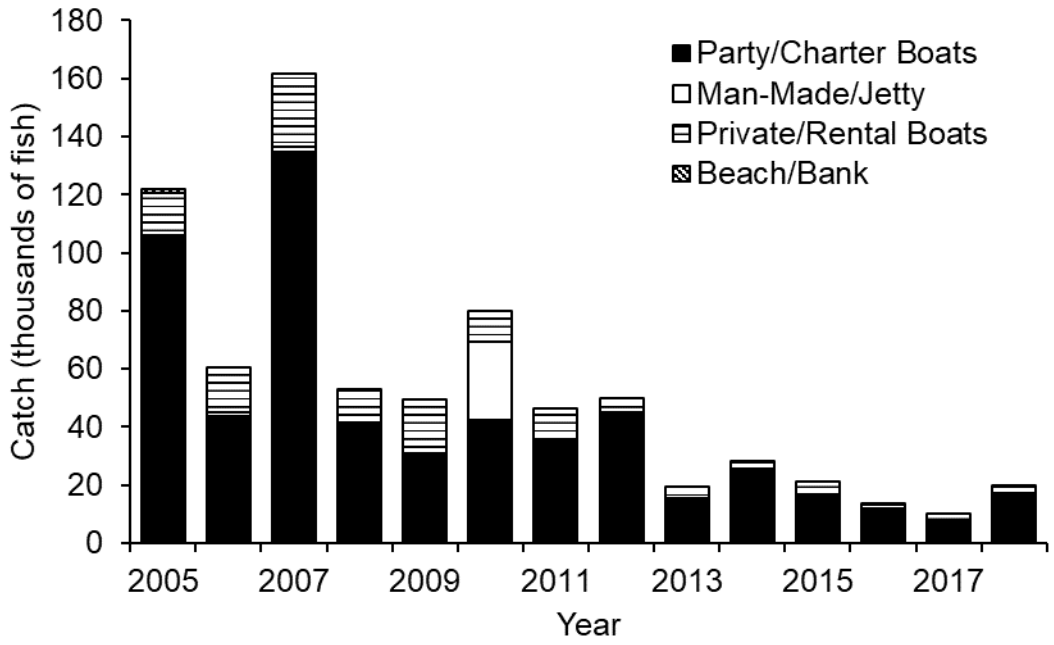

Figure 2-7. Pacific Barracuda recreational catch in thousands of fish kept by mode from 2005 to 2018 (RecFIN 2019).

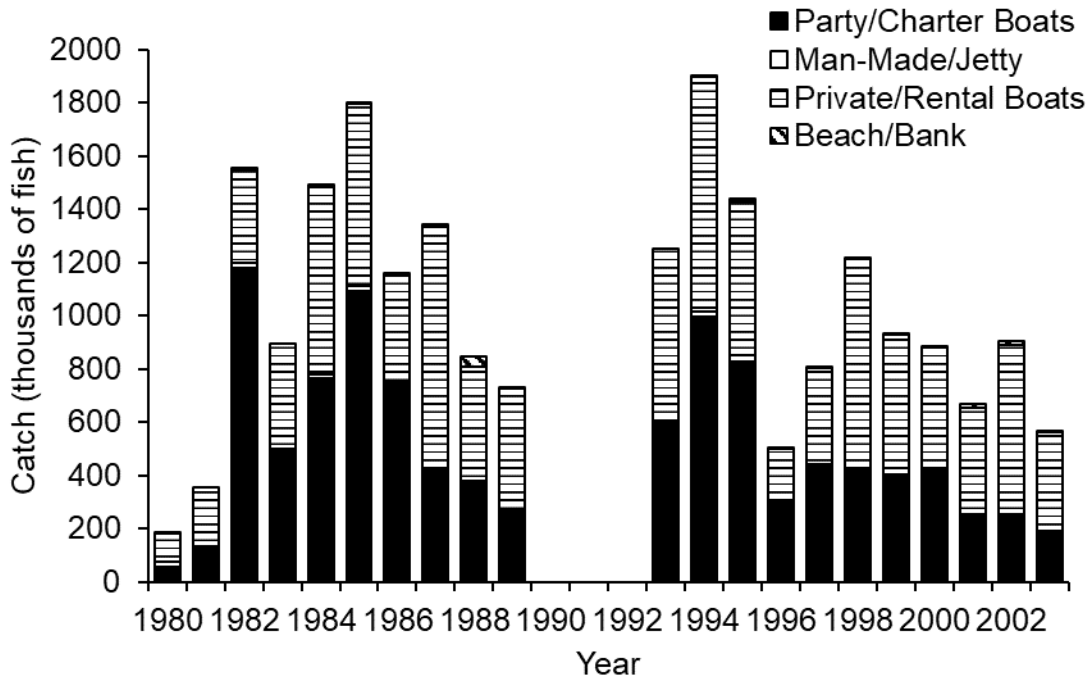

Figure 2-8. Pacific Barracuda recreational catch in thousands of fish kept by mode from 1980 to 2003. No data were collected from 1990 to 1992 (RecFIN 2018).

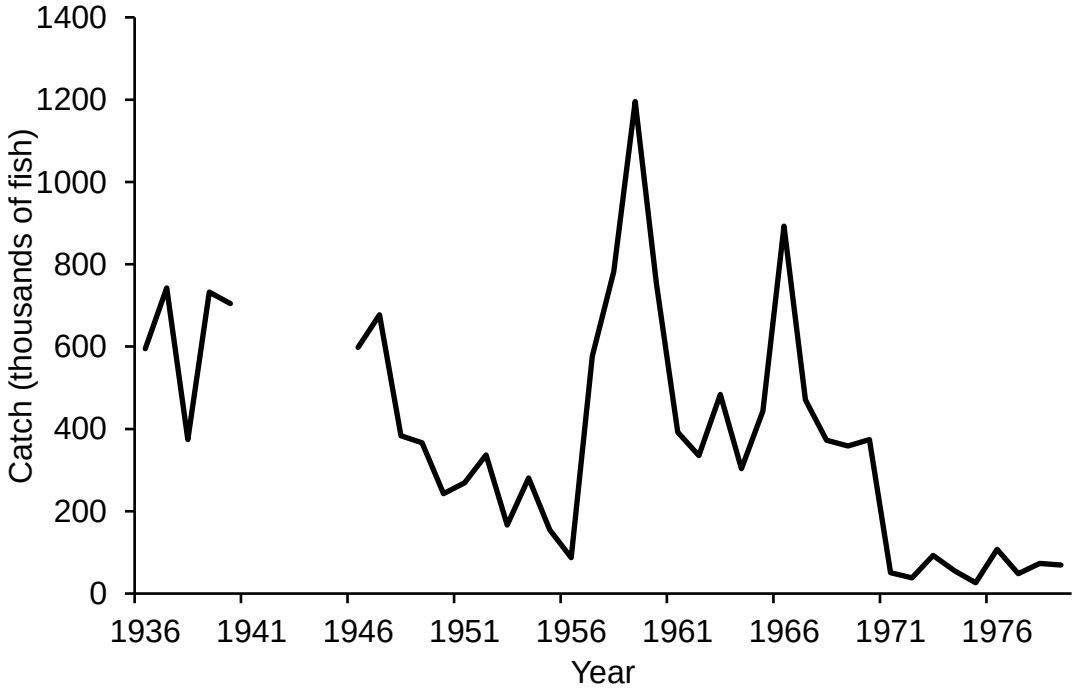

Figure 2-9. Historical CPFV catch of Pacific Barracuda in thousands of fish kept from 1936 to 1979. (Schultze 1983; no data collected from 1941 to 1945).

2.3.2 Commercial

Catch data for the commercial fishery are available from two sources: (1) landing receipts within the Department's MLDS database and, (2) gill net logbooks that are required to be submitted by all gill net fishers. Commercial landings of Barracuda have fluctuated throughout the history of the fishery (Figure 2-9, Figure 2-10). Annual commercial landings peaked at over 3,700 mt (4,079 ton) in the 1920s when there was a year-round fishery for Barracuda. During this time, gill nets and trolling vessels fished off California in the spring and summer and purse seine vessels caught Barracuda off Baja California in the fall and winter. A decline in commercial landings were seen in the 1930s, possibly due to declining fishing pressure because of a more restrictive purse seine regulation (See Chapter 3.1 for details), economic difficulties faced by the fishing industry during depression years, as well as a possible unconfirmed decline in Barracuda stock abundance (Janssen 1937; MacCall et al. 1976). Landings increased again in the 1940s, likely due to warm water events increasing Barracuda availability off the California coast. Following World War II Barracuda landings steadily declined as purse seine fishing off Mexico ended by 1956 and a cooling trend from 1948 to 1956 decreased their abundances. During the very strong El Niño of 1957 to 1958 and with a return to normal sea surface temperatures for several years after, landings increased again in the 1960s; however, the commercial fishery almost disappeared in the 1970s and 1980s due to increased difficulty to catch legal sized Barracuda and low market demand (Figure 2-9, Figure 2-10) (Schultze 1983). In the 1990s the fishery increased again, due to strong-very strong El Niños in 1991 to 1992 and 1997 to 1998, respectively, and has been following a decreasing trend since then with fluctuations until 2018 (Figure 2-10). The CPUE from the gill net fishery has averaged 310 lb (140.6 kg) of Barracuda caught per trip from 1980 to 2018 (Figure 2-11). Despite some large fluctuations in recent years due to decreased effort of less than 100 gill net trips from 2013 to 2018, the average CPUE has remained stable at 303 lb (137.4 kg) per trip from 1980 to 1999 and 318 lb (144.2 kg) per trip from 2000 to 2018.

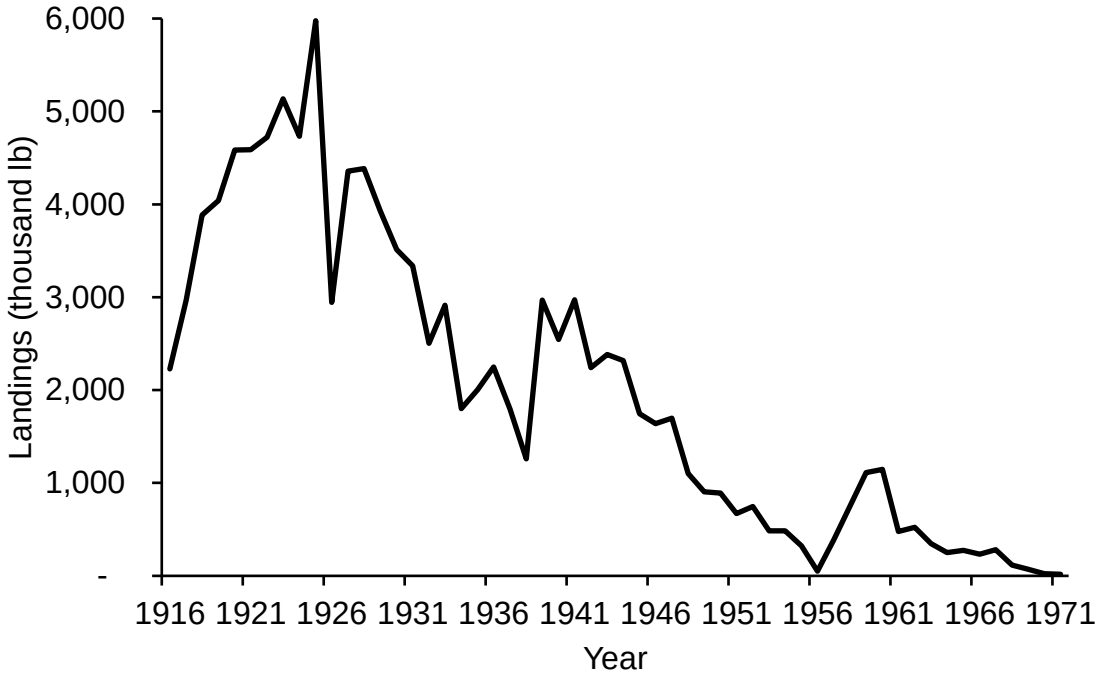

Figure 2-10. Historical commercial landings of Pacific Barracuda in thousands of pounds from 1916 to 1975 (Schultze 1983).

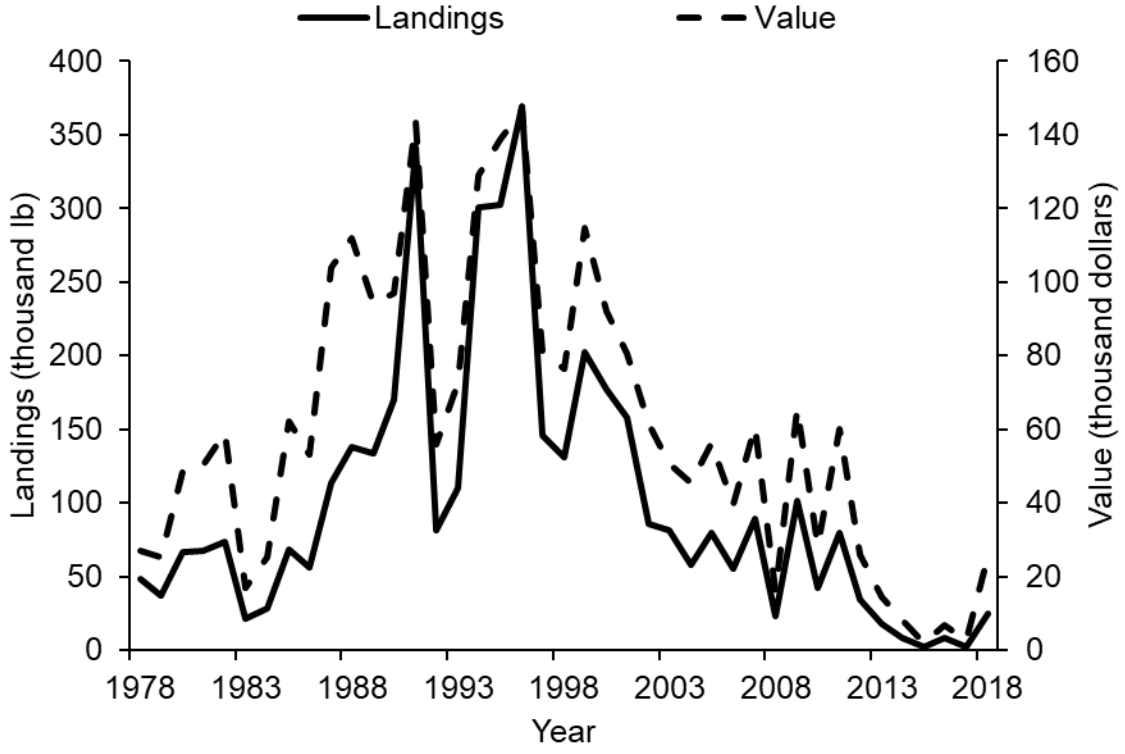

Figure 2-11. Pacific Barracuda commercial fishery landings in thousands of pounds and value in thousands of dollars from 1978 to 2018 (CDFW MLDS 2019).

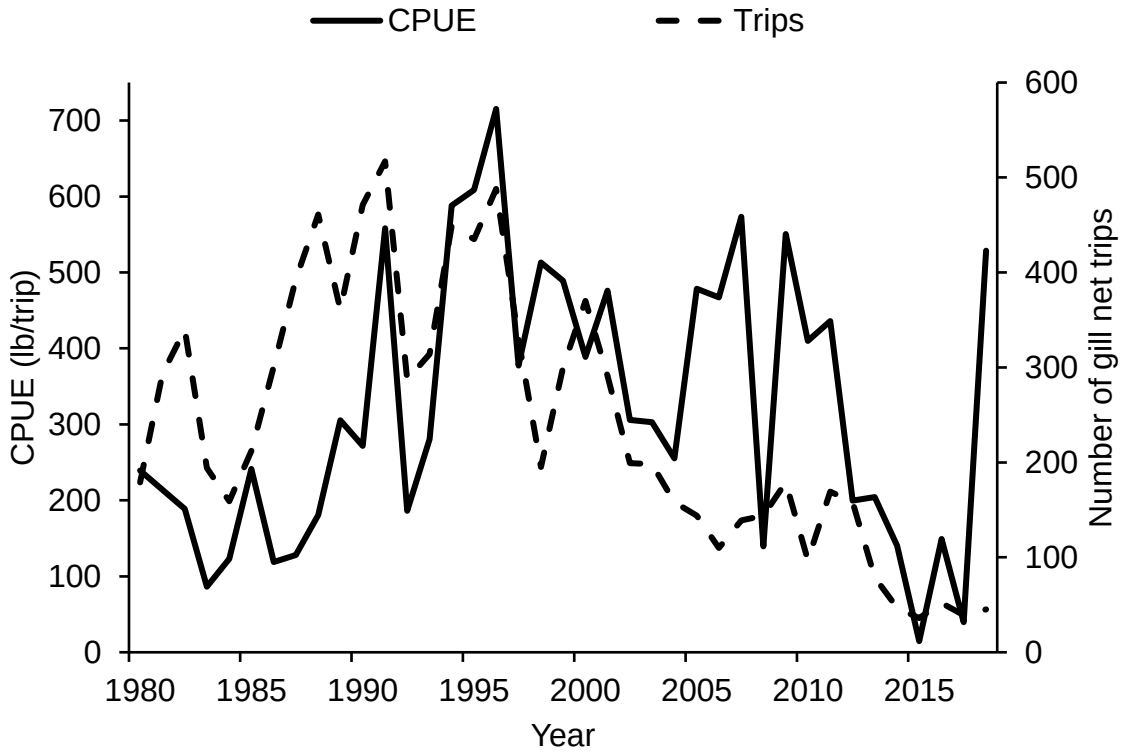

Figure 2-12. Pacific Barracuda gill net fishery CPUE in pounds per trip and number of gill net trips from 1980 to 2018 (CDFW MLDS 2019).

2.4 Social and Economic Factors Related to the Fishery

Commercially caught Barracuda are sold for human consumption. In the 1920s about 10% of the Barracuda landed was canned and the remainder was sold fresh at fish markets (Schultze 1973). On average, from 1978 to 2018, 99% of the Barracuda landed was sold for un-canned human consumption (CDFW MLDS). The remaining percentage was either used as bait, or personally consumed by the commercial fisher, and none were canned.

The popularity of the recreational Barracuda fishery is also highly dependent on ocean conditions and the availability of Barracuda off the coast of California. Shore fishing, CPFV trips, and private boat trip expenditures together comprise California's $923 million annual recreational fishing industry (Lovell et al. 2013). In summer months and warm water years when Barracuda are abundant off the coast, their angling popularity spikes, which probably contributes to the large recreational fishing industry. This seasonal availability of Barracuda may cause shifting effort away from other target species during the summer months when catch increases. Barracuda have ranked in the top ten species caught by CPFVs in southern California from 1959 to 1998, ranking fifth from Ensenada, Mexico to Oceanside, California, and comprising 11% of the total catch in that zone (Dotson and Charter 2003).

Both the commercial and recreational Barracuda fisheries provide economic benefits to California residents through direct commercial sales or via the income

generated by recreational fishing operators and associated tourism. The distribution of landings can provide information on what areas in California are most likely to benefit. From 2014 to 2018, all of the commercial and recreational Barracuda catch was landed in southern California. Most of the commercial landings (78%) were from San Pedro, Los Angeles County (Figure 2-12); most of the recreational landings (CPFV) were in San Diego, Orange and Los Angeles counties (Figure 2-13). Due to high levels of Polychlorinated Biphenyl (PCBs) or mercury, it is advised not to eat Barracuda or limit servings to one per week (depending upon gender and age) for fish caught between the Ventura harbor to the Santa Monica pier and south of Seal Beach pier to San Mateo Point (California Ocean Sport Fishing Regulations 2019 to 2020).

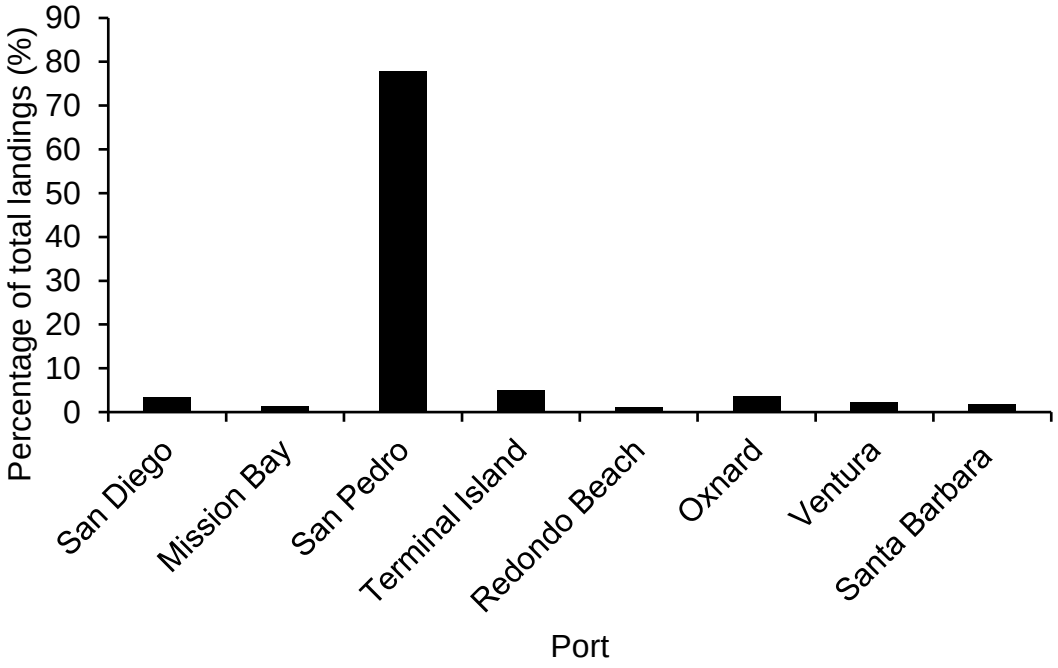

Figure 2-13. Percentage of total Pacific Barracuda commercial landings by port from 2014 to 2018 (CDFW MLDS 2018).

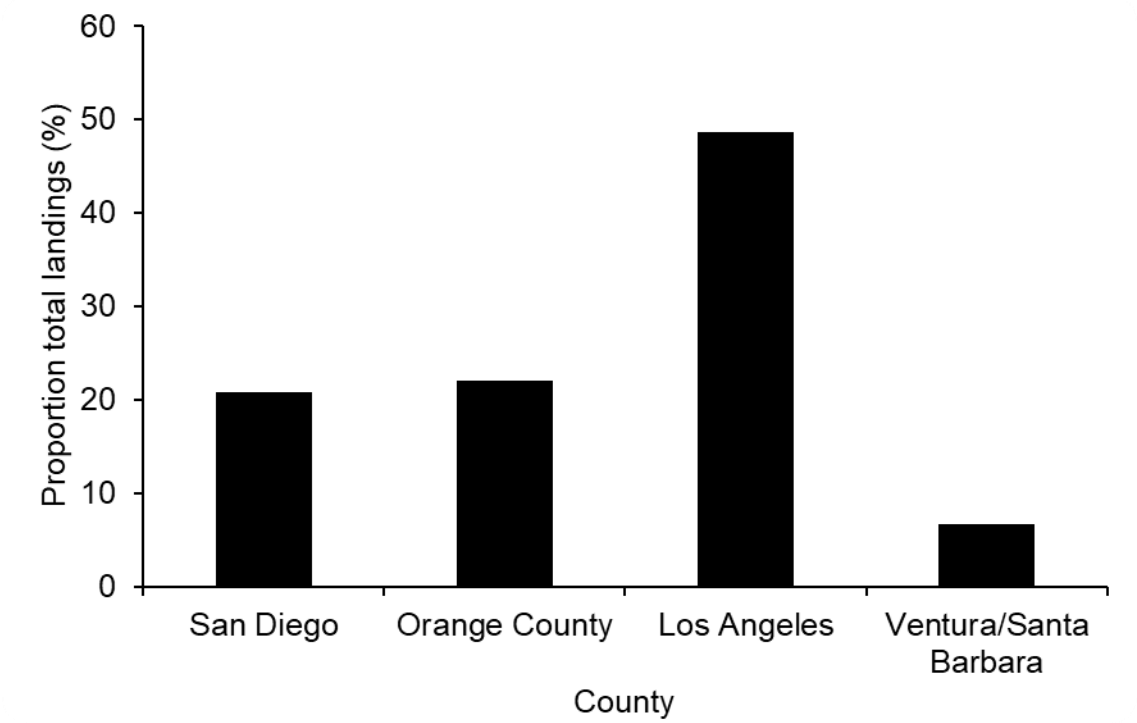

Figure 2-14. Percentage of total Pacific Barracuda CPFV landings (kept fish) by county from 2014 to 2018. (CDFW MLS 2018).

3 Management

3.1 Past and Current Management Measures

Management measures for Barracuda began to be put in place with the rapid expansion of the fishery after World War I (Table 3-1). In 1917, a 3 lb (1.6 kg) minimum size limit was established, but a size limit based on weight was difficult to enforce. Thus, in 1947 the minimum size limit was changed to the current 28.0 in (45.7 cm). In the 1930s there were many regulation changes regarding the use of nets to take Barracuda with the emphasis on prohibiting purse seining during their primary spawning months from May to July. In 1940 purse seining for Barracuda was banned in state waters, only allowing Barracuda caught in Mexico to be landed in California, and gill nets were required to be at least 3.5 in (8.9 cm) or larger stretched mesh. Up until 1971 there were few sport fishing regulations for Barracuda. In 1941, it became illegal to sell sport fish with a recreational license. In addition, in 1947 the weight limit of 3 lb (1.6 kg) changed to 28.0 in (45.7 cm) for sport and commercial fishing, although it allowed no more than five undersized Barracuda to be taken per day in the recreational fishery. In 1971, the strict 28.0 in (45.7 cm) minimum size limit that remains in effect today was enacted.

Table 3-1. Description of commercial and recreational regulations for Pacific Barracuda and the year they were enacted (Adapted from Schultze 1983).

Year	Regulation
1915	No barracuda less than 18 in may be bought or sold. Barracuda designated a game fish requiring a sport license to take
1917	No barracuda less than 3 lb may be bought or sold.
1927	Unlawful for purse seine or other roundhaul to take or possess barracuda from May 15 through July 31.
1932	Unlawful for purse seine or other roundhaul to take or possess barracuda from May 1 through July 31.
1934	No barracuda may be sold between May 1 and June 30. No more than five barracuda weighing less than 3 lb each may be possessed each day: they are not to be sold or purchased.
1935	Barracuda not less than 3 lb may be taken with hook and line. No nets may be used to take barracuda between May 1 and August 31. Between May 1 and August 31, a limit of 500 lb of barracuda per person or 2,500 lb per boat.
1939	Daily marine sport bag limit of 15 game fish in aggregate (no more than 15 barracuda if only barracuda caught).
1940	No purse seine or roundhaul may be used to take Barracuda north of the international boundary with Mexico. Barracuda gill net mesh must be no less than 3.5 in stretched mesh.
1941	May not sell any sportfish taken under the authority of a sport fishing license. Repeal restriction on 500 lb of barracuda per person and 2,500 lb of barracuda per boat.
1947	Weight limit of 3 lb changed to length limit of 28 in for sport and commercial. Not more than five barracuda less than 28 in per day in sport bag.
1949	Daily sport bag limit no more than ten of one species and 15 in aggregate of species
1957	No more than two barracuda shorter than 28 in allowed in the daily bag limit. Daily bag limit of ten game fish in aggregate.
1971	No barracuda less than 28 in allowed in daily bag limit.

3.1.1 Overview and Rationale for the Current Management Framework

Barracuda are primarily managed by the bag and minimum size limit established in 1971. The minimum size limit allows most Barracuda to reproduce before entering the fishery, and the bag limit was based on a general bag limit put in place for many species during that time. A ten fish bag limit was considered a satisfying number for sport take without risking stock depletion.

3.1.1.1 Criteria to Identify When Fisheries Are Overfished or Subject to Overfishing, and Measures to Rebuild

The Department has not established overfishing criteria for the Barracuda fishery. Due to Barracuda's wide geographic range, highly migratory nature and overlap with the Mexico purse seine fishery, their landings fluctuate greatly and may not be indicative of their population status, which makes it challenging to actively manage. Based on the available fishery-dependent data discussed in sections 2 and 4, there are currently some concerns about the status of Barracuda. More information and evaluation are needed to determine if existing regulations provide enough protection to maintain the sustainability of this highly variable fishery off the California coast. If landings continue to decrease, especially during warm water periods where Barracuda abundance typically increases, management change may become necessary.

3.1.1.2 Past and Current Stakeholder Involvement

There has been little need for stakeholder involvement with the Barracuda fishery, given involvement typically occurs during regulation change processes and the last regulation change related to Barracuda was in 1971. If there is need for change in Barracuda management strategies, the Department will work with various stakeholder groups including Tribes, CPFV operators, recreational and commercial anglers, Non-Government Organizations (NGOs), scientists, and the general public to ensure input from all groups is considered.

3.1.2 Target Species

3.1.2.1 Limitations on Fishing for Target Species

3.1.2.1.1 Catch

There is a general recreational bag limit, which applies to Barracuda, stating no more than ten of any species may be taken by any one person (§27.60, Title 14, California Code of Regulations (CCR)). This was put in place as a general bag limit for many species, as ten was considered a satisfying number for sport take without risking stock depletion.

3.1.2.1.2 Effort

The gill net fishery, which accounts for most of the commercial Barracuda catch, has no limit on days at sea or trip length.

3.1.2.1.3 Gear

The commercial fishery for Barracuda has specific gear requirements. From Fish and Game Code (FGC) §8623, "(a) It is unlawful to use any purse seine or round haul net to take yellowtail, barracuda or white sea bass. (b) It is unlawful to possess any yellowtail, barracuda, or white sea bass, except those taken south of the international boundary between the United States and Mexico, and imported into the state under regulations of the commission as provided in Section 2362 , on any boat carrying or using any purse seine or round haul net, including, but not limited to, a bait net as described in Section 8780. (c) Gill nets with meshes of a minimum length of 3 1/2 inches (350 cm) may be used to take yellowtail and barracuda."

3.1.2.1.4 Time

Barracuda are currently caught seasonally with warm water events. There are specific time restrictions pertaining to the take of sharks and Swordfish (*Xiphias gladius*) by drift gill nets with a mesh size smaller than eight inches (FGC §8576), but not to Barracuda.

3.1.2.1.5 Sex

There are no restrictions on the sex of Barracuda that can be retained.

3.1.2.1.6 Size

The minimum size limit for recreational-caught Barracuda is 28.0 in (45.7 cm) TL or 17.0 in (43.2 cm) alternate length (§28.25, Title 14, CCR). Fillets must be a minimum length of 17.0 in (43.2 cm). Each fillet shall bear intact a 1 in (2.54 cm) square patch of silver skin (§27.65 (b)(2), Title 14, CCR). For the commercial fishery, "No barracuda or yellowtail less than 28 inches in length may be sold or purchased, except that not more than five barracuda and five yellowtail per day may be possessed by the holder of a commercial fishing license for noncommercial use if taken incidentally in commercial fishing" (FGC §8384).

3.1.2.1.7 Area

The Marine Resources Protection Act of 1990 prohibited the use of gill nets in most nearshore waters along the mainland coast and islands in southern and central California. FGC §8610.2 states:

"(d) "Zone" means the Marine Resources Protection Zone established pursuant to this article. The zone consists of the following:

(1) In waters less than 70 fathoms or within one mile, whichever is less, around the Channel Islands consisting of the Islands of San Miguel, Santa Rosa, Santa Cruz, Anacapa, San Nicolaus, Santa Barbara, Santa Catalina, and San Clemente.

(2) The area within three nautical miles offshore of the mainland coast, and the area within three nautical miles off any manmade breakwater, between a line extending due west from Point Arguello and a line extending due west from the Mexican border.

(3) In waters less than 35 fathoms between a line running 180 degrees true from Point Fermin and a line running 270 degrees true from the south jetty of Newport Harbor. FGC §8610.3 continues:

(a) From January 1, 1991, to December 31, 1993, inclusive, gill nets or trammel nets may only be used in the zone pursuant to a nontransferable permit issued by the department pursuant to Section 8610.5.

(b) On and after January 1, 1994, gill nets and trammel nets shall not be used in the zone.

There are additional restrictions on gill nets being possessed on boats in specific districts, but these areas are fished much less for Barracuda.

3.1.2.1.8 Marine Protected Areas

Pursuant to the mandates of the Marine Life Protection Act (Fish and Game Code §2850), the Department redesigned and expanded a network of regional MPAs in state waters from 2004 to 2012. The resulting network increased total MPA coverage from 2.7% to 16.1% of state waters. Along with the MPAs created in 2002 for waters surrounding the Santa Barbara Channel Islands, California now has a statewide scientifically based ecologically connected network of 124 MPAs. The MPAs contain a wide variety of habitats and depth ranges. However, the commercial and recreational take of pelagic finfish such as Barracuda is permitted in a subset of Marine Protected Areas (MPAs) designated under MLPA. When targeting pelagic finfish during commercial fishing in MPAs, no more than 5% (by weight) of the catch landed can be other incidentally taken species. Considering Barracuda's wide geographic spread and highly migratory nature, they are not likely to benefit greatly from protection within those MPAs where pelagic fishing is restricted.

3.1.2.2 Description of and Rationale for Any Restricted Access Approach

The commercial gill net fishery has been restricted access for both set and drift gill nets since 1986. Those fishing drift gill nets are required to obtain a drift gill net permit along with the general gill net permit. FGC §8681 states: "Gill nets or trammel nets shall not be used for commercial purposes except under a revocable, nontransferable permit issued by the department." In addition, the department shall issue no new gill net or trammel permits (FGC §8681.5a), These restrictions are designed to control fishing capacity. As of 2018, 111 general gill net permits remain for the commercial gill net fishery and 64 permits remain for the drift gill net fishery. Of these permit holders, 12 landed Barracuda (CDFW MLDS).

3.1.3 Bycatch

3.1.3.1 Amount and Type of Bycatch (Including Discards)

The Fish and Game Code (FGC §90.5) defines bycatch as "fish or other marine life that are taken in a fishery but which are not the target of the fishery." Bycatch includes "discards," defined as "fish that are taken in a fishery but are not retained

because they are of an undesirable species, size, sex, or quality, or because they are required by law not to be retained" (FGC §91). The term "Bycatch" may include fish that, while not the target species, they are desirable and are thus retained as incidental catch.

In order to assess the most commonly caught species with Barracuda, all trips where at least one Barracuda was caught were analyzed. The most common species caught in 2018 on CPFV trips where Barracuda was caught included Kelp Bass, Ocean Whitefish, California Scorpionfish, unspecified species of rockfish, Pacific Bonito, and Yellowtail (Table 3-2). Although Barracuda were caught on 100% of these trips, they are often not the most abundant species. These other species may be primary or secondary targets on CPFV trips that may, or may not, be targeting Barracuda. Many of these species reside in kelp forests and rocky reefs, which are not Barracuda's primary habitat. Although as Barracuda primarily reside in open water habits surrounding kelp beds and rocky reefs, it is common for them to be caught on trips that are targeting kelp forest species. It is also possible that some of these species are caught on the same trips as Barracuda due to switching between fishing nearshore and offshore areas. All species listed in Table 3-2 have state or federal management measures in place.

Table 3-2. Number caught and percent of trips (frequency of occurrence) for the top ten most abundant species on CPFV trips (n=2,197) where at least one Barracuda was also caught in 2018 (CDFW MLS 2019).

Species	Number Caught	Percent of Trips	Number of Barracuda caught on associated trips
Kelp Bass	104,776	82	26345
Ocean Whitefish	53,822	47	14141
California Scorpionfish	33,499	20	9505
Pacific Barracuda	**31,930**	**100**	**31930**
Rockfish, unspecified	31,304	32	10148
Pacific Bonito	20,500	38	9428
Yellowtail	19,910	49	13174
Halfmoon	11,437	17	4729
California Sheephead	10,893	37	9382
Barred Sand Bass	9,455	21	10634
Pacific Mackerel	5,908	7	1598

Species that are most commonly caught with Barracuda in gill nets include White Seabass, California Halibut (*Paralichthys californicus*), Thresher Sharks (*Alopias vulpinus*), Shortfin Mako Sharks (*Isurus oxyrinchus*), Pacific Bonito, Yellowtail and various mackerel species (*Scomber* spp.). In addition to the same species caught in gill nets, the Barracuda commercial hook and line fishery catches various species of rockfish (*Sebastes* spp). There are occasional reports of both the hook and line and gill net fishery catching Giant Sea Bass, which is a protected species. It is more common in the gill net fishery as it is legal to retain one Giant Sea Bass incidentally caught per gill net trip (FGC §8380); all Giant Sea Bass caught in the recreational fishery must be released immediately. According to the gill net logbooks, 94% of Barracuda catch is from trips where Barracuda is listed as the target species. On these trips, Barracuda

comprises on average 88% of the catch. The remaining 6% of Barracuda gill net catch is primarily from the California Halibut, White Seabass and Yellowtail targeted gill net fisheries.

It is challenging to assess the level of discards associated with the Barracuda fishery because there is limited observer coverage on the small mesh drift gill net fishery where most of the Barracuda are caught. The small mesh drift gill net fishery had observer coverage from 2002 to 2004, although there were no occurrences of observers present on trips where Barracuda was the target species. From these small mesh observer trips, only two Barracuda were observed kept, two returned alive, and two discarded dead. This is from four different observed trips, where White Seabass was the target species and made up the majority of the catch. Assessing logbook data from 2002 to 2016, undersized Barracuda comprise 96% of the catch listed as released, along with small amounts of mackerel and only single accounts of Pacific Bonito, White Seabass, Shortfin Mako Sharks and Thresher Sharks. Discards are likely higher than what is recorded in the logbooks because the level of compliance and accuracy in self-reported logbook data are unknown and can be low (Sampson 2011).

There is no knowledge of seabird or marine mammal bycatch in the Barracuda targeted small mesh drift gill net fishery, although there is for the White Seabass targeted fishery where Barracuda are caught as an incidental species. The only observed cases of marine mammal mortalities in the small mesh drift gill net include two Long-beaked Common Dolphins (*Delphinus capensis*) and three California Sea Lions (*Zalophus californianus*) from 2002 to 2004 (Carretta et al. 2016). The only observed seabird bycatch associated with the White Seabass set gill net fishery were cormorants (*Phalacrocorax* spp.) (Carretta et al. 2016) and Common Murres (*Uria aalge*) both in central California (CDFG 2002). As these seabird interactions were with set and not drift gill net it cannot be extrapolated to the Barracuda targeted fishery, which has had no observed or reported cases of seabird bycatch, possibly due to no observer coverage.

3.1.3.2 Assessment of Sustainability and Measures to Reduce Unacceptable Levels of Bycatch

Regulations are in place to reduce the levels of shark bycatch, and specifically for Thresher Shark and Shortfin Mako Shark. From FGC §8576, “(a) Drift gill nets shall not be used to take shark or swordfish from Feb.1 to Apr. 30, inclusive. (b) Drift gill nets shall not be used to take shark or swordfish in ocean waters within 75 nautical miles from the mainland coastline between the westerly extension of the California–Oregon boundary line and the westerly extension of the United States–Republic of Mexico boundary line from May 1 to August 14, inclusive. (c) Subdivisions (a) and (b) apply to any drift gill net used pursuant to a permit issued under §8561 or 8681, except that drift gill nets with a mesh size smaller than eight inches in stretched mesh and twine size number 18, or the equivalent of this twine size, or smaller, used pursuant to a permit issued under §8681, may be used to take species of sharks other than thresher shark, shortfin mako shark, and white shark during the periods specified in subdivisions (a) and (b). However, during the periods of time specified in subdivisions (a) and (b), not more than two thresher sharks and two shortfin mako sharks may be possessed and sold if taken incidentally in drift gill nets while fishing for barracuda or white seabass and if at least 10 barracuda or five white seabass are possessed and landed at the same

time as the incidentally taken thresher or shortfin mako shark.". For more information on bycatch associated with the set gill net fishery, see the White Seabass and California Halibut ESRs. Due to the extremely low level of observer coverage on the small mesh drift gill net fishery, and zero coverage from Barracuda targeted trips, it is challenging to assess the sustainability of bycatch associated with this fishery. In order to deem if bycatch associated with the Barracuda targeted gill net fishery is at an acceptable level, an observer program would need to be implemented.

3.1.4 Habitat

3.1.4.1 Description of Threats

As Barracuda primarily reside in the coastal pelagic environment, there are few habitat threats from fishing. Drift gill nets do not touch the sea floor. The recreational fishery is primarily hook and line, and the most vulnerable habitat in which Barracuda fishing occurs is kelp forests and rocky reefs. Adverse impacts to kelp forests or marine invertebrates associated with rocky reefs can result from the anchoring of vessels or fishing gear snagging on structure or organisms; however, this is likely minimal.

Pollution from wastewater discharge can impact kelp forest habitats and especially bays and estuaries (North and Hubbs 1968; Schiff et al. 2000). Invasive species, climate change and increased variability in sea surface temperatures may also have detrimental effects on the health of nearshore kelp forest ecosystems (Caselle et al. 2017; Provost et al. 2017; Ramírez-Valdez et al. 2017). These threats are most likely to impact juvenile Barracuda given that they spend more time in nearshore waters closer to potential pollution sources than adults.

3.1.4.2 Measures to Minimize Any Adverse Effects on Habitat Caused by Fishing

Given the minimal threats from to habitat from the fishing gears used in the Barracuda fishery, no measures to minimize adverse habitat effects are in place at this time.

3.2 Requirements for Person or Vessel Permits and Reasonable Fees

Commercial Fishery

Any vessel commercially fishing must obtain a commercial fishing license to be permitted to fish in California waters. Fishers using gill nets to land Barracuda are additionally required to obtain an annual limited entry and restricted access gill net permit, as well as submit a complete and accurate record of fishing activities on forms provided by the Department (Table 3-3). However, no new gill net permits may be issued (see section 3.1.2.2 above) The most current license options, fees and other information for the commercial fishery may be accessed at https://www.wildlife.ca.gov/Licensing/Commercial/Descriptions.

Table 3-3. Annual commercial fishing license fees from January 1 to December 31, 2019. Accessed June 24, 2019 at https://www.wildlife.ca.gov/Licensing/Commercial/Descriptions.

License	Fee	Description
Resident Commercial Fishing License	$145.75	Required for any resident 16 years of age or older who uses or operates or assists in using or operating any boat, aircraft, net, trap, line, or other appliance to take fish for commercial purposes, or who contributes materially to the activities on board a commercial fishing vessel.
Commercial Ocean Enhancement Stamp	$54.08	Required for commercial passenger fishing vessels operating south of Point Arguello (Santa Barbara County). Any commercial fisherman who takes, possesses aboard a commercial fishing vessel, or lands any White Seabass south of Point Arguello.
Commercial Boat Registration (Resident)	$379.00	Required for any resident owner or operator for any vessel operated in public waters in connection with fishing operations for profit in this State; or which, for profit, permits persons to sport fish.
Gill/Trammel Net Permit	$498.25	Required for the owner or operator of a currently registered commercial fishing vessel to use a gill or trammel net. At least one person aboard each commercial fishing vessel must have a valid general gill net permit when engaged in operations authorized by the permit.
Drift Gill Net Permit Transfer fee	$1500.00	Required for gill net permits to be transferred following all restrictions described in the Commercial Regulations Transferring Permit Requirements (§8561.5)
Drift Gill Net Vessel Transfer fee	$130.00	Required for gill net vessels to be transferred following all restrictions described in the Commercial Regulations Transferring Permit Requirements (§8561.5)

Recreational Fishery

Unless recreationally fishing off a public pier, all anglers 16-yr-old or older are required to purchase a fishing license to fish for Barracuda. Anglers fishing south of Point Arguello must also have an ocean enhancement validation. Captains operating their vessels as CPFVs or private charters must purchase a permit. In 2019, the cost of an annual resident sport fishing license is $49.94, and an ocean enhancement validation is $5.66 (Table 3-4). The most current license options, fees, and other information for recreational fishing may be accessed at https://www.wildlife.ca.gov/Licensing/Fishing.

Table 3-4. Annual sport fishing license fees from January 1 to December 31, 2019. Accessed June 24, 2019 at https://www.wildlife.ca.gov/Licensing/Fishing and https://www.wildlife.ca.gov/Licensing/Commercial/Descriptions.

License	Fee	Description
Commercial Passenger Fishing Vessel License	$379.00	Required for any boat from which persons are allowed to sport fish for a fee.
Resident Sport Fishing	$49.94	Required for any resident 16 yr of age or older to fish.
Recreational Non-resident Sport Fishing	$134.74	Required for any non-resident 16 yr of age or older to fish.
Recreation Ocean Enhancement Validation	$5.66	Required to fish in ocean waters south of Point Arguello (Santa Barbara County). An Ocean Enhancement Validation is not required when fishing under the authority of a One or Two-Day Sport Fishing License.
Reduced-Fee Sport Fishing License – Disabled Veteran	$7.47 at CDFW offices $7.82 from license agents	Available for any resident or non-resident honorably discharged disabled veteran with a 50 percent or greater service-connected disability. After you prequalify for your first Disabled Veteran Reduced-Fee Sport Fishing License, you can purchase disabled veteran licenses anywhere licenses are sold.
Reduced-Fee Sport Fishing License – Recovering Service Member	$7.47	Available for any recovering service member of the US military. The Recovering Service Member Reduced-Fee Sport Fishing License is only available at CDFW License Sales Offices.
Reduced-Fee Sport Fishing License – Low Income Senior	$7.47	Available for low income California residents, 65 years of age and older, who meet the specified annual income requirements. The Reduced-Fee Sport Fishing License for Low Income Seniors is only available at CDFW License Sales Offices.

4 Monitoring and Essential Fishery Information

4.1 Description of Relevant Essential Fishery Information

FGC §93 defines Essential Fishery Information (EFI) as “information about fish life history and habitat requirements; the status and trends of fish populations, fishing effort, and catch levels; fishery effects on age structure and on other marine living resources and users, and any other information related to the biology of a fish species or to taking in the fishery that is necessary to permit fisheries to be managed according to the requirements of this code.” Fishery-dependent data collected by the Department provides a way to monitor fishing effort, catch levels, and the size structure of retained Barracuda. However, because the presence of Barracuda off the California coast is highly variable, many of these datasets are data-poor and not informative indicators of Barracuda’s population status.

4.2 Past and Ongoing Monitoring of the Fishery

4.2.1 Fishery-dependent Data Collection

The Department collects data from a combination of fishery-dependent sources that can be used to monitor the status of the Barracuda fishery. Recreational fishery data are reported in the form of CPFV logbooks and are also collected from all fishing modes by CRFS staff. Beginning in 1935, CPFV operators were required to keep daily catch logs and submit them to the Department monthly. These data were collected continuously to the present day, except for the years during World War II (1941 to 1946) when most CPFVs were not fishing (Hill and Schneider 1999). Logbook data have always included the date of fishing, port code, boat name, Department fishing block, angler effort and the number of fish kept by species. After 1994, logbook data also included discarded fish, bait type and sea surface temperature.

All modes of recreational fishing were surveyed by MRFSS for estimates of catch and effort between 1979 and 2003. The Pacific States Marine Fisheries Commission ran these surveys with both federal and state funding. A combination of dockside surveys, CPFV sampling and phone interviews were used to generate the estimates. In January 2004, the Department implemented its own sampling survey, CRFS, to replace the MRFSS surveys using similar methods. In addition to catch and effort data, CRFS also collects size information (length and weight) on kept fish, numbers of discards for all modes, and discard lengths aboard CPFVs. CRFS data on catch estimates and mortality are available electronically to the public within 40 days of collection on the updated RecFIN website (https://www.recfin.org).

All commercial fishers are required to submit landing receipts that are housed in the MLDS. Landing receipts record the weight of the fish landed, price paid to the anglers, date, type of gear used, port of landing, and the fishing block location where the fish were harvested. In addition to landing receipts, the drift gill net fishery, where most of the Barracuda are commercially caught, requires the submission of logbooks. Gill net logbooks are a mandated system for anglers fishing both drift and set gill nets to record target species, fishing locations, time, depth, net length, mesh size, buoy line

depth, soak time, total catch by species, market category, gear used, and information about the vessel and crew.

4.2.2 Fishery-independent Data Collection

Fishery-independent data can provide a better, less-biased assessment of relative abundance since sampling can be standardized and information on all life stages can be collected. However, there is currently no known fishery-independent data collection on Barracuda.

5 Future Management Needs and Directions

5.1 Identification of Information Gaps

The Barracuda fishery is data-poor and is challenging to actively manage given its high degree of variability. Fishery-independent data can provide a better, less-biased assessment of relative abundance; however, there are currently no fishery-independent efforts monitoring the Barracuda fishery off the California coast. Fishery-independent research on Barracuda abundances could provide information on the relative size of the Barracuda population, and how it might vary with changing environmental conditions (Table 5-1). Establishing an index of abundance for Barracuda would be challenging given that their abundances fluctuate seasonally, they're greatly impacted by the Mexico fishery, and they are a shared stock that seasonally migrates across the California-Mexico border.

Additionally, little is known about post-release survival of Barracuda that are caught and released, both recreationally from hook and line and in the commercial fishery. More information on post-release survival would aid in informing the effectiveness of the size limit regulation. Surveys to increase knowledge on the location and spatial extent of potential Barracuda spawning grounds would also be informative, as there is little information since spawning primarily occurs in waters south of California. Collecting fishery-dependent data on the sizes and ages of the commercial catch would also help determine the age composition of the Barracuda stock, as well as the effectiveness of the size limit regulation, and how it may vary with changing environmental conditions. Also, implementing observer coverage to assess the bycatch associated with the Barracuda targeted small mesh drift gill net fishery would aid in understanding the sustainability of the Barracuda fishery. Lastly, conducting a stock assessment or using other modeling approaches for Barracuda with updated EFI and potential fishery-independent research could be helpful in the sustainable management of the fishery.

Table 5-1. Informational needs for Pacific Barracuda and their priority for management.

Type of information	Priority for management	How essential fishery information would support future management
Relative abundance of Barracuda population off California coast	High	Provides information on the health of the Barracuda population, and how it changes with changing environmental conditions.
Bycatch associated with the small mesh drift gill net fishery	High	Quantifies the level of bycatch and condition of discarded catch from the small mesh drift gill net, which would aid in understanding the sustainability of the Barracuda fishery.
Size/age composition of commercial and recreational catch	High	Provides information on the effectiveness of the minimum size limit regulations.

Immediate and long term post-release mortality	Medium	Quantifies discard mortality, which would aid in informing the effectiveness of both the recreational and commercial minimum size limit regulation.
Location and spatial extent of spawning grounds	Low	Provides information on where the key spawning habitats for Barracuda are located, and how they have changed over time.

5.2 Research and Monitoring

5.2.1 Potential Strategies to Fill Information Gaps

Department staff will continue to use CPFV logbook, CRFS, and commercial landing receipt data to monitor Barracuda fishery trends. The Department will also continue to search for and incorporate any relevant results from other fishery-dependent or fishery-independent studies conducted by others, including data that are collected in the Mexican fisheries. As mentioned above, additional fishery-independent indices of abundance for Barracuda will be important for monitoring future trends in the stock. This may require a combination of efforts led by the Department and independent researchers through various grants or other funding sources. In addition, several of the other information gaps could be filled though collaborative studies (see below).

5.2.2 Opportunities for Collaborative Fisheries Research

The Department has collaborated in the past and will continue to work with outside entities such as academic organizations, NGOs, citizen scientists, and both commercial and recreational fishery participants to help fill information gaps related to the management of state fisheries. The Department will also reach out to outside persons and agencies when appropriate while conducting or seeking new fisheries research required for the management of each fishery.

Several of the information gaps identified above (section 5.1) are potential areas for collaborative studies. In particular, short term and long term monitoring of Barracuda survival after capture and release, along with identification and disposition of bycatch, may be well-suited for collaborative studies involving Department staff or graduate students with both recreational and commercial fisheries participants.

5.3 Opportunities for Future Management Changes

This section is intended to provide information on changes to the management of the fishery that may be appropriate, but does not represent a formal commitment by the Department to address those recommendations. ESRs are one of several tools designed to assist the Department in prioritizing efforts and the need for management changes in each fishery will be assessed in light of the current management system, risk posed to the stock and ecosystem, needs of other fisheries, existing and emerging priorities, as well as the availability of capacity and resources.

At this time, there are no suggestions to change the management of Barracuda. Barracuda landings fluctuate greatly with changing environmental conditions; however, the recent low amount of recreational and commercial landings despite favorable (warm water) conditions is cause for some concern. Increased monitoring and research, modeling, and a stock assessment may help determine current Barracuda population status and better inform management of this fishery. In lieu of this, the Department may consider reduction of bag limits, an increased size limit, or other measures to help bring about sustainable management of Barracuda.

5.4 Climate Readiness

To incorporate climate readiness into Barracuda management it is important to increase our understanding of possible impacts of climate variability. California's coastal waters are already highly variable due to episodic events such as ENSO, Pacific Decadal Oscillation, and North Pacific Gyre Oscillation. Climate change may increase this variability with potential implications for ecosystem function and fishery sustainability in coastal areas (Chavez et al. 2003). With increased warm water events, the fishing season for Barracuda might be extended, their geographic range may expand, their population abundance center may shift northward, and spawning events could increase off the California coast. Climate change, invasive species and the predicted increased variability in the cool and warm regimes may also have detrimental effects on the health of kelp forest and rocky reef ecosystems (Caselle et al. 2017; Provost et al. 2017; Ramírez-Valdez et al. 2017). Although Barracuda primarily occupy coastal pelagic habitats, these changes could impact prey availability and have larger impacts on juveniles occupying nearshore habitats. Increased monitoring of environmental variables, fish abundance and distribution from all available data sources will be important to anticipate change and take proactive management actions.

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