REVIEW OF SELECTED CALIFORNIA FISHERIES FOR 2011: OCEAN SALMON, CALIFORNIA SHEEPHEAD, CALIFORNIA HALIBUT, LONGNOSE SKATE, PETRALE SOLE, CALIFORNIA SPINY LOBSTER, DUNGENESS CRAB, GARIBALDI, WHITE SHARK, AND ALGAL BLOOMS

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SUMMARY

In 2011, commercial fisheries landed an estimated 184,825 metric tons (t) of fish and invertebrates from California ocean waters (fig. 1). This represents a decrease of nearly 7% from the 197,956 t landed in 2010, an increase of 15% from the 160,615 t landed in 2009, and a 27% decline from the peak landings of 252,568 t observed in 2000. The preliminary ex-vessel economic value of commercial landings in 2011 was nearly $198 million, which continued the increasing trend in value of California fisheries since 2008, with a 13% increase from the $175 million in 2010, a 37% increase from the $144 million in 2009, and a 37% increase from the $145 million in 1999 which was, until 2010, the highest value observed in the last decade.

Four of the top five volume and valued fisheries were represented by invertebrates in 2011. California market squid remained the largest volume and highest value fishery in the state with 121,555 t landed and an ex-vessel value of more than $68.5 million (table 1). Although this represents a decrease from the nearly 130,000 t landed in 2010 with an ex-vessel value of approximately $73.8 million, 2011 was the second year in a row that the commercial fishery was closed due to the catch limit being reached before the end of the fishing season. In 2011 the fishery was closed on November 18, one month earlier than the December 17 closure in 2010. It is thought that cooler water along the West Coast has provided good squid spawning conditions and an increase in abundance throughout the state. Pacific sardine was the second highest volume fishery with 27,714 t, but only seventh highest in ex-vessel value at $5.4 million. The other top five volume fisheries were Dungeness crab at 9,344 t, red sea urchin at 5,213 t, and pink shrimp at 3,345 t. The other top five valued fisheries were Dungeness crab at $51.5 million, sablefish at $15.1 million, California spiny lobster at $12.9 million, and red sea urchin at $8.1 million.

In 2011, California ocean salmon fisheries were less constrained than in 2010 due to an increase in the forecasted ocean abundance of Sacramento River fall Chinook (SRFC), which support 80%–90% of California's ocean salmon fisheries. Commercial fisheries had 369 days open to fishing in 2011 compared to 70 days during the 2010 season. Total 2011 commercial landings were estimated at 69,800 Chinook salmon (448 t) with an ex-vessel value of $5.1 million. Recreational fisheries had 209 more days open than in 2010, for a season total of 709 days. An estimated 49,000 Chinook were landed in 2011 compared to 14,800 Chinook in 2010. The commercial and recreational numbers continued to show an increasing trend in landings since major closures were enacted in 2008 and 2009 after the lowest recorded landings in 2006 and 2007, respectively. During fall 2011, record numbers of SRFC and Klamath River fall Chinook (KRFC) jack salmon (age-2 fish) returned to spawn in the Central Valley and Klamath-Trinity basins, respectively. These returns, combined with other relevant

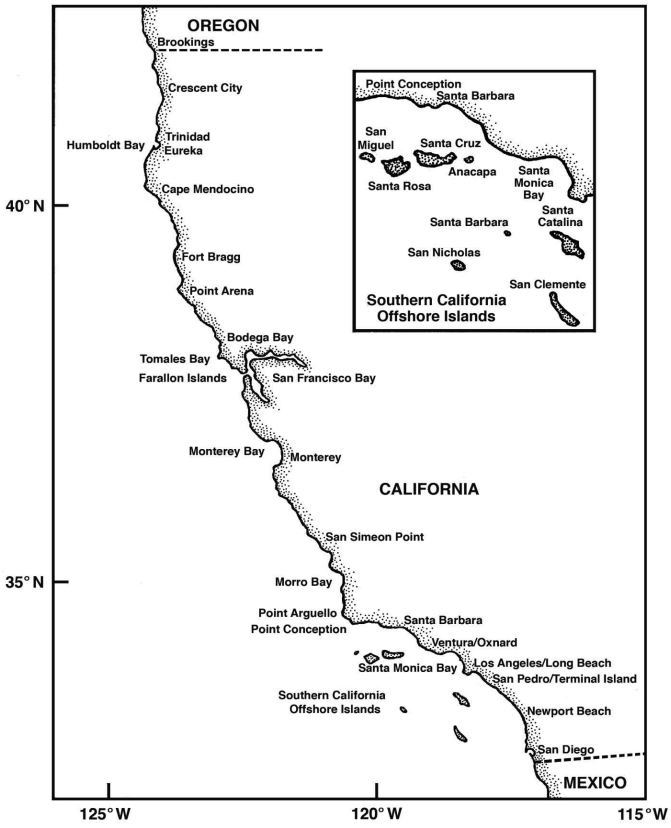

Figure 1. California ports and fishing areas.

TABLE 1
Landings of Coastal Pelagic Species in California (metric tons)

Year	Pacific sardine	Northern anchovy	Pacific mackerel	Jack mackerel	Unspecified mackerel	Pacific herring	Herring roe	Market squid	Total
1977	2	101,132	3,316	47,615		5,286		12,811	170,163
1978	1	11,439	8,241	34,349	48	4,473		17,145	75,696
1979	51	48,880	22,404	21,548	301	4,257		19,982	117,424
1980	21	42,946	25,739	24,181	56	8,061		15,385	116,389
1981	34	52,308	35,257	17,778	132	5,961		23,510	134,980
1982	2	42,150	17,667	19,618	18,398	10,604		16,308	124,747
1983	1	4,427	17,812	9,829	23,659	8,024		1,824	65,576
1984	1	2,889	26,043	9,149	18,038	3,847		564	60,532
1985	6	1,626	18,149	6,876	19,624	7,984		10,275	64,540
1986	388	1,535	22,095	4,777	25,995	7,658		21,278	83,727
1987	439	1,390	26,941	8,020	19,783	8,420		19,984	84,978
1988	1,188	1,478	30,127	5,068	20,736	8,641		37,233	104,471
1989	837	2,449	21,067	10,746	26,661	9,296		40,893	111,950
1990	1,664	3,208	31,077	3,223	9,039	7,436		28,447	84,094
1991	7,587	4,014	31,680	1,693	339	7,347		37,389	90,048
1992	17,950	1,124	18,574	1,209	3	6,319		13,110	58,289
1993	15,346	1,958	11,798	1,673		3,846	0	42,722	77,345
1994	11,644	1,789	10,008	2,704	0	77	2,874	55,508	84,603
1995	40,328	1,886	8,625	1,728		3	4,664	72,433	129,667
1996	32,559	4,421	9,597	2,178	4	249	5,162	80,784	134,954
1997	43,246	5,718	18,398	1,160	1	0	9,147	70,387	148,057
1998	42,956	1,457	20,515	824		0	2,009	2,895	70,656
1999	59,493	5,179	8,688	953	0		2,279	91,950	168,542
2000	53,612	11,754	21,916	1,269	0	26	3,450	118,816	210,843
2001	51,894	19,277	6,925	3,624	1	0	2,768	86,385	170,873
2002	58,354	4,643	3,367	1,006	2	0	3,324	72,920	143,615
2003	34,732	1,676	3,999	156	0	34	1,808	45,061	87,467
2004	44,305	6,793	3,570	1,027	0	60	1,581	41,026	98,362
2005	34,633	11,182	3,244	199		219	136	58,391	108,005
2006	46,577	12,791	5,891	1,167	0	37	694	49,159	116,316
2007	80,981	10,390	5,018	630	1	336	261	49,474	147,091
2008	57,806	14,285	3,530	274	0	131	626	38,101	114,754
2009	37,578	2,668	5,079	119	1	74	460	92,338	138,317
2010	33,658	1,026	2,056	310	0			129,904	166,954
2011	27,714	2,601	1,357	80	453		1,566	121,555	155,326

Data Source: Commercial Fisheries Information System (CFIS)

data, were used to forecast the largest ocean abundance (approximately 2.5 million Chinook) estimated for management purposes since the early 1980s.

California sheephead support both commercial and recreational fisheries, and are one of the 19 species managed under the Nearshore Fishery Management Plan. In 2011, commercial landings for California sheephead were 29.7 t, 33% lower than the average annual landings of 44.2 t from 2000 to 2011, with an ex-vessel value of over $311,000. Recreational landings data showed 31,422 California sheephead were landed by Commercial Passenger Fishing Vessels (CPFVs). That is higher than the decade's average of 25,883 and the highest CPFV landings reported since 2002.

Total commercial landings for California halibut in 2011 were 200 t, a 17% decrease from 2010 landings. Preliminary data for the recreational fishery showed a 41% decrease from 2010 with an estimated 117 t (25,000 fish) of halibut landed. In 2011, the Department contracted for the first statewide stock assessment of California halibut, with separate estimates for areas north and south of Point Conception. The period assessed was 1971–2010. The status of the halibut biomass north of Point Conception was relatively high with several recent recruitment events. Favorable environmental conditions appear to be driving recruitment and fishing was not considered to be a significant factor impacting biomass. South of Point Conception, the halibut population was estimated to be depleted at 14% of historic levels. An independent peer-review panel concluded that the results were acceptable for use in management decisions, but required additional sampling to be conducted to improve the next assessment, which the Department plans to conduct in 2016.

California's commercial groundfish harvest for 2011 was 7,205 t, a 28% decrease from 2010 (table 2). However, the fishery once again saw an increase of the ex-vessel value over 2010 values. In 2011 the Groundfish Fishery Management Plan's (FMP) Trawl Rationalization and Individual Fishing Quota Program was implemented, which sets trawl allocation limits in combination with 100% observer coverage to help ensure all trawl-

TABLE 2
California commercial groundfish landings (in metric tons) and ex-vessel value in 2011 with comparisons to 2010. The top six species by weight for the flatfishes and rockfishes are represented in the table.

	2011		2010		% change from 2010	% change from 2010
	Harvest (t)	Value ($)	Harvest (t)	Value ($)	(t)	($)
Flatfishes						
Dover sole	2,412	$2,258,482	2,622	$1,798,113	–8	26
Petrale sole	174	$553,556	213	$557,412	–18	–1
Arrowtooth flounder	86	$19,670	68	$14,921	26	32
Rex sole	68	$53,181	55	$43,385	24	22
Sanddabs	51	$99,392	56	$91,722	–9	8
English sole	19	$17,298	24	$21,091	–21	–18
Other flatfishes	36	$78,584	33	$60,601	9	30
Total Flatfishes	2,846	$3,080,163	3,071	$2,587,246	–7	19
Rockfishes						
Chilipepper	293	$412,552	342	$457,029	–14	–10
Blackgill rockfish	126	$356,725	96	$247,963	31	44
Group slope rockfish	59	$82,304	78	$108,166	–24	–24
Gopher rockfish	30	$460,099	28	$412,792	7	11
Brown rockfish	29	$382,574	27	$336,953	7	13
Black rockfish	27	$108,939	53	$219,347	–49	–50
Other rockfishes	82	$741,689	88	$982,306	–7	–24
Overfished species						
Bocaccio	8	$18,183	4	$9,299	100	95
Canary rockfish	0.33	$456	0.44	$637	–25	–28
Cowcod	0.01	$17	0.03	$132	–67	–87
Darkblotched rockfish	3	$6,301	17	$21,750	–82	–71
Pacific ocean perch	0.07	$63	0.04	$47	75	34
Widow rockfish	1	$2,189	10	$8,937	–90	–75
Yelloweye rockfish	0	$0	0	$8	—	—
Total Rockfishes	658	$2,572,091	781	$2,516,817	–16	2
Roundfishes						
Sablefish	2,406	$15,119,335	2,449	$11,501,299	–2	31
Pacific whiting	5	$234	2,427	$694,248	–100	–100
Lingcod	33	$144,337	47	$173,276	–30	–17
Cabezon	32	$384,929	23	$266,032	39	45
Kelp greenling	2	$28,864	2	$22,154	0	30
Total Roundfishes	2,478	$15,677,699	4,947	$12,657,009	–50	24
Scorpionfish, California	5	$38,307	3	$26,734	67	43
Sharks & unsp. skates	39	$31,972	35	$28,834	10	10
Longnose skate	171	$129,556	142	$48,829	17	62
Thornyheads	921	$3,072,533	1,026	$2,957,617	–10	4
Other groundfish	87	$41,654	95	$44,453	–8	–6
Total Groundfish	7,205	$24,643,975	9,960	$20,818,711	–28	18

Data Source: CFIS (CMASTR) Extraction Date: 06-27-2012

caught groundfish species stay within established catch limits. The federal groundfish trawl individual fishing quota program allowed fishermen to trade their Pacific whiting quotas for sablefish quotas, which led to a drastic decline in Pacific whiting landings. Sablefish landings remained about the same but the ex-vessel value increased nearly $4 million, as many fishermen switched from trawl to longline gear which commands a higher price per pound. Longnose skate were removed from the "Other Fish" complex to be separately managed with a preliminary preferred Annual Catch Limit (formerly referred to as the optimum yield) set at approximately 2,000 t for the 2011 and 2012 regulatory cycle. Petrale sole experienced significant changes to the fishery due to restricted fishing regulations as a result of stock decline, and landings dropped to the lowest on record since 1931.

California spiny lobster commercial landings increased 7% in 2011 with 340 t landed, and also set a new record high ex-vessel value of $12.9 million which exceeded the fisheries previous highest record ex-vessel value in 2010 of $11.3 million. Based on results from the Department's lobster stock assessment, which was completed in 2011 and independently reviewed, the current levels of commercial and recreational fishing are considered to be sustainable.

Dungeness crab had a record-breaking season for statewide landings, totaling 12,493 t, and landings in the central area totaled 8,666 t which were more than twice the 3,826 t caught in the northern area. Land-

ings in the central management area have not exceeded 3,000 t since the late 1950s and this record season for the area was more than five times the catch of 1,539 t from the previous season. New legislation was passed in 2011 that will impose trap limits on Dungeness crab permit holders by the 2013–14 season. Once established, permit holders will be grouped into one of seven tiers, based on their total catch from a prescribed, consecutive 5-season period. Permit holders will also be required to purchase a biennial trap permit along with Department-issued trap tags for each trap in their tier.

Historically, garibaldi supported a minor commercial fishery for Los Angeles fish markets and also a commercial marine aquaria trade which targeted both adult and juvenile fish. There has never been a significant sport fishery. Garibaldi was designated California's state marine fish in 1995, and a prohibition on all commercial take was implemented. There has been a prohibition on recreational take of garibaldi since 1953.

The great white shark has historically interacted with several California commercial fisheries; most often with the set gill net and other entangling net fisheries. In the 1980s, as seabird and marine mammal mortalities associated with these nearshore fisheries increased and the target species populations declined, regulations were put in place to restrict these fisheries. This indirectly protected white sharks, especially in the vulnerable pupping grounds of the Southern California Bight. In 1994, two significant regulations went into effect that supported a rebuilding of the white shark population in California waters. The first was the Marine Resources Protection Act of 1990, which banned entangling nets in state waters. The second was Title 14, CCR, §28.06 and FGC §8599, which prohibits take of white sharks except under Fish and Game permits for scientific or educational purposes.

Marine phytoplankton are microscopic, single-celled plants that live in the ocean. With over 5,000 species of phytoplankton, less than 10% undergo periods of explosive population growth due to favorable environmental conditions. These instances are called algal blooms and they typically support fisheries and ocean productivity. However, some species of phytoplankton can produce toxins and when they bloom can create harmful algal blooms (HABs) which create numerous management considerations for the health and safety of humans and marine animal populations. Federal and state agencies, along with public-private partnerships, are working to establish predictive models for HAB occurrences and improve response time for affected marine resources.

Ocean Salmon

Ocean salmon fisheries in California primarily target Chinook salmon (*Oncorhynchus tshawytscha*). The retention of coho salmon (*O. kisutch*) has been prohibited in the commercial and recreational fisheries since 1993 and 1996, respectively. Pink salmon (*O. gorbuscha*) are taken occasionally in the fisheries, primarily in odd-numbered years. Each season, the Pacific Fisheries Management Council (PFMC) and the Fish and Game Commission (Commission) regulate California's ocean salmon fisheries to meet the conservation objectives for Klamath River fall Chinook (KRFC) and Sacramento River fall Chinook (SRFC) stocks as described in the Salmon Fishery Management Plan (FMP). In addition, the fisheries must meet the National Marine Fisheries Service (NMFS) Endangered Species Act (ESA) consultation standards for listed stocks, including Sacramento River winter Chinook (endangered), Central Valley spring Chinook (threatened), California coastal Chinook (threatened), Central California coast coho (endangered), and Southern Oregon/Northern California coho stocks (threatened).

In 2011, California ocean salmon fisheries were primarily constrained by the NMFS consultation standards for threatened California coastal Chinook which limit the KRFC age-4 ocean harvest rate to a maximum of 16%. Fishing in San Francisco and Monterey-south port areas was open May 1 through September 30 with several short-term closures occurring during June, July, and August. The Fort Bragg port area was open July 23 through September 30 (closed July 28 and August 29–30) while the Crescent City/Eureka port area (Klamath Management Zone; KMZ) had two quota fisheries—13 days open in July (1,400 Chinook quota) and 2 days open in August (880 Chinook quota).

Commercial fisheries in the four major port areas (Crescent City/Eureka, Fort Bragg, San Francisco, and Monterey-south) had 369 days open to fishing in 2011 compared to 70 days open during the 2010 season. An estimated 69,800 Chinook salmon (448 t) were landed during the 2011 commercial season (fig. 2). The average weight per fish was 6.45 kg (14.2 lbs). The average price was $11.37/kg ($5.17/lb). The total ex-vessel value of the fishery in 2011 was estimated to be $5.1 million. Total commercial effort was estimated to be 6,900 days fished in 2011.

The 2011 recreational fishing season increased 209 days compared to the 2010 season, for a season total of 709 days (days open in each of four management areas combined). The recreational fishery opened in Fort Bragg, San Francisco, and Monterey-south port areas on April 2 while the KMZ area opened on May 14. All fisheries remained open through the summer until closing on various dates in September and October. An estimated 49,000 Chinook were landed in 2011 compared to 14,800 salmon in 2010 (fig. 3). There was an estimated 91,100 angler days in 2011 compared to 48,700

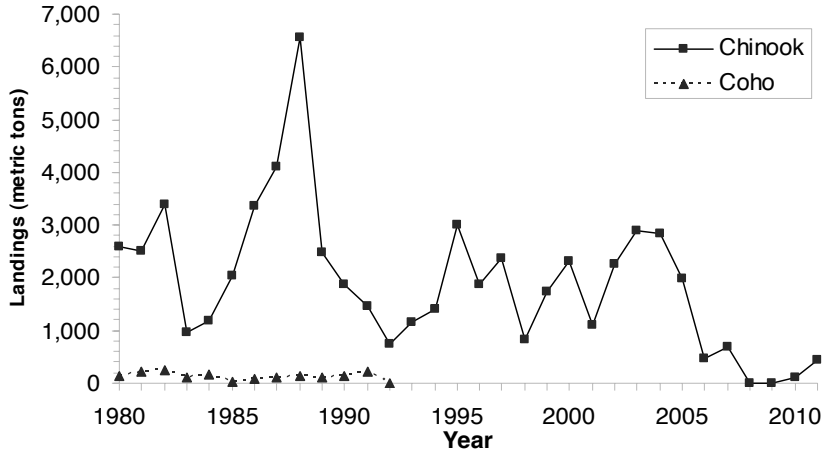

Figure 2. California commercial landings of ocean salmon, 1980–2011. Note: Commercial fishery landings of coho salmon (*Oncorhynchus kisutch*) have been prohibited since 1993 to protect ESA-listed California coastal coho salmon stocks.

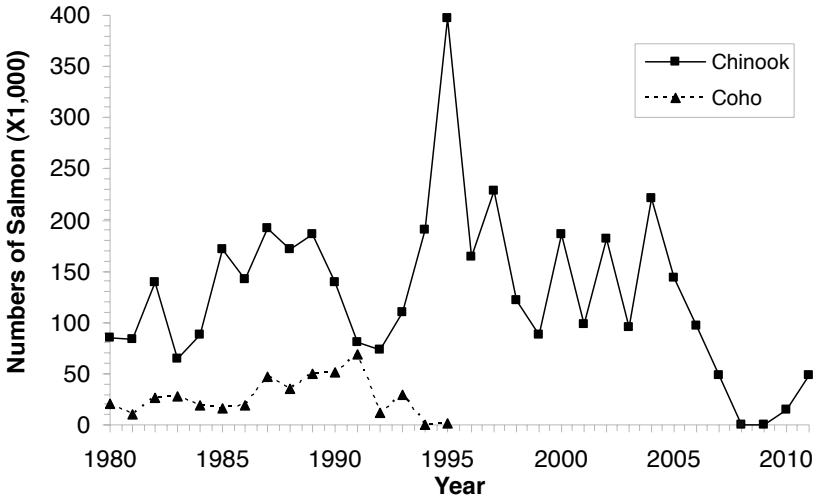

Figure 3. California recreational landings of ocean salmon, 1980–2011. Note: Recreational fishery landings of coho salmon (*Oncorhynchus kisutch*) have been prohibited since 1996 to protect ESA-listed California coastal coho salmon stocks.

angler days in 2010. The bag and possession limit was two salmon per day of any species except coho and anglers were required to use no more than two single-point, single-shank barbless hooks when fishing for salmon. The minimum size limit was 610 mm (24 in.) total length (TL) to protect the generally smaller-sized ESA-listed endangered Sacramento River winter Chinook. Approximately 300 coho were landed illegally during 2011, presumably by anglers who misidentified their salmon as Chinook.

During fall 2011, record numbers of Sacramento River fall Chinook (SRFC) and Klamath River fall Chinook (KRFC) jack salmon (age-2 fish) returned to spawn in the Central Valley and Klamath-Trinity basins, respectively. These returns, combined with other relevant data, were used to forecast the largest ocean abundance (approximately 2.5 million Chinook) estimated for management purposes since the early 1980s. As a result, California ocean sport and commercial salmon fishing opportunities in 2012 were greatly increased compared to recent seasons. Although all FMP conservation objectives were met, a few fishery constraints (e.g., increased size limit, 22-day June commercial closure) were still enacted specifically to protect ESA-listed salmon stocks.

California Sheephead

California sheephead (*Semicossphus pulcher*) are a hermaphroditic species, maturing first as female and may transition to become male later in life. Currently, there is both a commercial and a recreational fishery for sheephead. The commercial fishery targets smaller, plate size individuals for a live-fish market while the recreational

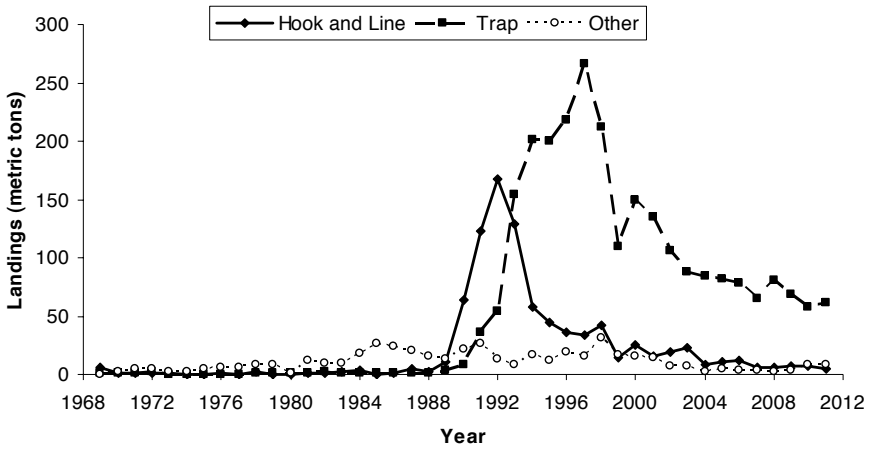

Figure 4. California sheephead (*Semicossyphus pulcher*) commercial landings by gear, 1969–2011.

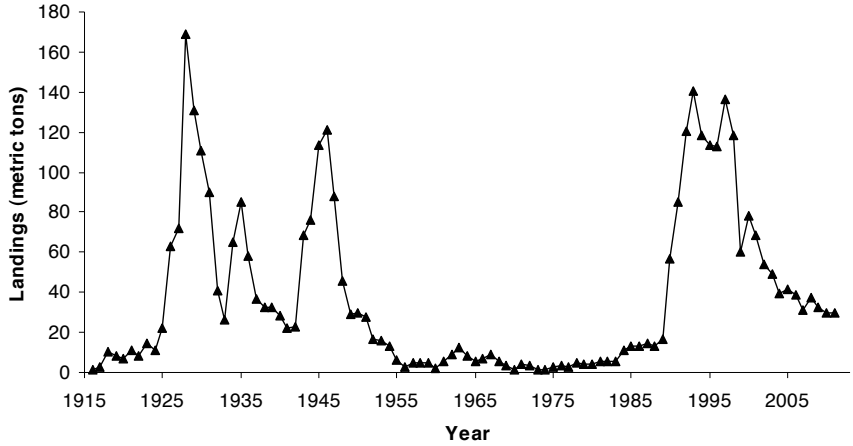

Figure 5. California sheephead (*Semicossyphus pulcher*) commercial landings by weight, 1916–2011.

fishery targets larger, trophy individuals. Most commercially caught sheephead are caught by trap but some are caught by hook and line and also by gill net and longline gear (fig. 4). Because sheephead are a sex-changing species, smaller individuals tend to be female while the largest individuals tend to be male making each of the fisheries both size and sex selective.

In 2011, commercial landings for sheephead were 29.7 t, 33% lower than the average annual landings of 44.2 t from 2000 to 2011 and 72% lower than the average annual landings in the 1990s (fig. 5). Landing receipt records show that the commercial fishery for sheephead has experienced two booms since 1916. During the 1925–51 boom, sheephead landings averaged 63.3 t per year and reached a historical high of 169.2 t in 1928. Then, commercial sheephead catch declined dramatically from 1952–89 averaging less than 7.3 t per year. The second boom began in 1990, initially driven by a live-fish fishery that began in the mid-1980s. The live-fish fishery primarily supplied the California Asian community at first but has since expanded and may supply other states and even other countries. Landings for sheephead increased nearly tenfold from 16.6 t in 1989 to almost 141 t in 1993 (fig. 5). After 1993, annual landings stayed above 113 t until 1999 when concern for the sustainability of the sheephead stock brought about regulatory changes in 1999 and 2001. These changes resulted in a steady decrease in landings since 2000. Since 1994, when landing receipts were first required to indicate the condition of fish sold at market, 87% of commercially caught sheephead were sold in a live condition. The value of the commercial fishery followed general trends in the catch data, peaking in the 1990s and decreasing over the last decade (fig. 6). In 2011, the ex-vessel value of the sheephead fishery was $311,135. In a contrasting trend, the market price for sheephead increased steadily since the second boom began in 1990.

Recreational fishers target large, trophy sheephead by spear and by hook and line; most sheephead are caught aboard Commercial Passenger Fishing Vessels (CPFVs). According to CPFV logbook data, the recreational sheephead fishery has also experienced a boom beginning in 1964 when average landings went from less than 15,000 fish (1936–63) to an annual average of almost

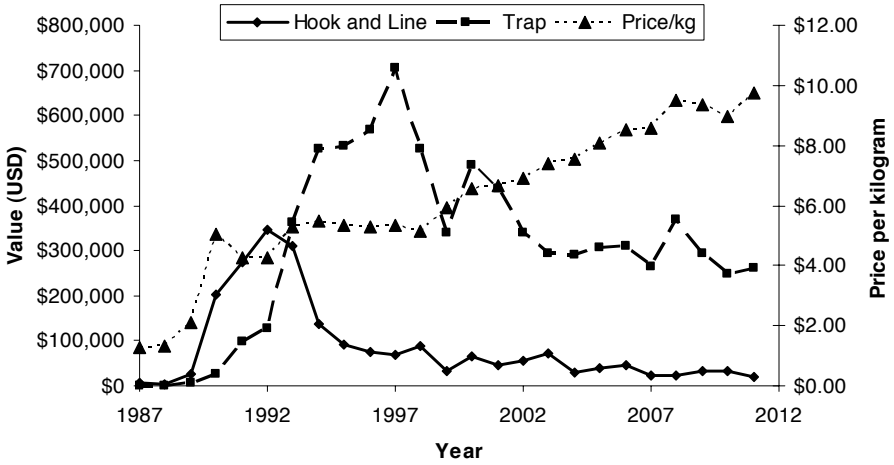

Figure 6. Total value of commercial California sheephead (*Semicossyphus pulcher*) hook-and-line and trap fisheries, and price per kilogram, 1987–2011.

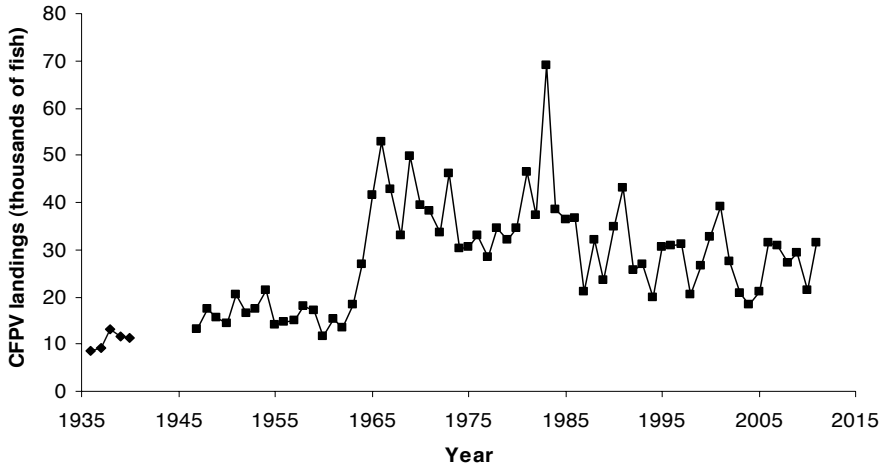

Figure 7. Recreational California sheephead (*Semicossyphus pulcher*) landings from Commercial Passenger Fishing Vessel (CPFV) logbooks, 1936–2011; no data for 1941–46.

39,000 fish (1964–86) (fig. 7). In the last 25 years, average annual landings have decreased to less than 28,000 sheephead per year, still almost twofold that of historical annual landings. In 2011, 31,422 sheephead were landed by CPFVs, higher than the decade's average of 25,883 and the highest CPFV landings reported since 2002. The decrease in recreational landings since the late 1980s may be in part due to increased competition for fish from the commercial fishery and the introduction of minimum size and bag limits in the early 2000s.

California sheephead are one of the 19 nearshore species managed under the Nearshore Fishery Management Plan (NFMP). The minimum size limit for commercially caught sheephead was first set in 1999 at 30.5 cm (12 in) total length (TL) but the size limit was then increased to 33 cm (13 in) in 2001. For the recreational fishery, a minimum size limit was first set in 2001 at 30.5 cm (12 in) TL and the bag limit was reduced from 10 fish to 5. Also in 2001, annual catch limits for sheephead based on optimum yield estimates were first set and the commercial fishery met those limits and closed early every year from 2001 to 2004 and also in 2007. To avoid closing the sheephead fisheries in mid-season, seasonal closures were implemented in both the commercial and recreational fisheries, and seasonal fishing restrictions remain today. The statewide total allowable catch for sheephead in 2011 is 93 t, 59 t allocated to the recreational fishery and 34 t allocated to the commercial fishery. The commercial live-fish trap fishery for sheephead is a restricted access fishery requiring permits.

A stock assessment of California sheephead conducted in 2004 estimated the stock was approximately 20% of the unfished level, well below the target level of 50% estimated as sustainable. Unfortunately, most of the biological data used in the stock assessment were collected before the booms in the fisheries that began in the 1980s and 1990s and before the effects of size limits and catch limits set between 1999 and 2001 could be

fully observed. Data used in the stock assessment were also limited because they came from only a few southern California populations.

Recent studies show there is wide spatial variation in the demography and life history of sheephead populations in the Southern California Bight. New research indicates that sheephead in four southern populations (Santa Catalina Island, San Clemente Island, Palos Verdes, and Point Loma) attain smaller maximum sizes (for females and males), reach maturity, and undergo sexual transition at smaller sizes and younger ages than five northern populations (Santa Cruz Island, Santa Rosa Island, Anacapa Island, Santa Barbara Island, and San Nicolas Island). The growth rate of sheephead was also slower in the southern populations than in the northern populations.

As a sex-changing species, sheephead present a unique challenge for fisheries managers. For populations of sheephead in the most southern populations in California, the current minimum size limit of 30.5 cm (12 in) preserves some mature females and males allowing them to spawn at least once before they are recruited to the fishery; however, in the more northern populations, sheephead are still immature at 30.5 cm (12 in) and individuals may not get to spawn before they are recruited to the fishery. A new modeling study for sheephead made estimates of fishery yields under different minimum size limits. Models indicate that a statewide increase in the minimum size limit by at least 5 cm (2 in) would allow more individuals in northern populations to spawn at least once and may increase fishery yield by up to 15%. Models also highlight the potential for increasing fishery yield by dividing the management area into northern and southern management zones with unique size limits.

California Halibut

California halibut (halibut), (*Paralichthys californicus*) is an important flatfish species to the commercial and recreational fisheries in central and southern California. Halibut may be found in relatively shallow nearshore waters on the west coast of North America from Almejas Bay, Baja California Sur to the Quillayute River, Washington, with the species most common south of Bodega Bay, California. Individual fish can grow up to 1.5 m (5 ft) in total length (TL) and weigh as much as 32.7 kg (72 lbs). Halibut are sexually dimorphic with females growing at a faster rate compared to males of the same age. Female halibut will attain a larger size, and may become sexually mature between 5 and 6 years of age. Males do not grow as large as females and mature earlier, at 1 to 3 years of age. Fecundity is considered high with mature females producing up to one million eggs per spawning event. Successful recruitment is dependent upon favorable environmental conditions and availability of suitable nursery habitat.

In regard to the commercial fishery, halibut are harvested using three primary gears: trawl, hook and line, and set gill net. Over the past 30 years, from 1981 to 2011 (fig. 8), total annual landings of halibut peaked at 602.4 t with an ex-vessel value of $3.26 million in 1997, had a low of 176.3 t valued at $1.84 million in 2007, and averaged 438.3 t. Total landings for 2011 were 199.7 t with an ex-vessel value of $2.17 million. In 2011, the three principle gears comprised 99% of halibut landings. Trawl was the dominant gear in 2011, accounting for 49% of the total catch, followed by hook and line gear at 29% and set gill net at 21%.

Bottom trawls have produced more halibut landings than any other commercial gear type; landings have fluctuated from a high of 331.3 t in 1997 to a low of 71.9 t in 1985 (fig. 9). At the peak of the halibut trawl fishery (1997), 112 trawl vessels made at least one halibut landing. For this period, the year of lowest trawl landings (1985), 58 vessels made at least one halibut landing. In 2011, a total of 32 trawl vessels landed 98.8 t of halibut compared to 42 trawl vessels that landed 137.2 t in 2010. The San Francisco port complex received a majority (67%) of the landings in 2011, followed by the Santa Barbara port complex (27%), with Morro Bay accounting for 3% of the trawl catch. Directed trawling for halibut is by Department-issued permit only. Currently there are 43 permitted vessels, but not all actively fish. Vessels with a federal groundfish permit may take up to 68 kg (150 lb) of halibut incidentally per trip while fishing for groundfish.

Gill net landings generally have declined in the past 30 years, from a high of 421.7 t in 1985 to a low of 41.6 t in 2011. A series of depth restrictions, enacted to protect seabird and sea otter populations along the central California coast and prohibiting set net gear in 60 fm or less, greatly impacted the gill net fleet. This is evidenced by the lack of landings made north of Point Arguello since 2002. The gill net fishery now operates only in southern California, with the Santa Barbara port complex receiving 73% of 2011 landings, followed by the port complexes of San Diego (14%) and Los Angeles (13%). A limited-entry general gill net permit is required.

Annual landings reported by the hook and line fleet have fluctuated over the past three decades, ranging from a high of 94.4 t in 2003 to a low of 3.3 t in 1984. In 2011, 271 hook and line vessels landed 58.7 t statewide. The top two port complexes for hook and line landings were San Francisco (52%) and Santa Barbara (15% t). The hook and line fishery is open access; no special permit is required and only a commercial fishing license is needed.

For the halibut commercial fishery, California Fish and Game Code §8392 requires a minimum size of 559

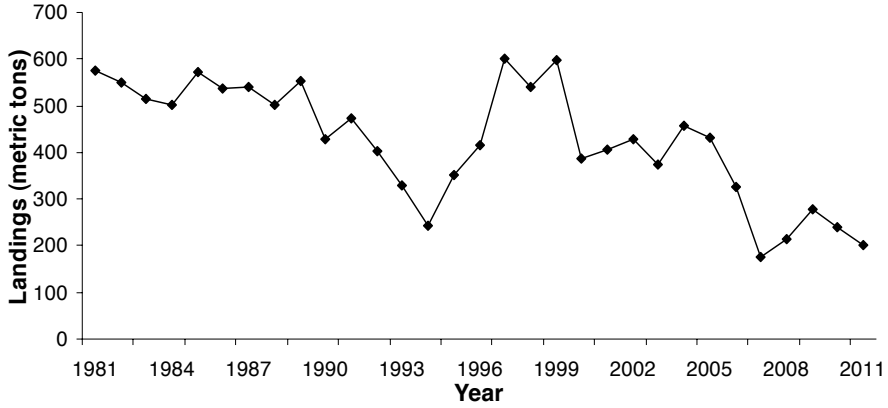

Figure 8. Statewide commercial ladings of California halibut (*Paralichthys californicus*) for 1981–2011.

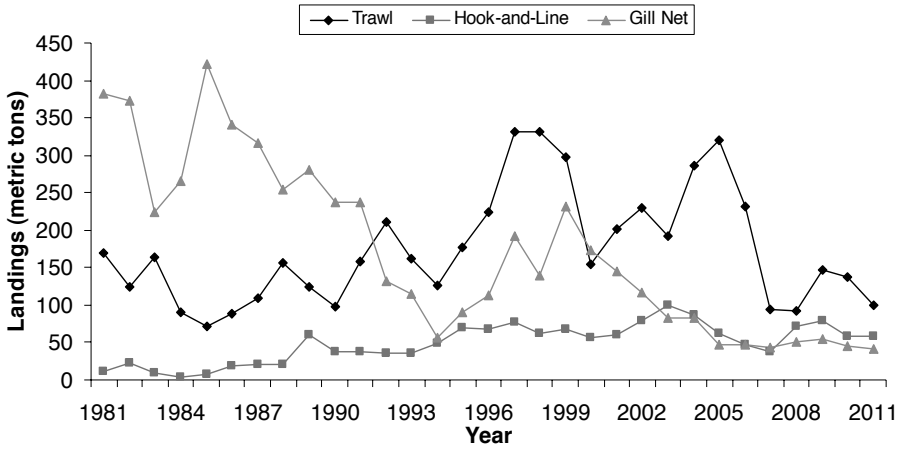

Figure 9. Catch comparison between the three principle commercial gears for California halibut (*Paralichthys californicus*), 1981–2011.

mm (22 in) TL for retention. This simple but effective statute was established in 1979. Various prohibitions on bottom trawling within state waters have been in effect since 1915 with some exceptions, one of these being the California Halibut Trawl Grounds (CHTG). Created in 1971, the CHTG by definition encompass an area one to three nautical miles from shore between Point Arguello (Santa Barbara County) and Point Mugu (Ventura County). The CHTG are closed to trawling from March 15 through June 15 and fishermen are required to use "Light Touch Trawl Gear" (Title 14 CCR §124(b)) with a minimum cod-end mesh size of 191 mm (7.5 in). In 2004, Senate Bill 1459 prohibited trawling in all state waters except those in the CHTG. The most notable closure, enforced since 2007, is the historical trawl area of Monterey Bay.

Recreational anglers target halibut from shore, private and rental skiffs, and party boats (Commercial Passenger Fishing Vessels or CPFVs) using hook and line gear. Some catch also occurs from scuba divers and free divers using spear guns or pole spears. From 1980 to 2004, the method for estimating recreational catch was the Marine Recreational Fisheries Statistical Survey (MRFSS). During this period, the highest estimated annual recreational catch was 1,062 t (337,000 fish) in 1995 and the lowest estimated annual catch was 122 t (40,000 fish) in 1984 (fig. 10). There are no MRFSS data available for 1990 through 1992. The predominant fishing mode for 1980 through 2004 was private/rental skiff, followed by CPFV. In 2004, the California Recreational Fisheries Survey (CRFS) replaced the MRFSS. CRFS and MRFSS data and estimates are not directly comparable because of differences in the estimation methodology. Preliminary data for the 2011 recreational fishery showed an estimated 117 t (25,000 fish) of halibut landed for all fishing modes statewide (fig. 11). CRFS data indicate that private and rental boats continued to be the primary mode within the recreational halibut fishery. Similar to the commercial fishery, a recreational halibut fishing regulation established in 1971 requires a minimum size of 559 mm (22 in) TL for retention. Each recreational angler is limited to five halibut per day south of Point Sur (Monterey County) and three halibut per day north of Point Sur.

In 2011, the Department contracted for the first state-

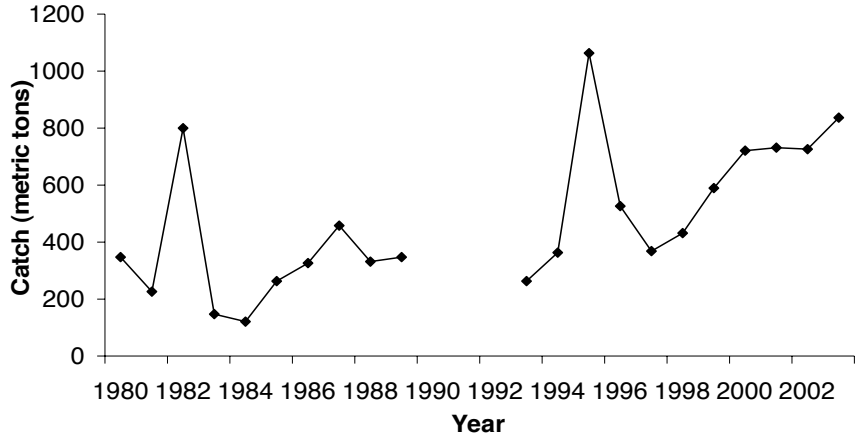

Figure 10. Marine Recreational Fisheries Statistical Survey (MRFSS) estimated recreational catch of California halibut (*Paralichthys californicus*), 1980–2003.

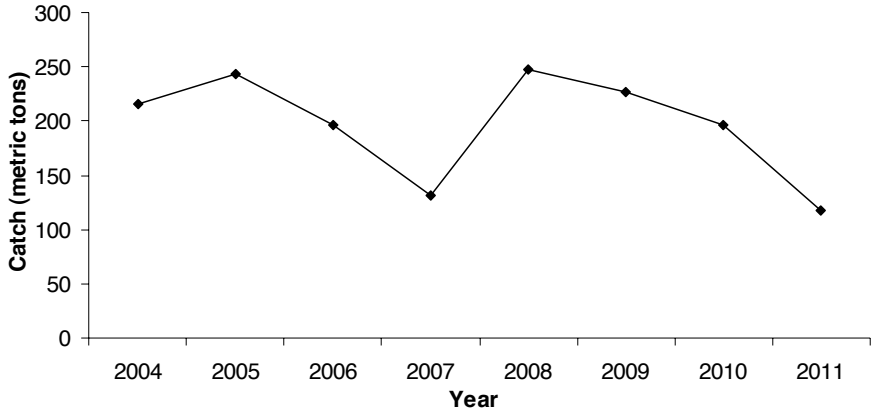

Figure 11. California Recreational Fisheries Survey (CRFS) estimated recreational catch of California halibut (*Paralichthys californicus*), 2004–11.

wide stock assessment of halibut, with separate estimates for areas north and south of Point Conception. The period assessed was 1971–2010. An independent peer-review panel concluded that the results were acceptable for use in management decisions, but required additional sampling to be conducted to improve the next assessment. It was recommended that the Department increase gender-specific sampling of the fished population, continue ageing studies, divide southern California into smaller sampling regions to increase precision in analysis, and examine the possible link between the north and south through larval abundance. After implementing these recommendations, the Department plans to conduct another assessment in 2016. In addition to the peer-review, Department staff conducted an evaluation of the stock assessment using methods to evaluate data-poor fisheries. None of the Department's findings were inconsistent with the results of the stock assessment.

The population status north of Point Conception was considered healthy, with a relatively high biomass associated with several recent recruitment events, especially in the San Francisco area. Favorable environmental conditions appear to be driving recruitment events and fishing was not thought to be a factor in controlling abundance.

South of Point Conception, the halibut population was estimated to be depressed to 14% of historic levels, characterized by a lack of significant recruitment during the past decade, but nevertheless the fishery appears to be sustainable at current levels of harvest. In general, flatfish are highly resilient marine finfish with high fecundity, and can respond relatively quickly to favorable environmental conditions with episodes of good recruitment. Southern California halibut stocks were considered depressed by the start of the evaluation period in 1971 due to sustained exploitation: the assessment found that the southern population was considered exploited since 1916. In response to the assessment, the Fish and Game Commission and the Department agreed that the best current course of action would be to increase monitoring of the fishery (both for catch level and total participation), investigate environmental bottlenecks, fill data gaps through fishery-independent survey work, and to revisit the assessment process in five years. The assessment did not take into account any potential benefits

from a recently implemented series of Marine Protected Areas (MPA), especially those with halibut habitat. The new southern California MPA network, which became effective January 1, 2012, accounts for 14% of soft bottom halibut habitat in this region.

Ageing of halibut otoliths, using thin cross sections, continues at present by Department staff, and individuals greater than 15 years of age are rare in the sampled catch. The majority of halibut aged from fishery sampling have been in the 5- to 8-year old range; this is true for historic samples from the late 1980s as well as those aged from 2007 to 2011. A recent recreational state-record fish, weighing 30.5 kg (67.3 lbs), was aged at 23 years, which is somewhat less than the maximum recorded age of 30 years for this species.

Longnose Skate

The longnose skate (*Raja rhina*) fishery in California is exclusively commercial due to their deep water habitat, and plays a moderate role in the seafood industry. Only recently has longnose skate been tracked and monitored as an individual market category allowing for more in-depth information regarding market behavior and fishery trends.

Longnose skates are easily distinguishable from other skate species, although still occasionally reported on landing receipts as "unspecified skate." As a result of their large size and wingspan, historically it was a common practice for vessel crews to "wing" skates by removing the marketable pectoral fins and discarding the carcass in order to save space onboard rather than storing skates in a whole condition. This practice contributed to the difficulty of identifying and recording landings of skates by correct species. Since 2009, changes in management resulted in better information on longnose skate landings. First, regulatory sorting requirements were implemented requiring longnose skate to be separated. In addition, dockside sampling protocols were expanded to include sampling of all skate species, resulting in increased identification and separation of species. Also in 2009, existing regulatory authority was enforced to disallow the practice of "winging" in order to more accurately record species composition and estimate life history parameters. There was initial concern that landing large whole skates, in addition to mandatory sorting, would impose time and safety constraints on industry and port sampling staff that would prevent compliance and possibly encourage increased discarding at sea. Despite these concerns, landings are being separated; now the majority of receipts record the longnose skate market category rather than the unspecified skate category, and sampling information has been safely obtained from both market categories (fig.12). Accordingly, industry spends some extra time sorting, but overall landings have not been negatively impacted by this requirement. Smaller vessels were moderately impacted because they could not accommodate the onboard space necessary to separate and land longnose skate whole. However, these smaller vessels were rarely encountering skate species, so the overall amount of discard was negligible.

As a result of these changes, it is apparent that longnose skate is the dominant species of skate caught in California (fig. 12), while the other skate species are landed to a much lesser extent (fig. 13). Longnose skate are considered an incidental species within the groundfish fishery in that they have never been individually targeted in California waters. Instead, they are caught in the process of targeting other groundfish species with high market demand and value such as sablefish. Despite being taken incidentally, the commercial fishing industry has utilized longnose skate rather than discarding at sea, often at substantially lower market value than other more lucrative and targeted groundfish species. In 2010 and 2011, the median price for longnose skate was $0.40/lb. In 2010, total ex-vessel value was $48,829, with an average price of $0.07/kg ($0.16/lb). In 2011, 171 t was landed, and total ex-vessel value was $129,556 with an average price of $0.15/kg ($0.34/lb). The increase in ex-vessel value resulted from a combination of increased landings of longnose skate with a corresponding decline in the unspecified skate category, and likely changes in market demand.

From 1990 to 2011, all skates species, which longnose skate likely comprised the majority, were almost exclusively caught with trawl gear (96% average) and minimal amounts were taken with hook and line and gill net gears. When market demand peaked from 1995 to 2001, an average of 75% of skates were landed in the northern California Crescent City and Eureka port complexes. In 2010 and 2011, there was a significant shift away from northern California and a majority of the landings came from Fort Bragg and central California (fig. 14). This was likely due to changes in the trawl fishery and market demand.

Historical landings in the commercial skate fishery in California have been documented by the California Department of Fish and Game (Department) since 1916. Despite historical record keeping, it has been difficult to determine what proportion of these landings were composed of longnose skate because the general "unspecified" skate category was used when recording landings rather than using individual market categories to distinguish between various skate species. In addition to longnose skate, the general "unspecified" skate category has also been composed of big skate (*Raja binoculata*), California skate (*Raja inornata*), shovelnose guitarfish (*Rhinobatos productus*), and thornback skate (*Platyrhinoidis triseriata*). These combined commercial skate landings

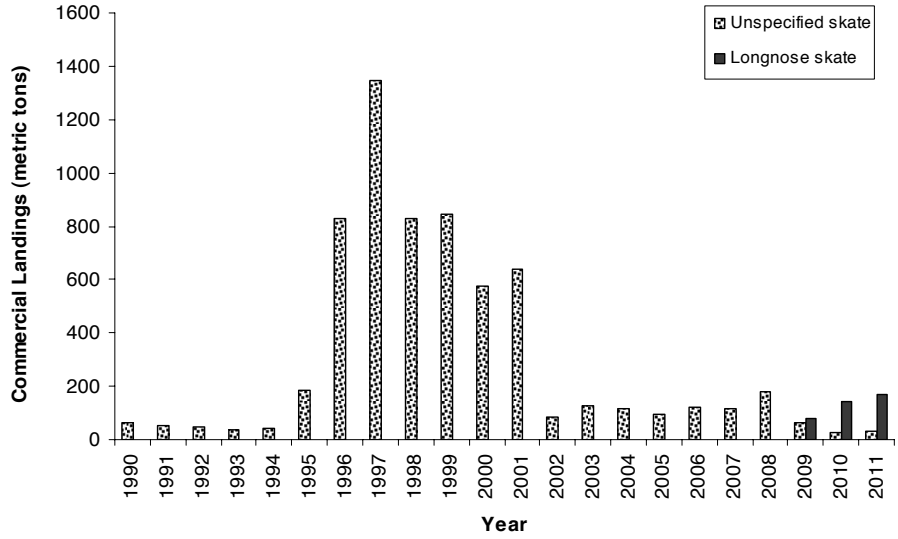

Figure 12. Longnose skate (*Raja rhina*) and unspecified skate commercial landings by species, 1990–2011.

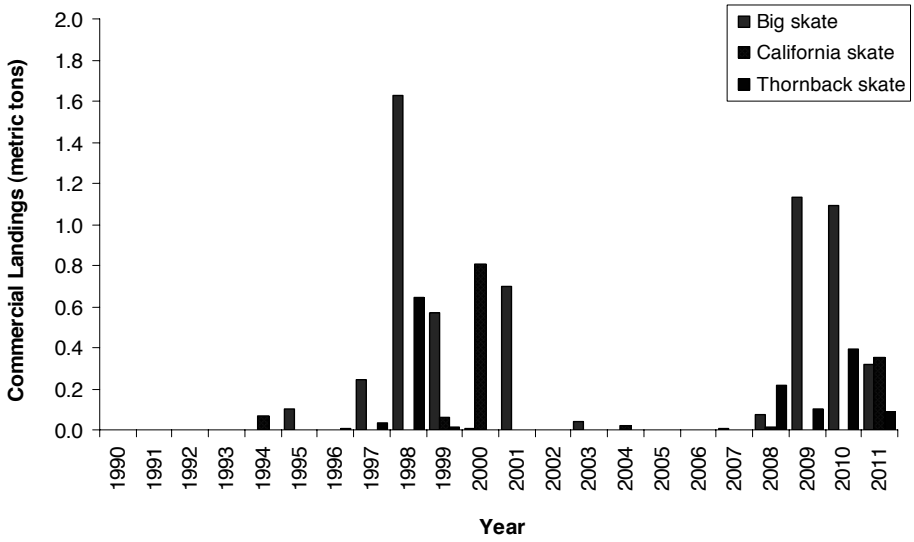

Figure 13. Big skate (*Raja binoculata*), California skate (*Raja inornata*), and thornback skate (*Platyrhinoidis triseriata*) commercial landings, 1990–2011.

varied widely in the past due to a combination of fluctuations in market demand and changes to fishing regulations. From 1916–89, the skate catch ranged from a low of 23 t in 1944 to a high of 286 t in 1981. Throughout the last two decades, landings of all skates peaked in 1997 at 1,315 t and an ex-vessel value of $575,000 (fig.15).

Stock Status and Management. In general, skates are vulnerable to overfishing due to sensitive life-history parameters such as slow growth, late age maturation, low fecundity, and relatively long life spans compared to other fishes. Because the cumulative landings equate to a significant fishery along the entire U.S. West Coast, the first longnose skate stock assessment was conducted in 2008. The results revealed a healthy West Coast stock estimated at 66% of the unfished spawning stock biomass. However, the assessment relied on critical assumptions regarding species composition of California's skate catch to estimate the longnose skate landings, which resulted in uncertainty in the model. Future research was recommended in order to reduce uncertainty in the population model for successive stock assessments. Reducing uncertainty in the model is imperative for the development of effective management measures to maintain a sustainable population in the future.

In 1982, longnose skate, big skate, and California skate were adopted as part of the federal Pacific Coast Groundfish Fishery Management Plan (Groundfish FMP). These skate species were managed in the "Other Fish" complex, which is an aggregate of species that are un-assessed and generally considered underutilized.

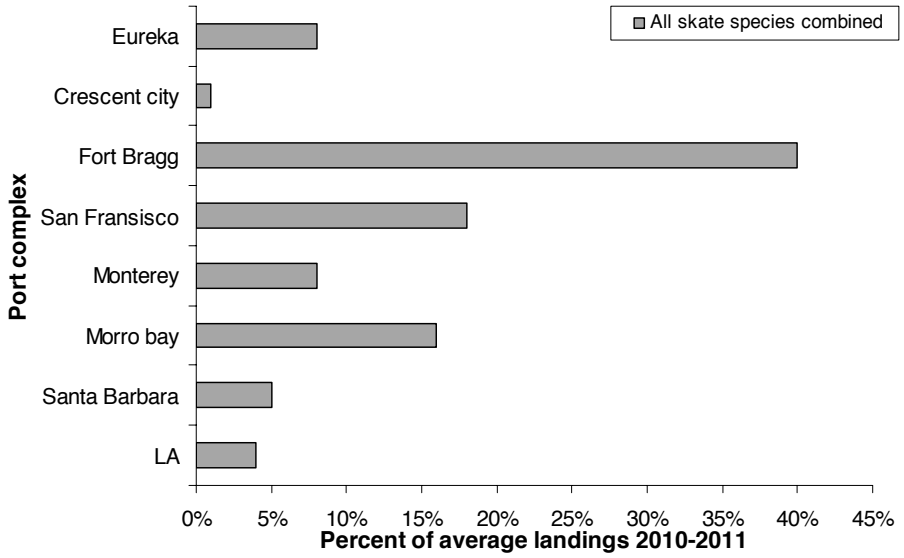

Figure 14. Skate, all species combined, percent of average commercial landings by port complex, 2010–11.

Figure 15. Skate commercial landings and value (all species combined), 1990–2011.

As a result of the healthy stock assessment outcome in 2008, adequate information was provided to set an optimum yield contribution for longnose skate of approximately 1,349 t to the "Other Fish" complex in 2009 and 2010. The Pacific Fishery Management Council (PFMC) decided on the mandatory sorting requirement for longnose skate beginning in 2009. The requirement was intended to provide more species-specific catch data to inform future stock assessments, which minimizes the need to take more precautionary management measures for the sake of protecting sensitive skate species. In addition, with the implementation of the Groundfish FMP's Trawl Rationalization and Individual Fishing Quota Program in 2011, all trawl fishing has 100% observer coverage and greater catch accounting, assuring further catch accuracy for all skates. It will not be necessary to reassess the stock for several years until sufficient new data can be collected to significantly inform the population model, due to the healthy outcome of the initial longnose skate assessment. The preliminary preferred Annual Catch Limit (formerly referred to as the optimum yield) for longnose skate was set at approximately 2,000 t for the 2011 and 2012 regulatory cycle and it was removed from the "Other Fish" complex to be separately managed.

Fish and Game Code Section §5508 requires that longnose skate be landed in whole condition (the fish cannot be dressed or cut). A conversion factor which calculates the weight of the whole fish based on the weight of the wings would be needed to remedy the necessity of landing longnose skate in whole condition.

Petrale Sole

Commercial Fishery. Petrale sole (*Eopsetta jordani*) is a larger flatfish found throughout the state of California and it is among the most valuable commercial flatfish

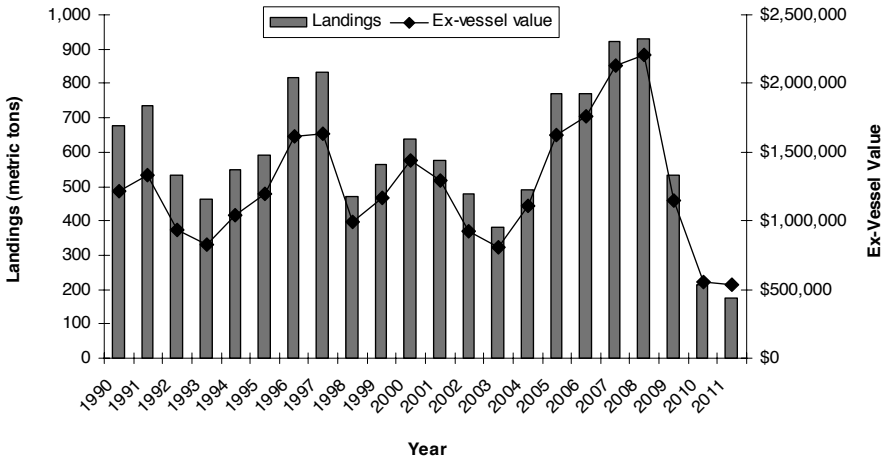

Figure 16. Petrale sole (*Eopsetta jordani*) commercial landings, all gear types combined, 1990–2011.

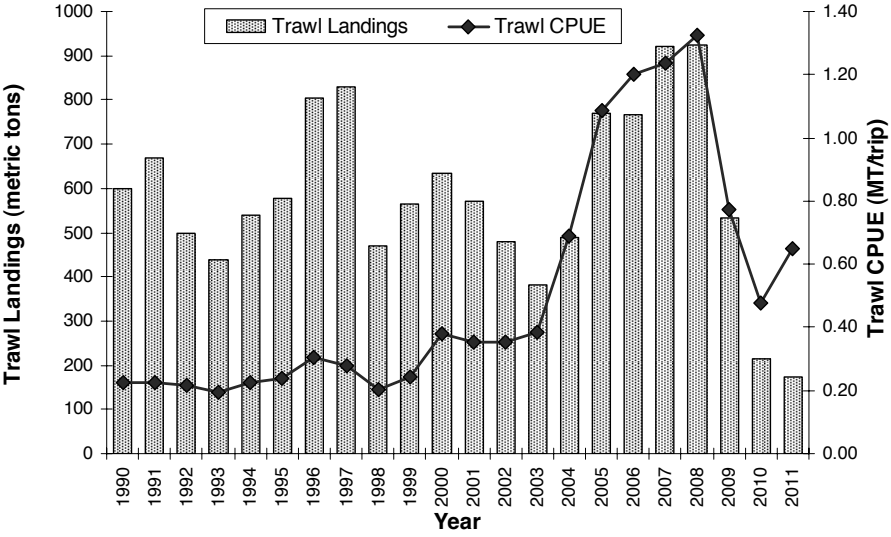

Figure 17. Petrale sole (*Eopsetta jordani*) commercial landings by trawl gear and trawl CPUE, 1990–2011.

species for consumptive use. Because they are caught in deep, offshore waters, the fishery has remained almost entirely commercial.

In 2010 and 2011, significant changes to the fishery occurred due to restricted fishing regulations as a result of stock decline, and landings dropped to the lowest on record since 1931. From 1990–2009, annual landings of petrale sole had an average ex-vessel value of $1.2 million followed by an annual drop in 2010 and 2011 to an ex-vessel value of $557,352 and $534,504, respectively (fig. 16). In 2011, 174 t of petrale sole were landed which is an 18% decrease from 2010 in which 213 t were landed.

Petrale sole is primarily trawl-caught and 98% were taken using trawl gear since 1990. From 1990–2011, a significant shift occurred in the composition of the trawl fleet which affected the catch-per-unit-effort (CPUE). The CPUE, measured by average landings per trip, significantly increased since 2004 (fig. 17) as a result of multiple factors. These factors included: federal government buy back programs reducing the overall fleet size, continued restrictions on the entire groundfish fishery, and higher fuel expenses. The result is a more efficient fleet that has fewer vessels landing the same if not slightly more tonnage than previous years, except for 2010 and 2011 when fishing regulations were severely constrained. Additionally, the implementation of the federal Trawl Individual Quota Program in 2011 will stabilize the catch over the course of the fishing year to further the efficiency of the fleet (see the federal Groundfish Fishery Management Plan for more information).

This fishery is characterized by strong winter and summer seasonality. During winter months, petrale sole aggregate in deep water for spawning and the trawl fleet harvests greater volume with less landings of associated groundfish species (such as chilipepper, *Sebastes goodei*).

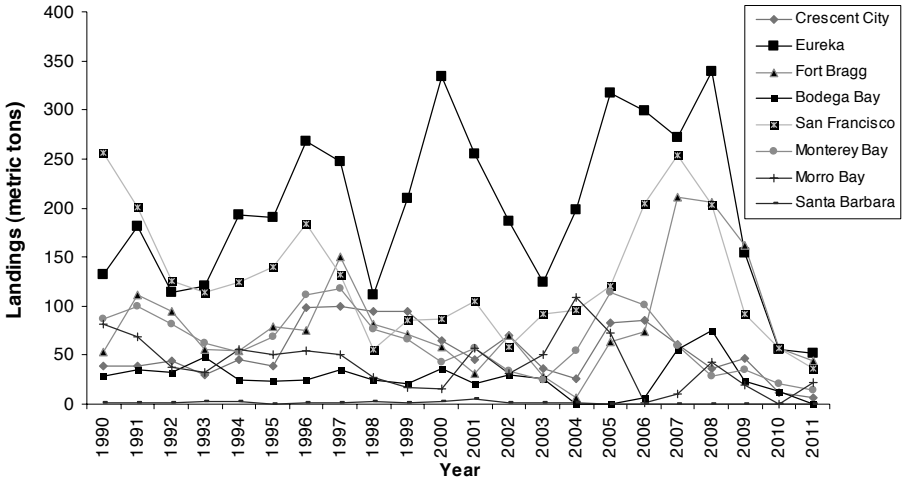

Figure 18. Petrale sole (*Eopsetta jordani*) commercial landings by port complex, all gear types combined, 1990–2011.

Figure 19. Petrale sole (*Eopsetta jordani*) commercial landings, all gear types combined, 1931–2011.

Conversely, during spring and summer petrale sole are found in shallower water—spread out over the continental shelf where they are harvested with a large mixture of various rockfish species. It is commonly caught with sablefish (*Anoplopoma fimbria*), Dover sole (*Microstomus pacificus*), and other flatfishes throughout the year.

During the last decade, the majority of petrale sole were landed in the Eureka port complex, followed by the San Francisco and Fort Bragg port complexes (fig. 18). South of Santa Barbara, petrale sole landings are minimal and do not amount to more than several hundred pounds per year.

Historically, petrale sole landings have been documented in California as far back as the late 1800s, with official documentation beginning in 1916. In early records from 1916–31, petrale sole was recorded as "sole" which was an aggregate category additionally composed of English sole (*Pleuronectes vetulus*), rex sole (*Errex zachirus*), Dover sole (*Microstomus pacificus*) and, to a lesser extent, with rock sole (*Pleuronectes bilineata*), sand sole (*Psettichthys melanostictus*) and other various flatfish species. The average landings of "sole" during this period were 3,629 t per year. It is estimated that petrale sole comprised approximately 20% or 726 t per year of the entire sole landings. Consistent with today's current fishery, trawl gear dominated the entire composition of flatfish landings during this time period and a majority were landed from San Francisco north to the California-Oregon border.

Beginning in 1931, petrale sole was officially recorded under an individual market category so that more accurate accounting of total individual harvest was possible. Despite high landings throughout most of the mid-1900s, which peaked in 1948, since 1980 the fishery landed at or below 907 t per year (fig. 19).

Recreational Fishery. Petrale sole is a very minor

component of overall total removals in the recreational fishery. It is not a targeted species, but it is taken while fishing for other species such as rockfishes and other bottomfish. Recreational encounters are limited due to recreational depth restrictions that restrict anglers to 240 feet (40 fms) or less where petrale sole are more common, and its deeper depth distribution. An evaluation of both Marine Recreational Fisheries Statistical Survey (MRFSS) data (1980–89, 1993–97, 1999–2003) and California Recreational Fisheries Survey (CRFS) data (2004–11) suggests that, since 1980, estimated annual recreational landings of petrale sole averaged 2.6 t.

Population Status and Management Considerations. Because of the economic and biological importance of petrale sole, periodic stock assessments are conducted by National Marine Fisheries Service (NMFS) scientists. In 2009, the Pacific Fishery Management Council (Council) adopted a new full stock assessment for one stock along the Pacific west coast of Washington, Oregon, and California. The outcome indicated the stock was at 11.6% of its unfished biomass and officially declared "overfished" (under the NMFS newly revised reference point for flatfish of 12.5% of unfished biomass). The most recent assessment in 2010 included CPUE data from the winter trawl fisheries and accounted for a strong 2007 recruitment; a more optimistic stock status was the result at 18% of the unfished biomass.

Current management of petrale sole is largely driven by the stock status. As a result of the "overfished" status of the 2009 stock assessment, the Council recommended immediate action to decrease the fishing pressure on petrale sole in the 2010 season by limiting access to winter fishing grounds and reducing trip limits. The effect of reducing trip limits led to a 60% decrease in petrale sole landings and a 51% decrease in ex-vessel value from 2009 to 2010, a trend that continued into 2011 (fig. 16). To offset this lost opportunity, the Council also recommended increased trip limits for other healthy, actively managed groundfish species such as sablefish, longspine and shortspine thornyheads (*Sebastolobus altivelis* and *S. alascanus*), slope rockfishes, and Dover sole, in an attempt to balance some of the petrale sole losses. This restriction on petrale sole continued into 2011 based on the outcome of the results of the 2010 stock assessment. The fishery continues to be constrained to allow the stock to fully rebuild, although the 2010 assessment had an improved outlook. An additional benefit to the fishery was the implementation of the NMFS Individual Fishing Quota program which began in early 2011. As anticipated from this program, establishing trawl allocation limits in combination with 100% observer coverage enabled all groundfish trawl-landed species to stay within established catch limits.

All groundfish stocks declared overfished are held to a standard of 10 years to rebuild and require strict management measures in both state and federal waters, including strict annual catch limits. Because petrale sole grow relatively quickly and reach maturity at a young age, the recommended management changes and a more optimistic stock assessment outcome project petrale sole to be fully rebuilt by 2016—well within the 10 year goal.

California Spiny Lobster

A total of 315 t of California spiny lobster (*Panulirus interruptus*) was commercially landed during the 2010–11 season, continuing a trend of 300 t or more in seasonal landing weight begun in the 2000–01 season (fig. 20). While lower than the previous season (341 t), landings were approximately 10 t higher than the lowest catch total of the last 10 seasons (306 t). The 2010–11 ex-vessel value of the lobster fishery was $11.5 million, up from the previous high of $9 million in 2009–10.

The California spiny lobster is the target of both a commercial and recreational fishery during a season extending from the beginning of October to the middle of March. Essential fishery information is collected using fishermen logbooks and dealer landing receipts for the commercial fishery; and spiny lobster report cards, Commercial Passenger Fishing Vessel (CPFV) logbooks, and California Recreational Fisheries Survey (CRFS) data for the recreational fishery. For the commercial fishery (which is trap only) this includes location and date of catch, number of traps pulled, the number of lobster released, and the number, weight, and price paid per pound of lobster kept. For the recreational fishery, the information recorded includes date and location of catch, type of gear (dive or hoop net), and number of lobster retained. The report cards also provide a measurement of fishermen that did not fish for lobster despite purchasing a lobster report card.

Unlike the recreational fishery, which allows anyone with a fishing license and lobster report card to take lobster, the commercial lobster fishery is managed by a restricted access program. The number of commercial lobster permits issued in 1998 was 274. This number has steadily declined and in 2011 there were 197 permits issued. Since 2008, the number of lobster permittees actively fishing has hovered at 150. In 2005, over two-thirds of the commercial lobster permits became transferable. Permit transfers were limited to 10 per season for the first three years, and now there is no restriction on the number of permits that may be transferred. Given the high cost of these permits ($50,000–$100,000) which are sold in private transactions, it's likely that fishermen with newly acquired permits will fish more traps to recoup the cost of the permit. It's not clear if this will adversely affect the lobster population, since the majority of spawning females are undersized and cannot be

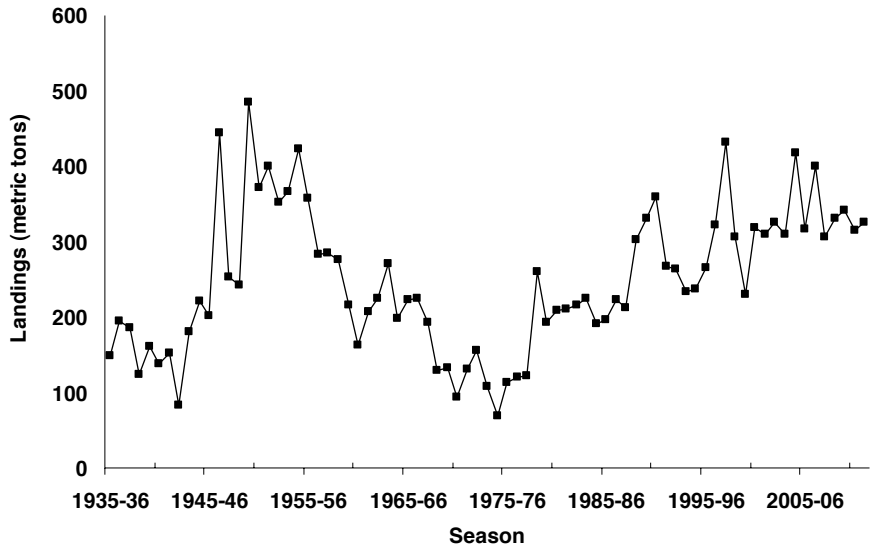

Figure 20. California spiny lobster (*Panulirus interruptus*) commercial landings by season, 1935–36 to 2011–12.

retained. Since 2005, there have been 91 permit transfers, and some of those permits have been transferred more than once.

Currently, there are no limits on the amount of lobster that commercial permittees can land or the number of traps they can use. Traps are generally set along depth contours in the vicinity of kelp beds along the mainland and at all the Channel Islands. Typically, between 100 and 300 traps are set at a time, although operators with larger boats or a crewmember may set more.

Soak times during the 2010–11 season averaged three days, as during 2009–10. The total number of trap pulls in the 2010–11 season is estimated at approximately 973,000 pulls, 120,000 more than in 2009–10, resulting in a catch of approximately 1.95 million lobster, of which 23% were retained. For comparison, in the 2009–10 season, 1.7 million lobster were caught, of which 28% were retained. While more lobster were caught in response to the increased effort in the 2010–11 season, the overwhelming majority of the lobster caught above the 2009–10 seasonal levels were short. Because of this, the number of retained lobster weighed approximately the same as in 2009–10 (315 t).

The median ex-vessel price of lobster for the 2010–11 commercial season was approximately $36.82/kg ($16.70/lb). The ex-vessel price ranged primarily from $35.27/kg ($16.00/lb) to $44.09/kg ($20.00/lb) for the 2010–11 season while the highest price paid in the previous season was $37.48/kg ($17.00/lb). Overall, prices were generally higher in 2010–11 with the ex-vessel value of the lobster fishery estimated at $11.51 million, up from the previous high of $9 million in 2009–10. Landed catch originating around the Point Loma area had the highest ex-vessel value at $2.21 million, representing 19% of the total season value, up from 15% in 2009–10.

Recreational fishermen are allowed to catch lobster by hand when skin diving or scuba diving, or by using baited hoop nets. Up to five hoop nets per person, with a maximum of ten hoop nets per boat, can be used. There is a daily bag and possession limit of seven lobster per fisherman. In both the recreational and commercial fisheries, lobster must have a carapace length of at least 83 mm (3.25 in) to be kept. More lobster are caught with hoop nets than by diving, and since 2005, the more efficient conical-style hoop nets have become progressively more popular than the traditional-style hoop net. During the 2010–11 season, more trips were made with conical-style hoop nets in all counties except San Diego.

Lobster report cards have been used to track recreational catch since the beginning of the 2008–09 season. Required by law to be carried by anyone fishing for lobster, approximately 30,000 cards have been sold each year. Report cards are required to be turned into the Department at the end of the calendar year.

The return rate of lobster report cards fell from 22% of 2008 cards to 11% in 2010, but increased for 2011 to 15%, with report cards still being tallied. For the 2010–11 season, preliminary results indicate that approximately 40% of 18,000 reported fishing trips recorded zero lobster caught (skunked). The number of lobster per trip, including skunked trips, was approximately two, the same catch per unit effort seen each season since the report cards were introduced in the 2008–09 season. Likewise, the total catch reported on each report card returned has remained at nine lobster per card since the 2008–09 season. These numbers estimate the potential extent of the recreational fishing effort. However, there is an additional, unquantified number of lobster taken illegally by poachers. How significant this illegal effort is compared to the reported level of take is unknown.

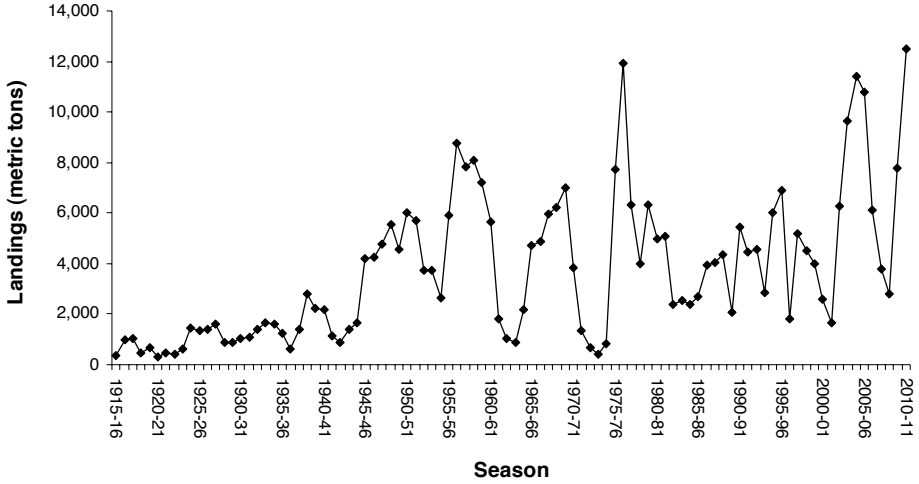

Figure 21. California commercial Dungeness crab (*Metacarcinus magister*) landings, 1915–16 to 2010–11.

Department biologists used the data from the returned recreational report cards to estimate that 25,000 lobster fishermen went fishing in calendar year 2010, and 29,000 went fishing in 2011. An estimated 265,000 lobster were retained in 2010, increasing to 317,000 in 2011. Department creel survey data indicates that a legal-sized (83 mm) lobster weighs on average 0.6 kg (1.3 lbs), allowing a total retained weight of the recreational catch to be estimated. Total retained catch was estimated at 155 t (345,000 lbs) in 2010 and 187 t (413,000 lbs) in 2011, corresponding to 50% and 59% of the commercial catch in 2010 and 2011, respectively. Although these estimates are based on returned report cards, which represent a small fraction of the total number of report cards sold, the size of the recreational fishery is a significant portion of the total lobster harvest in California. The actual percent of the commercial landing represented by the recreational catch is thought to be between 30% and 61%.

Based on results from the Department's lobster stock assessment, which was completed in 2011 and its findings upheld by an independent technical review panel, the current levels of commercial and recreational fishing are considered to be sustainable. The assessment results, which include the size of lobster caught by the combined fisheries, suggest that these fisheries are removing most lobster within a couple of seasons of attaining legal size, and have been doing so for at least a decade and probably longer. One consequence of this is that the spawning stock, upon which the health of the population is dependent, is contained primarily in the sexually mature, sublegal portion of the population. The importance of the relatively few legal-size spawners to the health of the population is currently being explored by the Department. The Department is also interested in determining if the current level of poaching of sublegal lobster is stable. If this level of sublegal poaching is increasing, it could impact the future health of the lobster population.

Dungeness Crab

The fishery for Dungeness crab, *Metacarcinus magister* (formerly *Cancer magister*), spans the west coast of North America from Alaska to Point Conception, California. In California there are two distinct management areas, the northern and central regions, demarcated by the Sonoma/Mendocino county line.

The Dungeness crab fishery has generally been much more productive in the north compared to the central region. However the 2010–11 season was not only a record-breaking season for statewide landings of Dungeness crab, totaling 12,493 t, but landings in the central area totaled 8,666 t and were more than twice the 3,826 t caught in the northern area. Landings in the central management area have not exceeded 3,000 t since the late 1950s and this record season for the area was more than five times the catch of 1,539 t from the previous season. The total landed for the season is over 1.5 times the 10-season moving average of 7,279 t and over 2.5 times the 50-season moving average of 4,671 t (fig. 21).

The average price paid to fishermen was $4.56/kg ($2.07/lb), which was only slightly higher than the 10-season moving average of $4.43/kg ($2.01/lb), but the record landings have resulted in one of the highest total ex-vessel values for the fishery on record, at $56.8 million. Value increased by 66% from the 2009–10 season, which was worth an estimated $34.2 million. Preliminary data from the 2011–12 season continues to show another high year of Dungeness crab landings statewide, 12,133 t (through February 2012), including the central area at 6,178 t. Also, the average price of $6.41/kg ($2.91/lb) paid to fisherman thus far in

2011–12 is almost 1.5 times the price paid the previous season for an ex-vessel value of $75.6 million, surpassing the previous season record. The last decade of Dungeness crab commercial landings has had four of the top five record high seasons of landings (over 9,500 t), contributing to its place as California's second most valuable commercial fishery, behind market squid (*Doryteuthis opalescens*).

The commercial trap fishery is regulated through the state legislature and managed on the basis of size, sex, and seasonal restrictions. Dungeness crab also supports a popular sport fishery that is managed through the Fish and Game Commission primarily by season, size, and bag limit restrictions. Male crabs larger than 159 mm (6.25 in) carapace width (CW) are harvested commercially while up to 10 crabs of either sex and larger than 146 mm (5.75 in) CW can be taken daily by sportfishing, unless taken from a Commercial Passenger Fishing Vessel (CPFV) from Sonoma to Monterey Counties, then the bag limit is reduced to six and the minimum size must be 153 mm (6 in) CW. The sport season begins the first Saturday of November statewide and ends June 30 in the central area and July 30 in the northern area. The commercial season in the central area begins November 15 and ends June 30, while it conditionally begins on December 1 and ends July 15 for the northern area. The timing of the seasons avoids the portion of the lifecycle when most crabs are molting or soft-shelled, and thus vulnerable to predation and handling mortality.

Starting with the 2009–10 season, the California Recreation Fisheries Survey (CRFS) began sampling Dungeness crab sport fishing from shore and private, rental and CPFV vessels. For the 2010–11 recreational season, CRFS estimated that 301,000 Dungeness crabs were caught, or approximately 205 t, based on an estimated weight of 0.68 kg (1.5 lb) per crab. This is less than 2% of the combined recreational and commercial catch for the season.

Mature males annually molt in the summer months and then begin gaining weight in their new shells. The timing of this molt varies, but the December 1 fishery opening along most of the West Coast usually results in adequately filled out crab reaching the popular holiday markets. However, commencing in the 1995–96 season the state legislature authorized an industry-funded preseason crab quality test to ensure crab meat has adequately filled the new hardened shell on the target opening date. The test is conducted in concert with tests in Washington and Oregon. The states then mutually agree, through the Tri-State Crab Committee, on whether to delay the opening of the season in order to let the crabs accumulate more body meat weight. The recent 2011–12 season in the northern management area was the first season to be delayed as late as January 15, the maximum allowed by law. Central California coast crab typically molt earlier than northern crab, and the area is not subject to opening delays by statute. In case of a northern season delay, "fair start" statutes mandate that anyone fishing in the central area must wait 30 days after the delayed northern season opener to fish in those northern waters.

Of the approximately 570 vessels with a 2011 commercial Dungeness Crab Vessel Permit, 435 vessels made at least one landing in the 2010–11 season. About a quarter of these permits are considered "latent," not actively participating in the fishery. Legislation restricted access to commercial Dungeness crab fishing permits beginning in 1995. A limited entry permit system was then enacted by the legislature with the provision that most permits are transferable. However, there is concern among some fishermen that an increase in the use of the latent permits sometime in the future could cause overfishing and worsen the overcrowding on crab fishing grounds.

The Dungeness crab fishery can be characterized as a derby-type fishery where much of the total catch is caught in a relatively short period of time at the beginning of the season. For the 2010–11 season, 86% of the total statewide catch was landed before February, 2.5 months after the season opened in the central management area. There are currently no reliable estimates of effort as there is no limit to the number of traps a vessel may fish or the frequency with which they are fished. According to a 2004 report based on a survey of Dungeness crab vessel permit holders, 171,000 traps were estimated as being fished in California during the 2000–01 season. Concerns over effort, in terms of crab traps deployed in both the central and northern management areas of California, led to multiple unsuccessful legislative attempts by California fishermen to create a trap limit program for their district.

In 2008, Dungeness crab fishermen began working on a cooperative approach to managing their fishery. Their effort resulted in the formation of an advisory group, the Dungeness Crab Task Force (task force) that is facilitated by the Ocean Protection Council under the state's Resources Agency. The task force objective was to make recommendations on management measures such as trap limits, fleet size reduction, and season opening date changes, among others, to the Joint Legislative Committee on Fisheries and Aquaculture and the Department of Fish and Game.

Through the efforts of the task force, new legislation was passed in 2011 that imposes trap limits on Dungeness crab permit holders by the 2013–14 season. Once established, permit holders will be grouped into one of seven tiers, based on their total catch from a prescribed,

TABLE 3
Garibaldi commercial landings and ex-vessel value, 1975–95

Year	Landings (t)	Ex-vessel ($)	Year	Landings (t)	Ex-vessel ($)	Year	Landings (# of fish)	Ex-vessel ($)
1975	0.017	276	1984	0.077	3,398	1993	959	8,157
1976	0.020	0	1985	0.033	1,071	1994	859	8,767
1977	0.000	0	1986	0.071	3,300	1995	99	1,434
1978	0.000	0	1987	0.043	1,988			
1979	0.005	27	1988	0.118	6,864			
1980	0.001	30	1989	0.146	6,797			
1981	0.000	0	1990	0.236	14,144			
1982	0.060	3,714	1991	0.209	13,461			
1983	0.069	4,913	1992	0.018	300			

Data source: CFIS data and compiled landing receipt data for years 1990–95, all gear types combined. Data are not available prior to 1975 and garibaldi (*Hypsypops rubicundus*) landings originating from California ceased in 1996.

consecutive 5-season period. The highest tier is set at a maximum of 500 traps while the lowest tier is set at 175 traps. Permit holders will also be required to purchase a biennial trap permit along with department-issued trap tags for each trap in their tier. If they fail to do so their commercial permit will no longer be valid, potentially removing those "latent" permits from the fishery.

Garibaldi

The garibaldi (*Hypsypops rubicundus*), a member of the damselfish family (Pomacentridae), ranges from Monterey Bay, California to southern Baja California, Mexico. In California, they are rare north of Point Conception, but larvae and juveniles are transported to the north during El Niño events. In the late 1800s, garibaldi was a minor commercial species commonly taken at Santa Catalina Island with set gill nets for Los Angeles fish markets. There has never been any significant sport fishery for garibaldi. In 1995, garibaldi was designated California's state marine fish, and a prohibition on commercial take was implemented on January 1, 1996. Prior to the commercial ban, garibaldi was one of the main targets of the commercial marine aquarium trade.

Adult garibaldi are a brilliant orange color while juveniles are orange with iridescent blue spots. Because of their brilliant colors, both adult and juvenile garibaldi were harvested for the commercial marine aquaria trade, which supplies specimens for live pet, hobby, and display purposes. The take of marine aquaria species occurs statewide primarily in nearshore waters by commercial divers. Methods used to take garibaldi and other finfish for the aquarium trade include traps and hook and line, but primarily consist of dropnets and slurp guns used by divers. Commercial regulations governing the marine aquarium trade were first implemented in 1993, which established a marine aquaria fishing permit and aquaria receivers license, put restrictions on where fish may be taken, and created a list of prohibited species. Before 1993, only a general commercial fishing license was required to land fish destined for the aquarium trade.

According to the California Department of Fish and Game (CDFG) commercial landing receipt data reported by fish businesses, there were little to no landings reported for garibaldi from 1975 to 1981 (table 3). In 1982, 38 landings were made totaling 0.06 t (60.3 kg) and landings increased each year until peaking in 1990 at 0.24 t (236 kg) with 85 reported landings (table 3). The number of reported landings decreased to 10 in 1992 with only 0.02 t (18 kg) landed. The ex-vessel value (not adjusted for inflation) of garibaldi increased from $3,700 in 1982 to a high of $14,100 in 1990, with the price ranging from a high of $71.28/kg ($32.40/lb) in 1983 to a low in 1991 of $16.91/kg ($7.69/lb). The catch during this period mostly originated from the front side of Santa Catalina Island near the Isthmus, and at Palos Verdes and Laguna Beach along the mainland coast (fig. 22a). Before 1993, landing receipts required landings to be reported in pounds; however, most garibaldi (and other organisms in the aquarium trade) were sold by the individual and as a result landing receipts typically only contained estimates for pounds of garibaldi landed. Therefore, while the trends in catch from 1975 to 1992 are likely valid, landings during this period may not reflect true values.

In 1993, a Marine Aquaria Collectors Permit was required for landing species for the aquarium trade and a new landing receipt was created for this fishery requiring landings to be reported as numbers of individuals with price paid per individual. During this first year of new reporting requirements, 20 landings were reported for a total of 959 garibaldi with an average price of $8.50 each and an ex-vessel value of $8,157 (table 3). From 1994 to 1995, landings decreased from 859 to 99 individuals with only 8 and 4 landings reported; however, the price paid per individual increased from $10.20 to $14.50, respectively. After 1992, garibaldi catch shifted from Santa Catalina Island to the front side of San Clemente Island and the Laguna Beach area due to a restriction implemented in 1993 on commercial aquarium trade collecting at Santa Catalina Island (fig. 22b).

During the early 1990s, a commercial aquarium trade

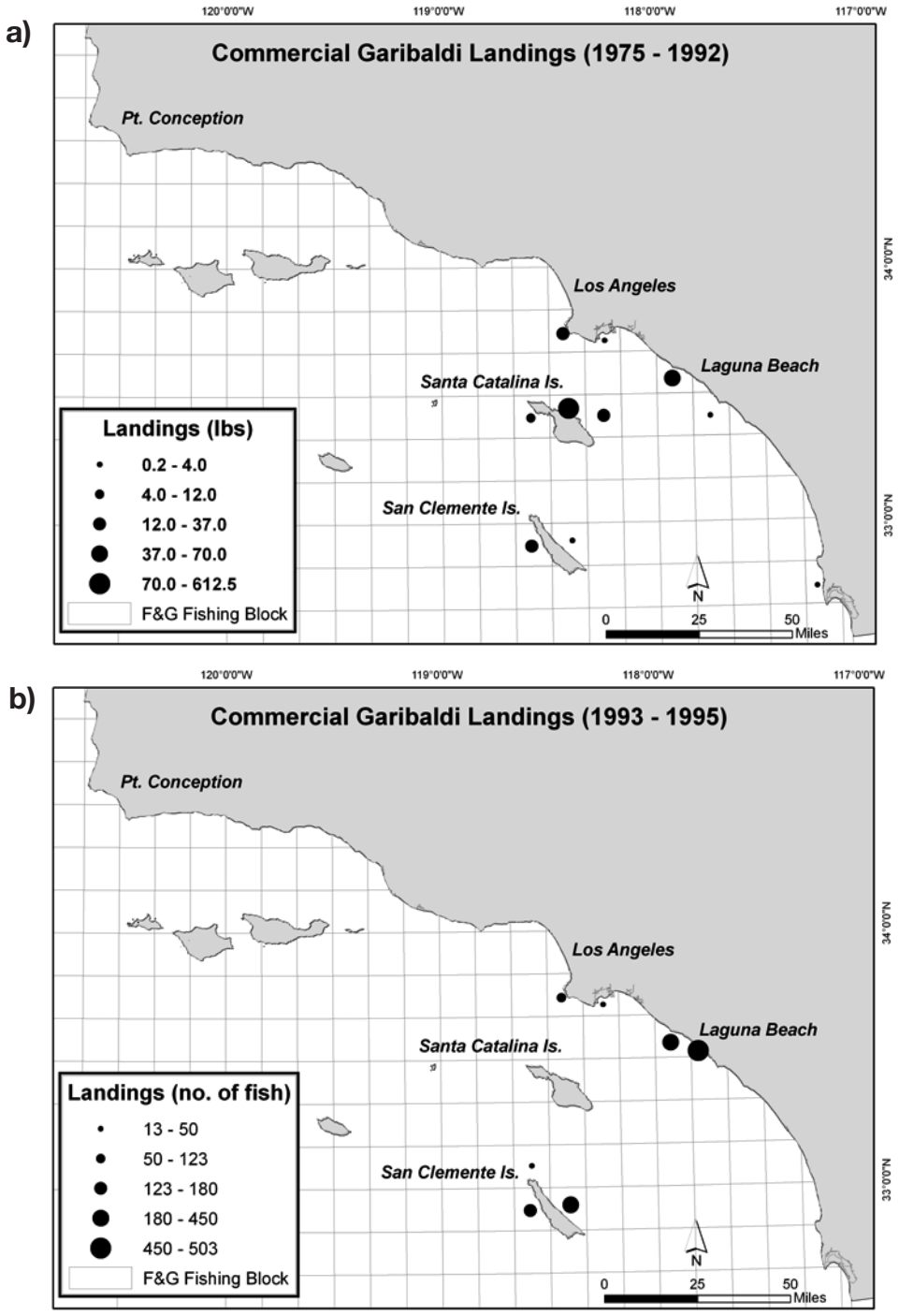

Figure 22. Origin of garibaldi (*Hypsypops rubicundus*) commercial catch: a) pounds landed, and b) numbers of fish landed.

developed for juvenile garibaldi. Although not substantial in terms of weight, because the fish were juveniles, these landings represented a large number of individuals. Because most of this take focused on one area, Santa Catalina Island, there was concern for localized depletion. Likely a result of concerns for garibaldi populations, Assembly Bill 77 (Morrow, 1995) was signed into California State law effective January 1, 1996. This Assembly Bill declared garibaldi the state marine fish and imposed a three year ban on its commercial collection "unless a study, the methodology of which is approved by the Department of Fish and Game, shows a less than significant impact on the population of the resource." Three years later in 1999, the Fish and Game Code was

amended to add garibaldi to the list of no-takes species without exceptions. The prohibition on the commercial take of garibaldi continues today and garibaldi are now imported from Mexico where the commercial fishery continues.

Historically, garibaldi was never an important component of the recreational fishery in southern California and no reliable catch data exists. In *How to Fish the Pacific Coast*, published in 1953, the author states that garibaldi are taken in swirling waters along rocky shores but are very difficult to tempt. The author goes on to say, "This fish is of such beauty in the water it should be left there." According to the California Fish and Game Commission (Commission) meeting notes from January 2, 1953, the CDFG presented recommended sportfishing regulation changes that included a recommendation to "prohibit skin diving fishing along the waterfront of Avalon, Santa Catalina Island" as proposed by the Santa Catalina Island Company. This proposed regulatory change was met with opposition because the public wanted to continue to spearfish near Avalon and the main concern was take of garibaldi. So the proposed regulation was modified to a statewide prohibition on the recreational take of garibaldi. At the January 30, 1953 Commission meeting, the "prohibition against the take or possession of garibaldi, by either angling or diving" was adopted. The prohibition on the recreational take of garibaldi is still in place.

White Shark

Globally, white sharks (*Carcharodon carcharias*) are found throughout most seas and oceans with concentrations in temperate coastal waters. The northeastern Pacific (NEP) population ranges from Oregon south to Baja California, Mexico and the Gulf of California, and as far west as the Hawaiian Islands. The white shark has historically interacted with several California commercial fisheries; most often with the set gill net and other entangling net fisheries. An increased appearance of white shark in commercial fisheries coincided with an increase in the popularity of entangling nets after the introduction of monofilament line in the 1970s (fig. 23). The majority of white shark landings were seen in the Southern California Bight (SCB), most often in the set gill net, trammel net, and entangling net fisheries targeting California halibut, Pacific angel shark, and white sea bass (fig. 24).

The SCB constitutes a major portion of the white shark pupping grounds in California, which is probably why a majority of white shark landings in commercial fisheries are of juveniles and young of the year (YOY). A second possible reason for the predominance of this demographic in the catch data is that larger white sharks would be able to break through monofilament nets and hook and line gear without steel leaders. In the 1980s, as seabird and marine mammal mortalities associated with these nearshore fisheries increased and the target species populations declined, regulations were put in place to restrict these fisheries. This indirectly protected white sharks, especially in the vulnerable pupping grounds of the SCB. In 1994, two significant regulations went into effect that supported a rebuilding of the white shark population in California waters. The first was the Marine Resources Protection Act of 1990, which banned entangling nets in state waters (<3 nautical miles of shore and <1 nautical mile of offshore islands). The second was Title 14, CCR, §28.06 and FGC §8599, which prohibits take of white sharks except under Fish and Game permits for scientific or educational purposes. These prohibitions and an overall decrease in the set and drift gill net fisheries resulted in significant declines in white shark landings in commercial fisheries through the 1990s and 2000s. In 2004, white sharks gained federal and international protection in a treaty approved by the United Nations affiliated Convention on International Trade in Endangered Species (CITES). White shark is not a managed species, but it is listed in the Fishery Management Plan (FMP) for West Coast Fisheries for Highly Migratory Species (Appendix E.1.2—Commercial Fisheries—Species-specific Regulations Including Prohibited Species) as a prohibited species in California. This is a reference to Title 14, CCR, §28.06. Internationally, white shark is listed in CITES as an Appendix II species, which restricts trade of a species that may become threatened with extinction to avoid utilization incompatible with their survival.

The increase in commercial white shark landings since 2005 (fig. 23) may appear to be a step backwards from the successes seen in previous years, but over 80% of these landings are for research being conducted on white sharks in California waters. These are primarily tagging studies and short-term captivity of juvenile white sharks by the Monterey Bay Aquarium White Shark Program. Also, this research has increased awareness of this species, and may have resulted in catch being reported that would have previously been discarded at sea. At the same time there was a significant increase in the ex-vessel value of a species that cannot legally be sold, on landings used for both research and non-research purposes. This is possible and legal in accordance with FGC §8599 subdivision (b) which states that commercial fishermen who take white shark incidentally to commercial fishing operations using set gill nets, drift gill nets, or roundhaul nets, if landed alive, may be sold for scientific or live display purposes. This resulted in a small incidental fishery, where live specimens were selling for $15–$33/lb (fig. 23). The decline in value after 2009 represents a decrease in the project's dependence on com-

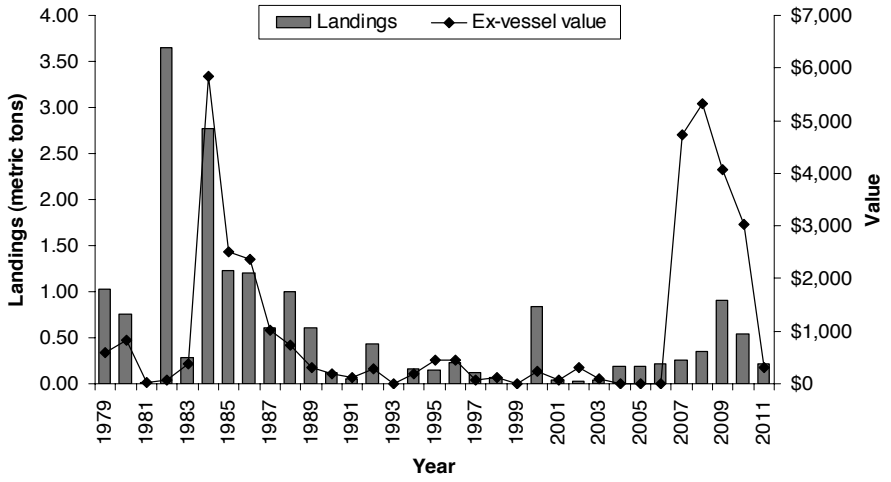

Figure 23. White shark (*Carcharodon carcharias*) commercial landings and value, all gear types, 1979–2008. Data is not available prior to 1979, because previous to 1979 white sharks were not coded separately, but were recorded in a miscellaneous shark category.

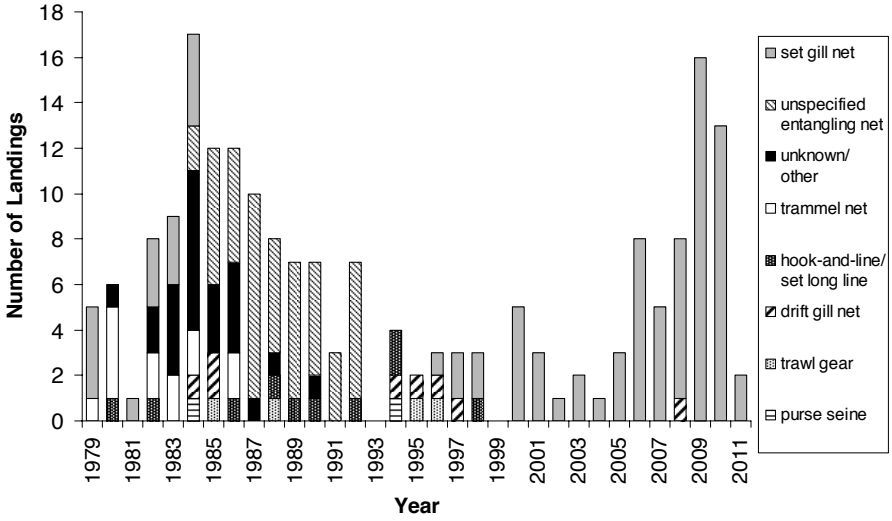

Figure 24. White shark (*Carcharodon carcharias*) commercial landings by gear type, 1979–2008. Data not available prior to 1979.

mercial fishermen as they conducted more of their own trips under a scientific collecting permit.

According to available data from the California Commercial Passenger Fishing Vessels (CPFV) Logbook program and the Marine Recreational Statistical Survey/ California Recreational Fisheries Survey (MRFSS/ CRFS) very few white sharks are caught in recreational fisheries. Since 1980, there have only been seven white shark interactions recorded in CPFV logbook records, and only one record in the RecFIN database (MRFSS and CRFS) since that program's inception in 1980. These records are not a full accounting of recreational activity, but they do show that this species is not commonly in the sport catch.

Adults of this population have been observed aggregating seasonally at two sites along the west coast of North America. One site is a network of hot spots off the coast of central California (CC) west of San Francisco Bay, and the other is off Guadalupe Island, Mexico (GI). Both of these locations support large breeding colonies of northern elephant seals, California sea lions, and other pinniped species, but availability of preferred prey does not account for the density of adult white sharks in the aggregation areas. It is believed the primary reason for these aggregations is mating. No white sharks have been observed mating anywhere in the world, so a lack of direct observation does not invalidate this theory. Several studies using pop-up archival transmitting (PAT) tags and satellite-linked radio transmitting (SLRT) tags to track individual movements and migration patterns have found significant circumstantial and indirect evidence that these two aggregations are where mating

occurs for the NEP population. Adult males from both aggregation sites migrate to a Shared Offshore Foraging Area (SOFA) located midway between North America and the Hawaiian Islands. Adult females migrate offshore in a much more diffuse pattern, and are only found passing through the SOFA while males are absent.

Tagging studies also show that white sharks in the NEP exhibit philopatric behaviors and usually return to the same aggregation site where they were tagged. This provides strong evidence that the NEP population is demographically isolated from populations near Australia/New Zealand and western South Africa, even though these populations show little genetic difference. When returning to the adult aggregation sites (CC and GI) males generally arrive over a few weeks from late July through early August, while most females return in October.

There is limited information available on pregnant female and embryonic specimens, but white sharks are believed to reproduce using aplacental viviparity, with the embryos being nourished by oophagy. It has been speculated that females give birth to live litters of 4–14 pups, but this is based on a very limited number of pregnant females that have been caught and examined worldwide. Unlike males that generally migrate directly between their offshore and aggregation sites, pregnant females will migrate to the nearshore waters of the SCB and Baja California, Mexico to give birth before returning to the adult aggregation sites. Appearance of YOY in scientific collections and as incidental catch to the set gill net fishery suggests that parturition occurs May through October, peaking in July with only a minimal amount occurring after August. Young of the year remain in these shallow, warm-water nursery areas for their first summer and fall, feeding on fish and invertebrates. As water temperatures cool in the fall the YOY migrate south to Baja California, Mexico. By the end of their first year YOY will usually weigh approximately 45 kg (100 lbs). As juveniles, the sharks continue to migrate north and south in nearshore waters from the SCB to the Gulf of California, staying in warmer water until they are large enough to exploit colder water areas. Juveniles prey on a variety of fish, invertebrates, and opportunistically scavenge marine mammal carcasses. In their third year, at approximately 2 m (6.6 ft) TL, juveniles begin to venture north of Point Conception. Subadults range widely from Oregon to the Gulf of California. They will begin to visit aggregation sites and make inshore/offshore migrations, but little is known about how they locate these sites, or when and how they switch behavior patterns and begin their migrations. It has been suggested that this may be a time when mixing occurs between the CC and GI populations. As subadults grow in size and skill, they will also start to actively prey on small marine mammals. Only rough estimates can be given for length at which individuals become sexually mature, as a wide range of maturities have been seen amongst sharks of similar size. Given this variance most males become sexually mature at 3.6–4.6 m (11.8–15.1 ft) TL and females at 4.5–5.0 m (14.8–16.4 ft) TL. Females are usually larger than males and have been documented with certainty to grow to a maximum of 6 m (19.7 ft) TL and males to 5.5 m (18 ft) TL. There are records and reports of larger individuals, but a recent examination of these accounts has shown them to be erroneous or unsubstantiated.

White sharks are challenging to study, have a naturally low abundance, and reproduce slowly. As a result, the population is difficult to measure and is vulnerable to incidental fishing pressure, habitat loss, and other negative pressures. A lack of effective means to measure the population may also result in a population decline that is not recognized until after significant decrease has occurred. This makes current and future research on migration patterns, individual identification for population estimates, recruitment and general life history, crucial to our understanding of the species and our ability to protect the population from anthropogenic and environmental impacts.

Algal Blooms

Marine phytoplankton are microscopic, single-celled plants that live in the ocean and can undergo periods of explosive growth due to favorable environmental conditions. These instances are called algal blooms. Phytoplankton are vitally important to the marine ecosystem and play a crucial role in providing food to the base of the food web. Phytoplankton use energy from the sun and carbon dioxide to produce sugar and oxygen through the process of photosynthesis. Toxins produced by algal blooms can be harmful to humans and biological resources; these harmful blooms are commonly referred to as Harmful Algal Blooms (HABs). Potentially harmful phytoplankton species can produce harmful toxins, produce large blooms that can cause depletion of oxygen levels, or some species can produce large oily mats of foam. These harmful algae species are generally present year-round in the water column in very small amounts, but only become a problem for humans and animals when the phytoplankton populations reach particularly high levels. Algal blooms and HABs, commonly referred to as "red tides," are often visible due to pigments produced by the phytoplankton.

Algal blooms can often be visible, but not always. "Red tides" often occur during algal blooms caused by dinoflagellates that produce a reddish pigment called peridinin, which gives the ocean a reddish hue during an algal bloom. *Phaeocystis*, an algae found throughout the world, is typically the algae that causes "green tides."

Water discoloration is not an accurate way to predict if an algae bloom is toxic or dangerous because HABs can occur in clear water, and there are numerous species of phytoplankton that cause visible algal blooms that are non-harmful.

Exactly what causes any individual phytoplankton bloom to become a HAB event or what the exact cause of a particular algal bloom may be is not fully understood. Known factors that influence algal blooms and are used as predictors for HAB events include nutrient levels, bright sunlight, water temperature and salinity, time of year, number of grazers and/or predators, and calm waters with low wind circulation patterns. The nutrient rich and dynamic upwelling zone along the California coast is particularly prone to blooms and HAB events for this very reason.

Not all algal blooms are HAB events, meaning they do not all cause harmful effects. During a phytoplankton bloom, researchers commonly look for the presence of the organisms through cell counts and DNA sampling, presence of a toxin, and harm or impact on the ecosystem, economy and/or human health. The information researchers gather during a bloom helps in identifying whether or not a particular bloom is a HAB event or has the potential of becoming a HAB event.

Also unknown is what causes a species of phytoplankton to release toxins during a HAB event. The Central and Northern California Ocean Observing System (CeNCOOS) reports multiple hypotheses. One hypothesis is that the phytoplankton are acquiring or detoxifying nutrients in the environment. Another hypothesis is the toxins are produced to protect the algae from grazers, such as krill, sardines, and anchovies. A third hypothesis is that the toxin prevents or minimizes the growth of other algae competing for the same resources.

The most common species of HAB-forming phytoplankton species on the California coast include *Akashiwo sanguinea*, *Alexandrium* spp., *Cochlodinium* spp., *Dinophysis* spp., *Lingulodinium polyedrum*, *Phaeocystis* spp., *Prorocentrum* spp., and *Pseudo-nitzschia* spp. The Southern California Coastal Ocean Observing System (SCCOOS) and CeNCOOS Web sites provide information on these species. Additionally, information and tracking of the current status of common HAB-causing phytoplankton species can be found on their Web sites. Researchers from the University of California, California State University, and private research stations submit regularly collected and real time data to the SCCOOS and CeNCOOS data portals allowing for the use and comparison of data collected in the field. The California Department of Public Health (CDPH) regularly tracks information along the California coast on harmful algae that may affect fish and shellfish for human consumption. The CDPH publishes monthly Marine Biotoxin Monitoring Reports which can be found on their Web site. The toxin levels surveyed by the CDPH are obtained from mussel tissue samples.

2011 Significant HAB Event. During 2011, there were multiple algal bloom events on the California coast with one significant HAB event. The HAB event occurred off the Sonoma Coast in August 2011 and continued into September 2011. Coinciding with a large bloom event located nearshore from Bodega Bay north to Anchor Bay and possibly beyond, a large die-off of marine invertebrates occurred. Invertebrate deaths were observed from many taxa including mollusks, echinoderms, and crustaceans. Marine mammals and fish did not appear to be affected by the event. Water samples were collected and it was found that the dominant phytoplankters were dinoflagellates belonging to the *Gonyaulax spinifera* species complex. It is still unclear whether the HAB caused the marine life deaths, but marine scientists are investigating this potential connection. The vector responsible for potentially transferring toxins produced by phytoplankton to the herbivores that died in this event remains unknown. Waterborne toxins including viruses and bacteria may also be involved, but further investigation is needed. Based on the widespread die-off as well as the unknown source and ocean residence time of the toxin responsible, the Fish and Game Commission voted on Sept. 15, 2011 to close the recreational abalone fishery in Sonoma County for the rest of the year. Research into the event is continuing and results will be released to the public as soon as it is available.

Management Considerations. Harmful algal blooms create numerous management considerations for the health and safety of humans and marine animal populations. Federal and state agencies, along with public-private partnerships, are working to establish predictive models for HAB occurrences and improve response time for affected marine resources.

The CDPH places an annual quarantine on sport harvesting of mussels for food from May 1 through October 31. Mussels are most likely to accumulate toxins during this time of year due to increasing phytoplankton populations and potential HAB events. The mussel quarantine provides protection to humans from Domoic Acid (DA) and Paralytic Shellfish Poisoning (PSP). The quarantine can be expanded beyond or prior to the annual time frame and include additional shellfish should monitoring activities indicate unsafe levels of toxins. Public health warnings are issued by local health officers advising people of the quarantine and warn people that clams and scallops may contain toxins as well. During the quarantine, people should remove the viscera from clams and scallops, the siphons from Washington clams, and eat only the remaining white meat.

The CDPH monitors marine toxins in sport and

commercial seafood year-round. This monitoring program allows CDPH to follow changes in toxin levels and to alert the public and local health agencies, if necessary. If CDPH finds unsafe toxin levels in seafood, they do not allow the affected species to be commercially harvested or sold; at the same time, they will also issue public warnings for sport harvesters of these species. The annual mussel quarantine does not apply to companies licensed by the state as certified shellfish harvesters. Mussels may be harvested and sold for bait at any time.

Marine mammals and seabirds are also affected by the neurotoxin DA each year in California. DA was first identified by the Marine Mammal Center in Sausalito, CA after a large HAB event in 1998. Marine mammals and birds are affected when they eat prey, like sardines and anchovies, that have been feeding during HAB events. The effect of DA on these animals depends on the amount they eat and the amount of toxin accumulated in the prey. Symptoms include severe cases of seizures and other central nervous system problems, as well as hippocampal degeneration and amnesiac shellfish poisoning. Diagnoses are difficult to establish definitively due to unknown toxicity levels of algal blooms and the unpredictable timing of DA outbreaks. The Marine Mammal Center has been studying the effects of DA on California sea lions, including the effects on memory and learning, to hopefully better understand how DA affects the human population.

In 2007, deaths of southern California sea otters were linked to a new type of HAB. "Superblooms" of cyanobacteria, normally a freshwater species, that produce potent and environmentally persistent biotoxins (microcystins) were linked to the deaths of 21 sea otters. The sea otters were found near the mouths of rivers where freshwater was released to the ocean. Additionally, bioaccumulation of the toxins was found in nearby clams, mussels, and oysters. A recent paper by Miller et al. 2010 suggests that this discovery points to the possibility that humans could be at risk from harvesting shellfish near the freshwater marine interface when high levels of cyanobacteria are present in the freshwater source.

The key to management of HABs is through a statewide and regional HAB monitoring network and forecast system. A February 2009 Working Draft White Paper "Harmful Algal Blooms in the West Coast Region: History, Trends, and Impacts in California, Oregon, and Washington" (Lewitus et al. 2009) strongly recommends the need for a regional network. A regional HAB monitoring network will improve the timeliness of HAB warnings by interstate dissemination of current HAB data, improve the efficiency and decrease the cost of HAB monitoring, improve the development and validation of forecast models, improve the accuracy of data for resource managers, improve public education, and improve the predictive models on factors promoting HABs. A California Current regional network is in the planning stages and will most likely include the efforts of the individual states (California, Oregon, and Washington), as well as monitoring efforts by SCCOOS, CeNCOOS, and the Northwest Association of Networked Ocean Observing Systems (NANOOS).

The greatest strides for creating a HAB monitoring network have been made at the state level. The California Harmful Algal Bloom Monitoring and Alert Program (HABMAP) is an effort initiated by National Oceanographic and Atmospheric Administration (NOAA), California Ocean Science Trust (CA OST), and the Southern California Coastal Water Research Project (SCCWRP) to develop a statewide Harmful Algal Bloom (HAB) alert network system for researchers and end user committees. This network is the culmination of multiple expert level workshops exploring the need for increased HAB monitoring. NOAA awarded $4 million in November 2011 for a five-year project to the SCCOOS and CeNCOOS systems to collaborate on the creation of the HABMAP monitoring network. The network will collect real time data from multiple federal, state, and private research stations. The HABMAP monitoring network and accumulated data will allow for a better understanding of HABs on the California coast. This understanding will ultimately lead to improved management strategies for California's resources. "This new effort will help us address a critical gap in past research, namely understanding the conditions leading to toxic blooms before they become a problem," said Raphael M. Kudela, professor at the University of California, Santa Cruz and project lead. "We are particularly excited because the project combines expertise from research and state public health managers in California with the developing national observing network established by NOAA." (NOAA 2011).

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