REVIEW OF SELECTED CALIFORNIA FISHERIES FOR 2014: COASTAL PELAGIC FINFISH, MARKET SQUID, GROUNDFISH, PACIFIC HERRING, DUNGENESS CRAB, OCEAN SALMON, TRUE SMELTS, HAGFISH, AND DEEP WATER ROV SURVEYS OF MPAs AND SURROUNDING NEARSHORE HABITAT

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SUMMARY

In 2014, commercial fisheries landed an estimated 161,823 metric tons (t) of fish and invertebrates from California ocean waters (fig. 1). This represents a decrease of almost 2% from the 165,072 t landed in 2013, a less than 1% decrease from the 162,290 t landed in 2012, and a 36% decline from the peak landings of 252,568 t observed in 2000. The preliminary ex-vessel economic value of commercial landings in 2014 was $233.6 million, decreasing from the $254.7 million generated in 2013 (8%), and the $236 million in 2012 (1%), but an increase from the $198 million in 2011 (18%).

Coastal pelagic species (CPS) once again made up four of the top five volume fisheries in 2014; red sea urchin (5,364 t) and Pacific pink shrimp (3,845 t) were ranked sixth and seventh respectively. California market squid continued to be the largest volume fishery, and it reemerged as the highest valued in the state with over 102,516 t landed and an ex-vessel value of approximately $71.8 million; a decrease of nearly 2% and 3%, respectively from 2013. For the fifth season in a row, market squid landings were projected to reach the seasonal catch limit of 107,048 t. However, by November 18, 2014, 97.2% of the catch limit had been landed, so the seine sector of the squid fleet made a voluntary decision to stop fishing so that the remaining portion of the catch limit could be set aside for the brail sector. The 2014/15 season also represents the first time in recent history that directed fishing for market squid has resulted in landings to the port of Eureka. Northern anchovy emerged as California's second largest volume fishery with 10,511 t landed worth greater than $1.6 million in ex-vessel revenue, which continues the dramatic increasing trend from 6,005 t in 2013 (>$1.0 million) and 3,485 t in 2012 ($872,820). For the first time since 1982, the northern anchovy fishery ranked as the largest by volume among the four federally managed CPS finfish (Pacific sardine, Pacific mackerel, jack mackerel, and northern anchovy), comprising nearly 42.9% of the total volume and 32.4% of the total value. Nearly all (98.7%; 10,378.8 t) of California's 2014 northern anchovy catch was landed in the Monterey port area. The Pacific sardine fishery has long been one of the largest in the state, and in 2014 it held its position as the fourth largest in volume, and was the twelfth largest in value, landing 7,768.0 t and generating an ex-vessel revenue of $2 million. Nearly all of California's 2014 sardine catch was landed in the Monterey port area (80.2%, 6,233.0 t). The recommended harvest guideline for 2014/15 season was 28,646 t based on a biomass estimate of 369,506 t (a 44% decrease from the 2013 biomass estimate of 659,539 t). A decrease in the biomass and harvest guideline in 2014 largely contributed to the general decrease in US commercial landings of Pacific sardine. Pacific mackerel was California's fifth largest volume fishery with 5,420 t landed generating over $1.2 million in ex-vessel revenue. Monterey area ports landed 243.4 t while landing nearly no Pacific mackerel in 2013. Landings of jack mackerel in California remained relatively low, with 784 t landed in 2014 (a decrease from 892 t in 2013); however, this still represents an increase over 2012 landings of 145 t. Landings of jack mackerel in Oregon and Washington increased with 800.4 t (549.7% increase from 2013) and 242.7 t (204.9% increase from 2013), respectively.

Dungeness crab ranked as California's third largest volume fishery in 2014 with 8,244 t landed, a decrease from the 14,066 t landed in 2013. The fishery dropped to the second highest valued fishery in the state with an ex-vessel value of over $65.8 million, decreasing from $88.7 million in 2013. Typically, the northern area contributes the majority of total crab landed statewide, however, for the 2013/14 season 61% of landings were reported from central area ports, between Bodega Bay and Morro Bay. The recent 2013/14 season is the first to implement the Dungeness crab trap limit program, the primary goal of which is to cap the overall amount of traps that are fished in California. Vessels in the fleet are now subject to fish up to a maximum trap number dependent on their placement in one of seven trap allotment tiers.

More than 90 species of bottom-dwelling marine finfish are included in the federally managed groundfish fishery. These groundfish species are grouped into 39 federal management units, consisting of species or

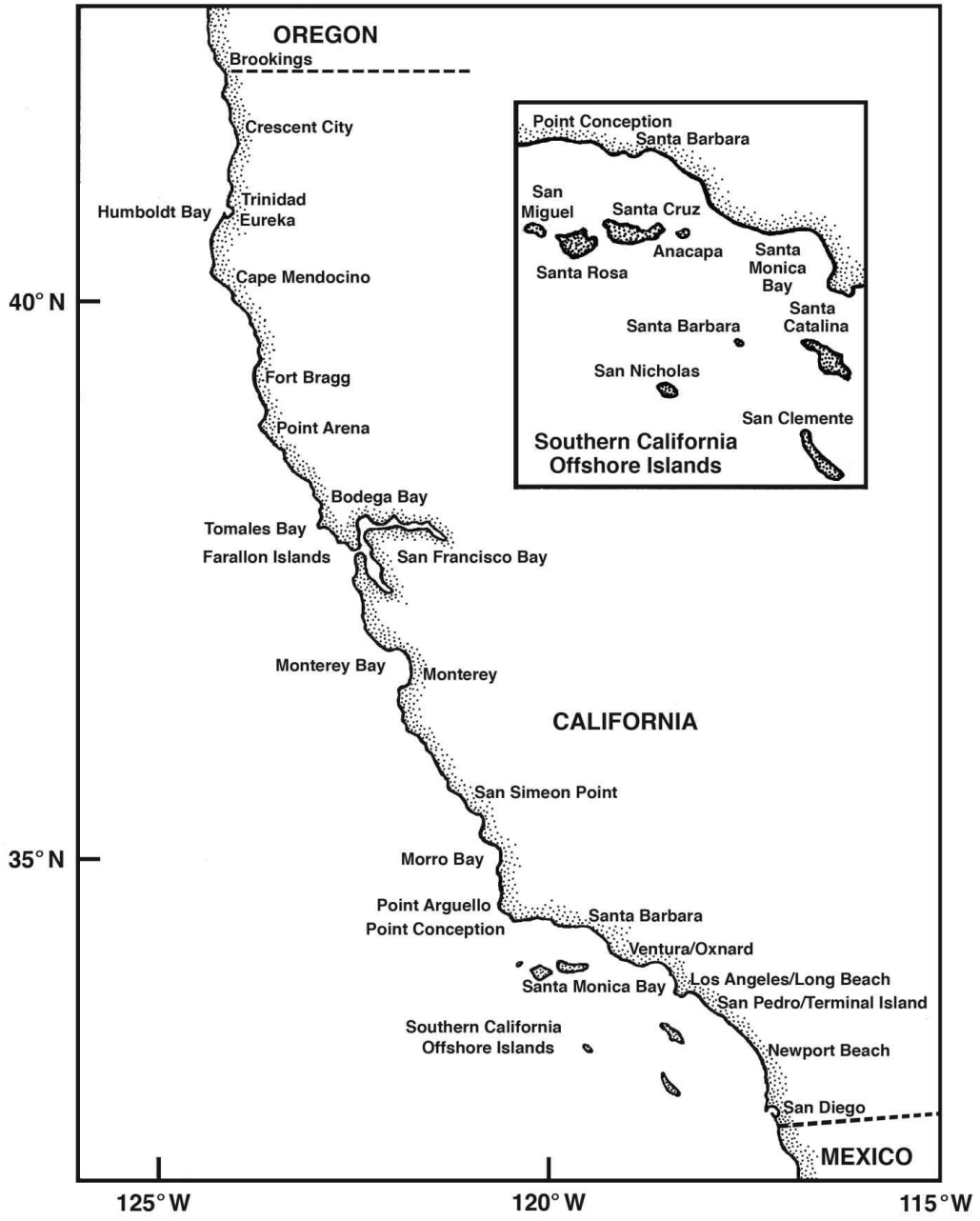

Figure 1. California ports and fishing areas.

species groups, to help facilitate management measures that balance biological and economical goals. In 2014, California's commercial groundfish landings totaled 6,603 t, worth an estimated ex-vessel value of $19.5 million. This represents a 2.4% increase in landings from 6,443 t in 2013 and an increase in ex-vessel value of 12% from $17.3 million. The majority (71%) of groundfish was landed between the California/Oregon border and the Monterey Bay area and generated 52% of the total ex-vessel value of the fishery. An estimated 2,220 t of groundfish were taken by the recreational fishery in 2014, which represents a 10% increase compared to 2013 (2,014 t). California anglers targeting groundfish participated in an estimated 950,801 trips in 2014, a small increase (<3%) from 2013 (925,682 trips). To date, full stock assessments have been completed for half of the nearshore species, including blue, black, brown, China, copper, and gopher rockfish, as well as California scorpionfish and cabezon. The remaining species have been assessed with less intensive data methods. Many stocks are considered to be healthy while others are in the precautionary zone; none are considered overfished.

Fishing effort for Pacific herring in 2014 continued at reduced levels when compared to historic landings

for California. During the 2014 sac roe season (January 2014–March 2014), the San Francisco Bay fleet landed 2,901.2 t, an increase over the 2013 landings (2,115.6 t) and 93% of the 3,122.5 t quota. The San Francisco Bay herring-eggs-on-kelp (HEOK) fishery landed 0 t during the 2014 season, however the fishery was active during the 2013 season, landing 35.7 t of HEOK product. During the 2014 season, the Department conducted spawn deposition surveys in San Francisco Bay to estimate the spawning biomass of the herring stock. The spawning biomass estimate for San Francisco Bay was 54,999 t, a 23.8% decrease from the previous season's estimate of 72,130 t. However, 2014 was the fifth consecutive year of increased biomass since the historic low in the 2009/10 season of 4,394 t and was above the long-term average biomass for San Francisco Bay (1979–2014) of 47,445.8 t.

The 2014 commercial ocean salmon fishing season was more constrained compared to 2013, primarily due to lower ocean abundance projections and restrictions to protect ESA-listed California Coastal Chinook. The commercial ocean salmon fishery was open for 342 days in all four ocean management areas combined during 2014. Nearly 166,500 Chinook (1,011 t) were landed in approximately 14,200 days fished. The average nominal ex-vessel price was $12.19/kg ($5.54/lb), with an ex-vessel value of $12.3 million, the fourth largest in the state. Recreational ocean salmon fisheries were open for 743 days across four management areas in 2014, a slight increase in opportunity compared to the previous season primarily due to an increase in the allowable ocean impact rate on ESA-listed Sacramento River winter Chinook (SRWC). Nearly 74,700 recreationally caught Chinook were landed in approximately 120,300 angler days. Protections in addition to NMFS guidance for ESA-listed endangered SRWC were deemed prudent when developing the 2015 ocean salmon fishing seasons. As a result of the drought's continuing detrimental effects on SRWC and based on the best available data, the Pacific Fishery Management Council, adopted more stringent recreational and commercial management measures to provide additional protection to SRWC.

The family Osmeridae is comprised of approximately 11 genera and 30 species. These "true smelts" are small, soft-rayed, schooling fishes with an adipose fin and are found in marine, estuarine, and freshwater habitats in the Northern Hemisphere. They range from Pt. Arguello, California, to the Gulf of Alaska. Historically, most of California's Osmerids contributed to sport, commercial, and tribal fisheries; however, only surf and night smelt support these fisheries today. Most commercial and recreational Osmerid fishermen use cast nets (Hawaiian throw nets) and/or A-frame dip nets. In 2014, night smelt landings totaled 138.5 t with an ex-vessel value of $169,000; surf smelt landings totaled 102.2 t with an ex-vessel value of $157,000. Over 97% of the 2014 statewide commercial Osmerid harvest was landed in Eureka with the remainder landed in the ports of Crescent City, San Francisco, and Half Moon Bay.

Prior to 1988 hagfish landings in California were nonexistent. However, hagfish imports were in great demand by South Korea due to a localized depletion of two related species, brown hagfish (*Paramyxine atami*) and inshore hagfish (*Eptatretus burgeri*). In 1988, a Korean hagfish importer recruited San Francisco and Monterey fishermen to target hagfish for export to South Korea. Statewide landings and fishing effort expanded in 1989 leading to 1,199 t of landed hagfish. Landed in fresh-dead condition, hagfish were then frozen, and shipped for use in the Korean leather goods market. In 2005, hagfish were exported in live condition for human food at a greater ex-vessel price. Fishing effort and catch began to increase with 54 t landed, and again in 2006 with 77 t landed. In 2014, five port complexes and 33 vessels contributed to a landings total of 675 t at an ex-vessel value of $1.17 million. The top three port complexes were Eureka, Morro Bay, and Bodega Bay.

In December 2012, California implemented the largest scientifically designed network of Marine Protected Areas (MPAs) in the United States, following an MPA design and siting process led by the California Department of Fish and Wildlife (Department). Even before the Marine Life Protection Act and the implementation of California's redesigned MPA network, the Department has been at the forefront of efforts to use ROVs for subtidal ecosystem monitoring. In 1999, Department scientists began developing techniques for using ROVs for MPA monitoring and in 2001 completed the first extensive baseline survey of an MPA in California using an ROV at Punta Gorda Ecological Reserve on the remote rugged coast near Cape Mendocino. Since then, the Department has successfully completed substantial surveys in all four of California's MPA regions. Data gathered from these surveys, on the abundance and distribution of fish and invertebrates, have provided much needed characterization of the baseline ecological condition of California's vast deep water habitats.

Coastal Pelagic Finfish

Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), and northern anchovy (*Engraulis mordax*) form a finfish complex known as coastal pelagic species (CPS). These species are jointly managed by the Pacific Fishery Management Council (Council) and the National Marine Fisheries Service (NMFS) under the Coastal Pelagic Species Fisheries Management Plan (CPS FMP). In 2014, total commercial landings for these spe-

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	0		1,566	121,556	154,874
2012	23,037	2,488	3,485	145	0		1,482	97,078	127,715
2013	7,074	6,005	8,066	892	1	0	2,086	104,404	128,528
2014	7,768	10,511	5,420	784	6		2,942	102,516	129,946

Data Source: Commercial Fishery Information System (CFIS)

cies equaled 24,483 t (table 1, fig. 2), with a combined ex-vessel revenue of over $4.9 million. When compared to landings in 2013, this represents an 11.1% and 15.3% increase in volume and value, respectively. For the first time since 1982, the northern anchovy fishery ranked as the largest by volume among these four species in 2014, comprising 42.9% of the total volume and 32.4% of the total value.

Pacific Sardine. The Pacific sardine fishery is composed of three subpopulations; northern, southern, and Gulf of California. While the fishery ranges from Baja California, Mexico, north to British Columbia, Canada, the majority of landings have occurred in southern California and northern Baja California since the 1980s. Landings of sardine have steadily increased in the Pacific Northwest and Canada since the recent expansion of the sardine fishery in 1999; however, there were no landings in Canada in 2014. Combined landings of Pacific sardine for California, Oregon, and Washington totaled 23,271.8 t, a 63.6% decrease from the 63,891.3 t landed in 2013 (fig. 3).

The US Pacific sardine harvest guideline (HG) for each calendar year is determined from the previous year's stock biomass estimate of the northern subpopulation (of ≥1-year-old fish on 1 July) in US and Mexican waters. The recommended HG for 2014/15 season was 28,646 t based on a biomass estimate of 369,506 t (a 44% decrease from the 2013 biomass estimate of 659,539 t). The Pacific sardine HG was apportioned coast-wide through the year with a 40% allocation of the annual HG from 1 July through 14 September, 25% (plus any portion not harvested) allocated from 15 September through 31 December, and the last 35% (plus any portion not harvested from the first two allocations) released on 1 January. Landings above the HG would be constrained by an incidental catch rate of 45% by weight when landed with other CPS with an additional 500 tons per allocation set aside for incidental catch.

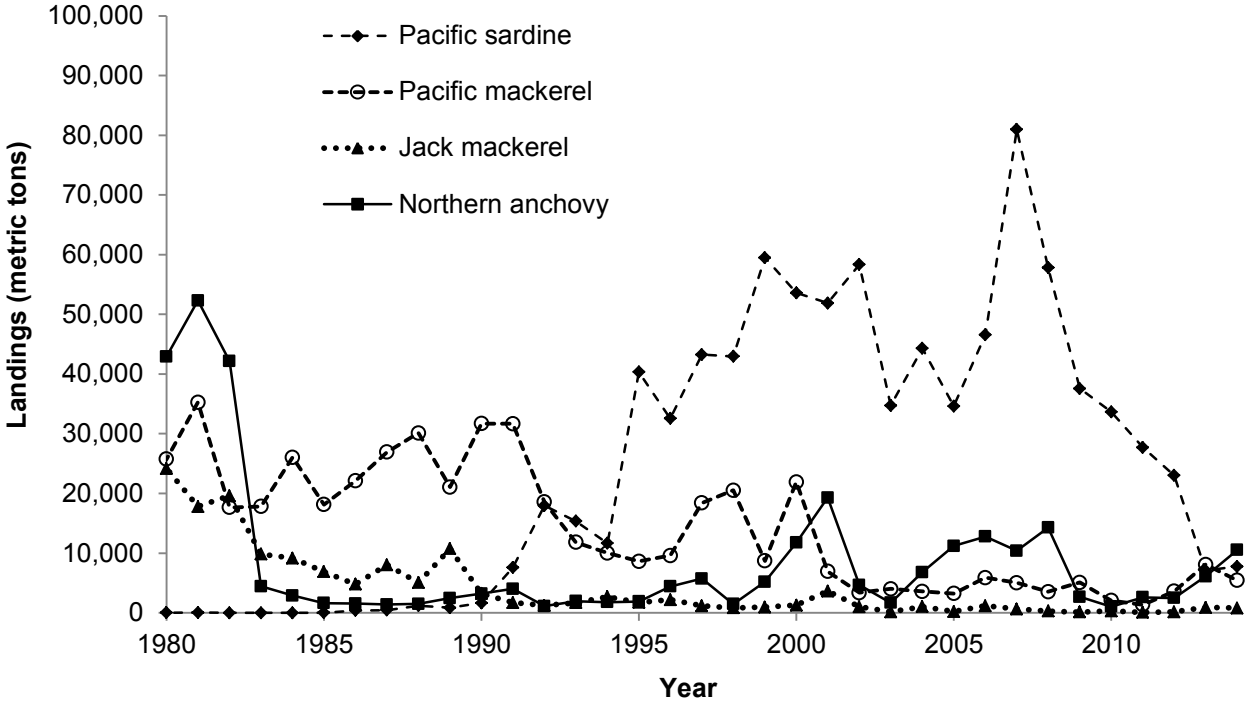

Figure 2. California commercial landings of Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), and northern anchovy (*Engraulis mordax*), 1980–2014.

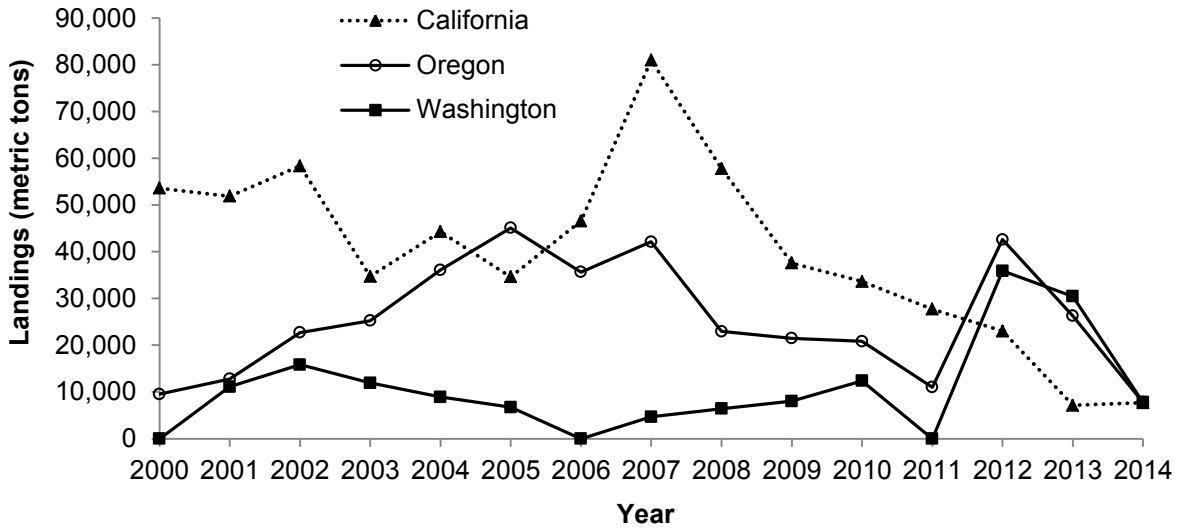

Figure 3. Commercial landings of Pacific sardine (*Sardinops sagax*) in California, Oregon, and Washington, 2000-2014.

In November 2013, the start date of the 12 month Pacific sardine fishery was changed from 1 January to 1 July; this changed the fishing season from one based on a calendar year (1 January–31 December) management cycle to a fishing season (1 July–30 June) cycle. This change better aligned the timing of the research and science required for annual stock assessments with the annual management schedule. A one-time interim harvest period from 1 January 2014 through 30 June 2014 was established with an allocation of 5,446 t to allow targeted fishing to continue during the transition to the new management cycle.

In 2014, the US West Coast fisheries harvested a large portion (81.2%) of the HG. The 2014 interim period (1 January–30 June) lasted almost the entire allocation period, 175 days. The first allocation period for the 2014/15 season (1 July–14 September) lasted 23 days. The second period (15 September–31 December) lasted only 5 days. A decrease in the biomass and harvest guideline in 2014 largely contributed to the

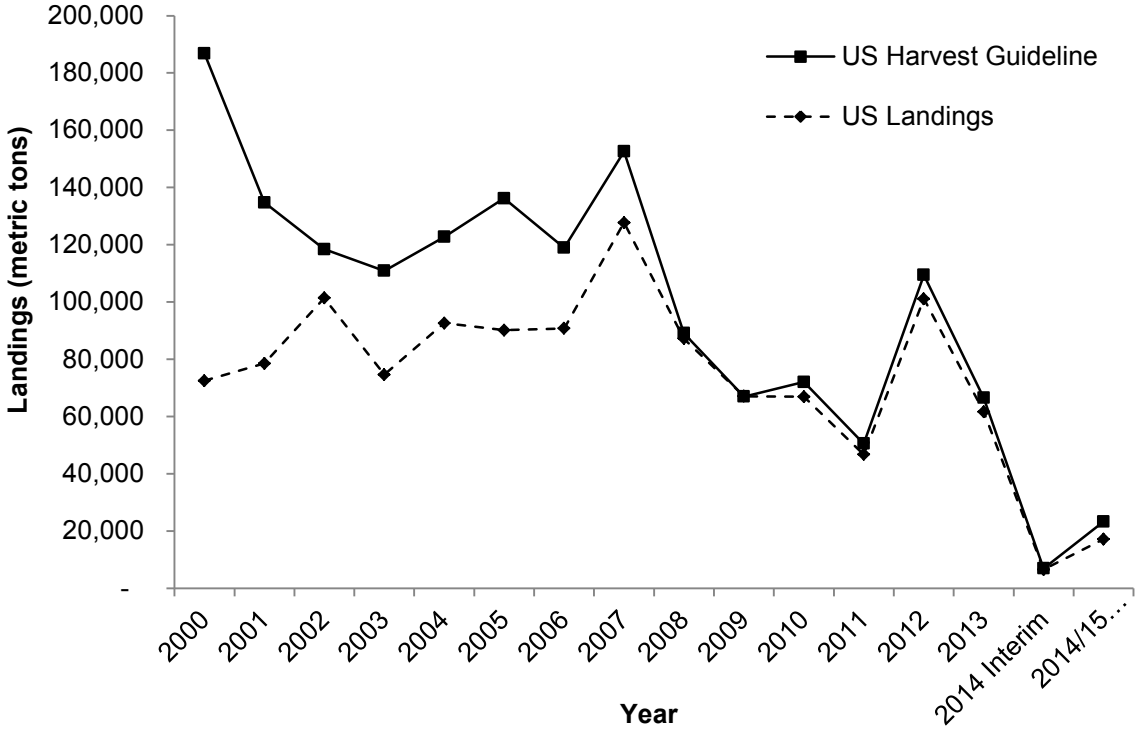

Figure 4. The US Pacific sardine harvest guideline (HG) for each calendar year; in November 2013, the start date of the 12 month Pacific sardine fishery was changed from 1 January to 1 July which changed the fishing season from one based on a calendar year (1 January–31 December) management cycle to a fishing season (1 July–30 June) cycle. A one-time interim harvest period from 1 January 2014 through 30 June 2014 was established to allow targeted fishing to continue during the transition to the new management cycle.

TABLE 2
Landings (metric tons) of Pacific sardine (*Sardinops sagax*) and Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), and northern anchovy (*Engraulis mordax*) at California port areas in 2014.

	Pacific sardine		Pacific mackerel		Jack mackerel		Northern anchovy	
Area	Landings	% Total	Landings	% Total	Landings	% Total	Landings	% Total
Monterey	6,233.7	80.2	243.4	4.5	90.3	11.5	10378.8	98.7
Santa Barbara	96.1	1.2	182.2	3.4	3.5	0.4	66.3	0.6
Los Angeles	1,438.2	18.5	4,994.2	92.1	690.6	88.0	65.6	0.6
Total	7,768.0	100	5,419.8	100	784.4	100	10,510.7	100

*Monterey totals include San Francisco landings; Los Angeles totals include Oceanside/SoCal landings.

general decrease in US commercial landings of Pacific sardine (fig. 4).

California commercial landings of Pacific sardine come from the northern subpopulation. This fishery in California has long been one of the largest in the state. In 2014, it was the fourth largest in volume and twelfth largest in value, landing 7,768.0 t and generating an ex-vessel revenue of $2 million (fig. 2). This was a 9.8% increase from 2013 (7,074 t). Commercial landings of sardine averaged 39,979 t over the fourteen-year period from 2001–14. Nearly all (98.6%) of California's 2014 sardine catch was landed in Monterey (80.2%, 6,233.0 t) and Los Angeles (18.4%, 1,438.2.0 t) port areas (table 2). California exported 6,497.1 t of sardine product worth over $6.2 million. Twenty-six countries received sardine product from California; Japan and Australia received the majority at 25.6% and 9.9%, respectively.

Oregon landings appeared to be leveling off since 2008; they experienced a large jump in 2012 and decreased in 2013 and 2014. Landings of Pacific sardine totaled 7,788.5.4 t, a 70.4% decrease from 2013 (26,288.4 t). In 2013, Oregon exported 88 t of sardine product to 1 country (Malaysia) worth $113,021.

Washington landings of Pacific sardine totaled 7,783.8 t in 2014, a decrease of 74.4% from 2013 (30,457.1 t). They exported 16,614.6 t of sardine product to 20 countries, totaling $15.8 million in revenue.

The recreational Pacific sardine catch as sampled from the California Recreational Fisheries Survey (CRFS) was 12.6 t (127,321 fish). The majority (94.8%) of the

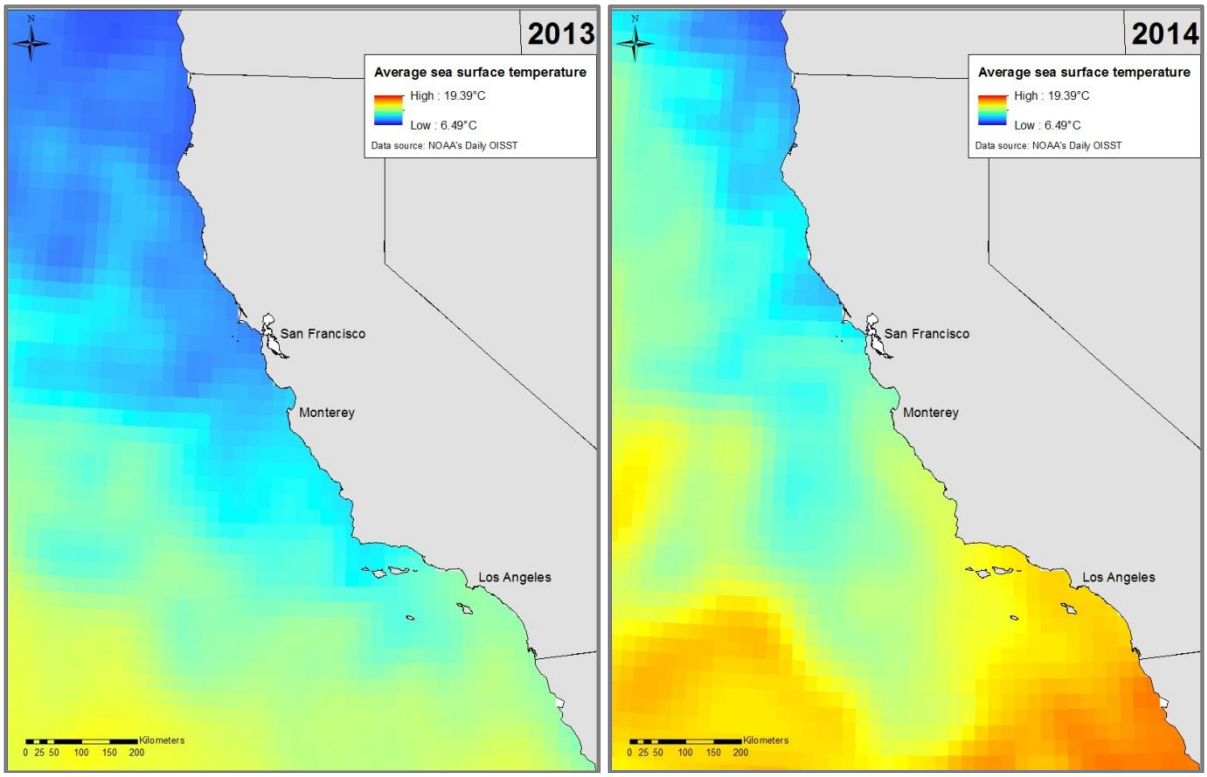

Figure 5. Average sea surface temperatures (SSTs) off the coast of California, 2013 and 2014 (data: http://gis.ncdc.noaa.gov/map/viewer/#app=clim&cfg=cdr&theme=cdr&layers=00001&node=gis).

fish landed were from manmade structures, such as piers. The tonnage and number of fish decreased from 2013, 83.6 % and 82.6% decreases, respectively.

Pacific Mackerel. In 2014, 5,420 t of Pacific mackerel were landed in California (table 1, fig. 2) generating over $1.2 million in ex-vessel revenue, and making it California's fifth largest volume fishery. This is a 32.8% decrease in volume and a 19.3% increase in ex-vessel revenue from 2013. Monterey area ports landed 243.4 t while landing nearly no Pacific mackerel in 2013. A shift in oceanic conditions, such as sea surface temperature, may have attributed to Pacific mackerel landings shifting northward (fig. 5).

Industry exported 2,994.5 t of mackerel product, valued at $2.6 million, mainly for human consumption, to 20 countries. The Philippines (1,074.3 t) and Egypt (447.5 t) received over 50% of this product.

Oregon reported landing 1,172.3 t of Pacific mackerel in 2014, with an ex-vessel revenue of $324,624. This is a 167% increase from the 2013 catch of 439.3 t. No exports were reported for Oregon.

Washington reported landing 544.6 t of Pacific mackerel in 2014, with an ex-vessel revenue of $155,337. There were no landings of Pacific mackerel in 2013. Washington exported 1,341.7 t of mackerel product, valued at $1.9 million, mainly for human consumption, to 15 countries. Ghana (247.3 t) and Malaysia (190.2 t) received over 50% of this product.

At the start of the 2014/15 season, which runs from 1 July to 30 June the following year, the PMFC set the HG at 29,170 t, including a 5,000 t set aside for incidental landings in other fisheries. Landings above the HG would be constrained by an incidental catch rate of 45% by weight when landed with other CPS.

The 2014 recreational Pacific mackerel catch as sampled from CRFS was 285.4 t (1,743,740 fish), a 79.3% increase (93.1% by number of fish) from 2013. The majority (49.5%, 863,230 fish) of fish landed were from manmade structures; 43.1% of fish were landed on commercial passenger fishing vessels (CPFVs).

Jack Mackerel. Jack mackerel has long been the smallest of the federal CPS finfish fisheries. It is a monitored species under the CPS FMP. Jack mackerel represented 3.2% of the total landings of the CPS finfish fisheries in California for 2014. Landings of jack mackerel totaled 784.4 t in 2014, with an ex-vessel revenue of $148,947 for California (table 1, fig. 2).

Oregon reported landing 800.4 t of jack mackerel, with an ex-vessel revenue of $146,577. This is a 549.7% increase from the 2013 catch of 123.2 t.

Washington reported landing 242.7 t of jack mackerel in 2014, with an ex-vessel revenue of $59,210. This is an

increase of over 204.9% from the 2013 catch of 79.6 t.

The 2014 recreational jack mackerel catch as sampled from CRFS was 8.6 t (56,091 fish), a 101.7% increase (152.6% by fish) from 2013. A total of 31,224 fish were landed on manmade structures.

Northern Anchovy. Composed of three stocks, southern, central and northern, landings of northern anchovy in California have been reported since the early 1900s. Northern anchovies are only occasionally landed in Oregon and Washington (primarily used for live bait). The California fishery is harvested from the central stock, which ranges from San Francisco to northern Baja California. Currently, northern anchovy are a monitored species under the CPS FMP. Studies of scale deposits on the sea floor suggest that their abundance has historically been quite large. Now used for animal food, live bait, and human consumption, anchovy was used mainly in a reduction industry to produce oil and fish meal in the 1900s. From the 1900s to the late 1970s, northern anchovy was a major component of California's commercial CPS fisheries. During periods of low sardine abundance, anchovy landings have increased, hitting a peak in the mid-1970s at over 100,000 t. However, commercial landings of northern anchovy have remained relatively low since the 1980s due to market constraints. Presently, landings of northern anchovy are modest, averaging 7,877 t per year over the last 14 years.

Landings of northern anchovy in California for 2014 were 10,511 t with an ex-vessel revenue of greater than $1.6 million (table 1, fig. 2). When compared to landings in 2013, this represents a 75.0 % and 49.9% increase in volume and value, respectively. Nearly all (98.7%; 10,378.8 t) of California's 2014 northern anchovy catch was landed in the Monterey port area (table 2). Exports of northern anchovy product from California totaled 416 t for an export value of over $1.5 million. Seven countries received anchovy product from California; Australia received the majority at 77.0%.

In 2014, Oregon and Washington reported no landings of anchovy. Oregon did not report any anchovy exports in 2014. Washington exported 1.9 t of anchovy product to Canada, totaling $13,336 in revenue.

The 2014 recreational northern anchovy catch as sampled from CRFS was 4.1 t (227,759 fish), a 25.1% decrease (50.1% by fish) from 2013. The majority (91.6%) of fish landed were from manmade structures, and 6.5% were landed from CPFVs.

California Market Squid

In 2014, market squid (*Loligo (Doryteuthis) opalescens*) continued to dominate commercial landings of marine species in California, contributing about 64% of the total tonnage and 30% of total ex-vessel value of all species landed. Landings of market squid in 2014 decreased 2% compared to 2013 landings, from 104,370 t to 102,516 t (fig. 6). Ex-vessel value in 2014 decreased 3% compared to 2013, from $73.7 million to $71.8 million. California fish businesses exported 89,240 t of market squid to 40 countries for a value of $114 million in 2014 (http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/). The majority (86%) was shipped to just 3 countries but most (73% of the total amount) went to China.

For the fifth season in a row, since the inception of the Market Squid Fishery Management Plan in 2005, market squid landings were projected to reach the seasonal catch limit of 107,048 t. By November 18, 2014, 97.2% of the catch limit had been landed. On this date, the seine sector of the squid fleet made a voluntary decision to stop fishing so that the remaining portion of the catch limit could be set aside for the brail sector. Neither the brail nor seine sector of the commercial fleet made directed landings of market squid after November 18, 2014, and the 2014/15 season ended without reaching the seasonal catch limit.

Commercial fishing for market squid is limited by fishery control rules set forth in the Market Squid Fishery Management Plan (MS FMP). Vessels are required to have a permit to commercially fish for market squid. In 2014, there were 75 market squid vessel (purse/drum seine), 34 light boat (attracting), and 44 brail (or dip net) permits issued. Of the 75 vessel permits issued, 64 vessels were active in the fishery with 52 vessels contributing 95% of the landings. Of the 44 brail permits issued, 11 brail vessels landed squid. Other fishery control rules include a seasonal catch limit that starts April 1 and ends March 31 of the following year, weekend closures, spatial closures, and lighting restrictions.

The geographic distribution of market squid landings in 2014 is particularly interesting. Although the fishery has its historical origins in Monterey Bay, it had been dominated by southern California landings in recent years (fig.7). Landings north of Point Conception have increased since 2010 and increased sharply in 2014. This sharp increase, paired with a sharp decrease in landings south of Point Conception, meant the fishery was no longer dominated by southern California in 2014. The Department's Commercial Fisheries Information System (CFIS) contains landing data back to 1980 and contains no record of directed squid landings north of the San Francisco Bay prior to 2014. The 2014/15 season represents the first time in recent history that directed fishing for market squid resulted in landings to the port of Eureka (2,174.8 t). A shift in oceanic conditions, such as sea surface temperature (SST), may have attributed to this northward shift of landings (fig. 5).

Market squid live less than a year and have been found in nearshore waters of the eastern Pacific Ocean from Baja California to the Gulf of Alaska. The population

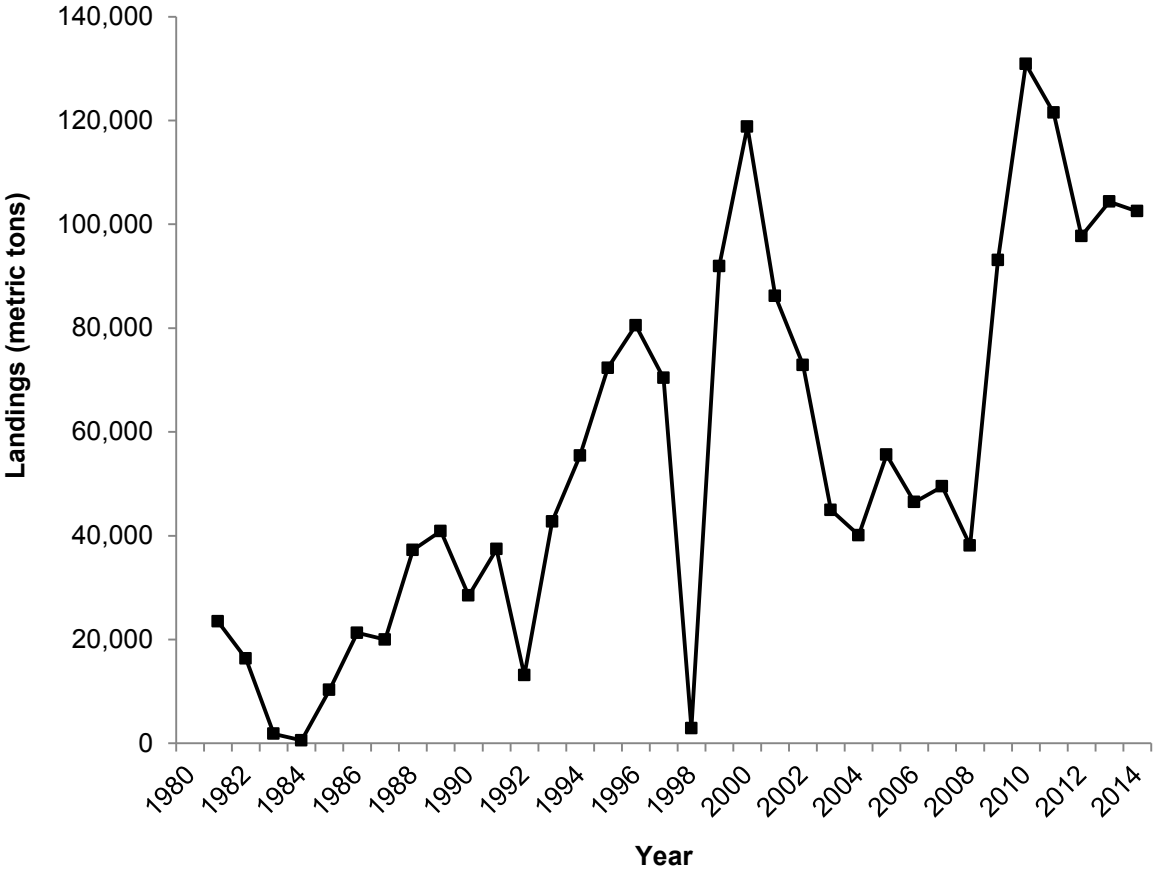

Figure 6. California commerical market squid (*Loligo (Doryteuthis*) opalescens) landings, 1981–2014.

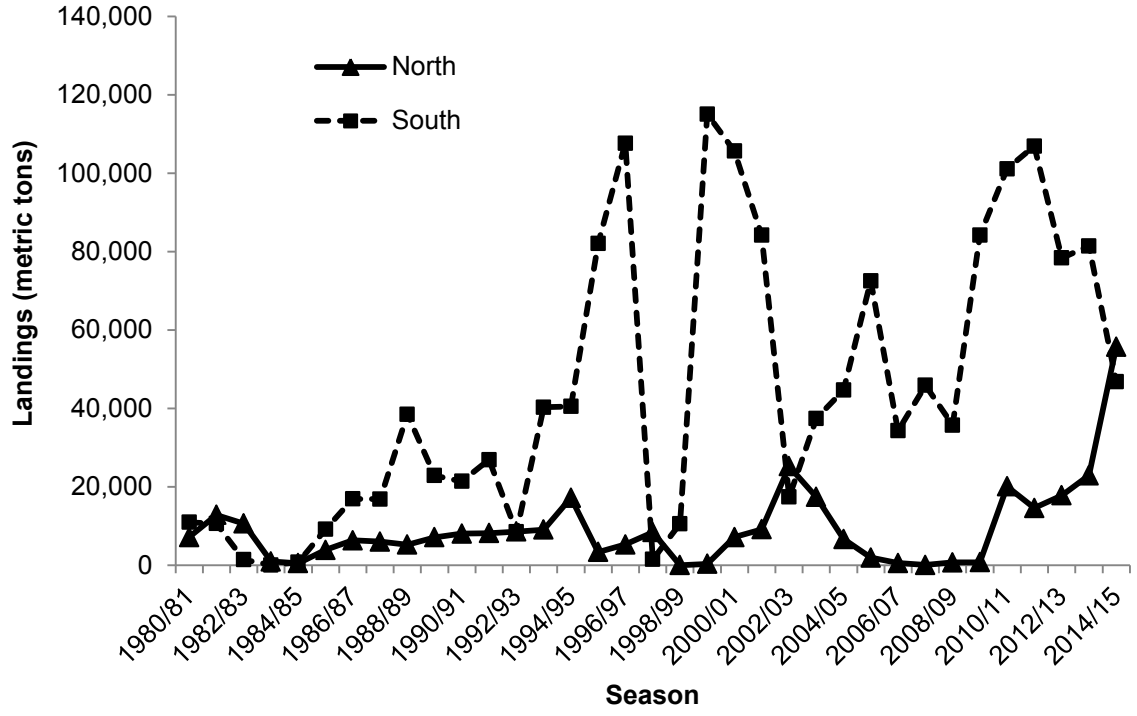

Figure 7. Comparison of market squid (*Loligo (Doryteuthis) opalescens*) landings for northern and southern fisheries by fishing season (1 April–31 March), from 1980/81 to 2014/2015 seasons.

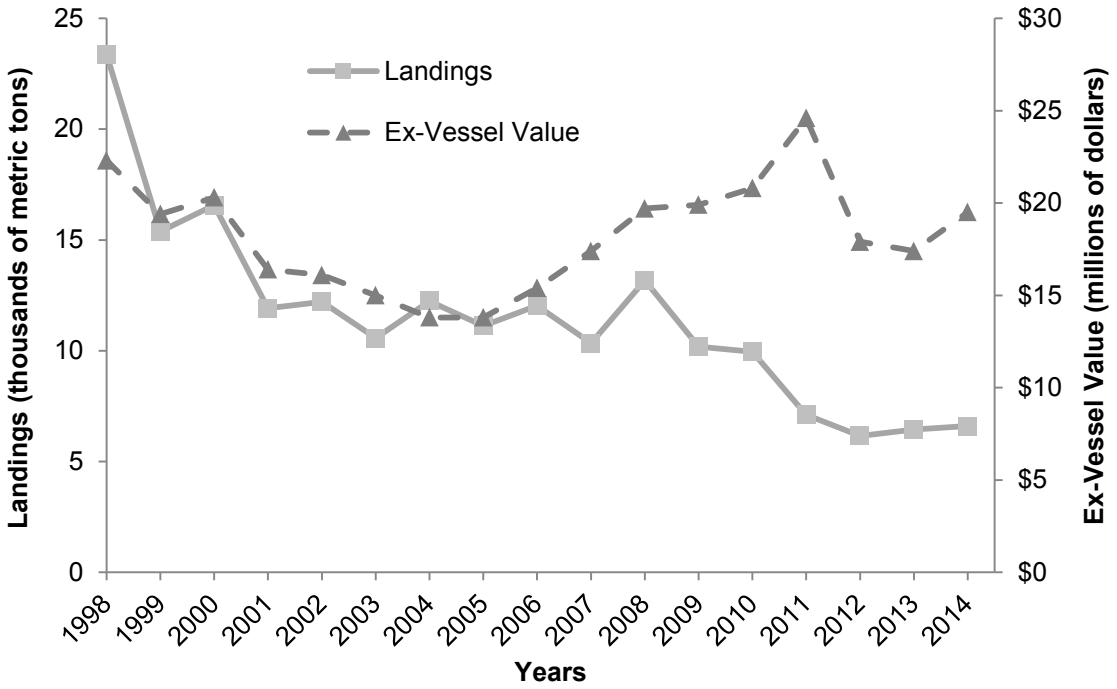

Figure 8. California commercial groundfish landings, 1998–2014.

appears to fluctuate widely in abundance in response to short-term oceanographic events, like the El Niño Southern Oscillation. Ecologically, they are considered important as forage for other species, including predatory fishes, marine mammals, and seabirds.

A live bait fishery exists for market squid, largely to supply recreational fishing in southern California. The live bait fishery is a low-volume, high-value endeavor, as recreational anglers are willing to pay up to $60 for a "scoop" of live squid, which averages 10 lbs.; as a comparison, the average price paid to the commercial fleet in 2014 was $0.32 per pound.

Groundfish

More than 90 species of bottom-dwelling marine finfish are included in the federally managed groundfish fishery. The species that comprise the groundfish fishery are diverse and complex; their primary distributions range from nearshore depths to deep offshore habitats. "Groundfish" species include all rockfishes in the Scorpaenidae family, flatfishes such as Dover sole (*Microstomus pacificus*) and petrale sole (*Eopsetta jordani*), roundfishes such as sablefish (*Anoplopoma fimbria*), and lingcod (*Ophiodon elongatus*), and various sharks and skates. These groundfish species are grouped into 39 federal management units, consisting of species or species groups, to help facilitate management measures that balance biological and economical goals.

Commercial Fishery. In 2014, California's commercial groundfish landings totaled 6,603 t, worth an estimated ex-vessel value of $19.5 million. This represents a 2.4% increase in landings from 6,443 t in 2013 and an increase in ex-vessel value of 12% from $17.3 million. During the last decade, groundfish landings declined by 46% (6,603 t in 2014 versus 12,243 mt in 2004); yet the ex-vessel value increased nearly 41% ($19.5 million in 2014 versus $13.8 million in 2004) (fig. 8). In 2014, the majority (71%) of groundfish was landed between the California/Oregon border and the Monterey Bay area and generated 52% of the total ex-vessel value of the fishery. By volume, trawl gear comprises 72% of the total statewide landings followed by hook and line and trap gear at 28%. While that 28% is low compared to trawl gear, hook and line and trap gear generated 41% of the total revenue generated by the fishery. The lower volume capacity of the hook and line gear accounts for the majority of total trips (89%) as compared to trawl gear (11%).

Landings of Dover sole, sablefish, thornyheads (*Sebastolobus altivelis* and *S. alascanus*), petrale sole, and chilipepper (*Sebastes goodei*) continued to be the top species by weight, with 1,897 t, 1,800 t, 989 t, 614 t and 276 t landed, respectively. These species comprised 84% of the groundfish landings.

Groundfish landings in 2014 were mostly comprised of flatfishes (41%), followed by roundfishes (29%), thornyheads (15%) and rockfish (10%). The "other" groundfish species category was comprised of grenadier (Macrouridae) which accounted for 61 t (table 3). Chilipepper was the top rockfish species by weight, with

TABLE 3
California commercial groundfish landings (in metric tons) and ex-vessel value in 2014 with comparisons to 2013. The top species by weight for the flatfishes and rockfishes are represented in the table.

	2014		2013		% change from 2013	% change from 2013
	Harvest (mt)	Value ($)	Harvest (mt)	Value ($)	(mt)	($)
Flatfishes						
Dover sole	1,897	$1,866,714	2,218	$2,143,990	–14%	–13%
Petrale sole	614	$1,644,155	470	$1,321,525	31%	24%
Arrowtooth flounder	75	$16,839	118	$26,824	–36%	–37%
English sole	59	$45,633	49	$39,777	20%	15%
Rex Sole	43	$38,219	45	$42,920	–4%	–11%
Sand sole	16	$36,136	15	$37,774	4%	–4%
Other flatfishes	14	25,811	28	$24,679	–49%	5%
Total Flatfishes	2,719	$3,673,507	2,944	$3,637,489	–8%	1%
Rockfishes						
Chilipepper	276	$455,998	322	$472,897	–14%	–4%
Blackgill rockfish	60	$142,603	72	$146,033	–17%	–2%
Bank rockfish	58	$119,993	52	$110,088	11%	9%
Black rockfish	40	$188,441	36	$159,878	12%	18%
Brown rockfish	26	$386,791	28	$422,334	–6%	–8%
Vermilion rockfish	27	$162,294	23	$142,335	15%	14%
Gopher rockfish	26	$436,526	23	$392,733	11%	11%
Other rockfishes	105	807,842	100	$751,094	5%	8%
Overfished species						
Bocaccio	15.2	$41,005	16.5	$39,700	–8%	3%
Canary rockfish	1.9	$2,984	1.6	$3,474	21%	–14%
Cowcod	0.2	$469	0.2	$191	11%	145%
Darkblotched rockfish	3.9	$8,208	4.2	$6,204	–6%	32%
Pacific ocean perch	0.04	$50	0.05	$56	–22%	–10%
Yelloweye rockfish	0.02	$34	0.01	$30	40%	12%
Total Rockfishes	638	$2,753,239	679	$2,647,047	–6%	4%
Roundfishes						
Sablefish	1,800	$8,964,857	1,375	$7,014,561	31%	28%
Lingcod	106	$514,508	64	$294,396	65%	75%
Cabezon	31	$402,236	29	$361,832	7%	11%
Kelp greenling	5	$60,085	5	$70,790	–15%	–15%
Pacific whiting	5	$223	4	$212	35%	5%
Total Roundfishes	1,947	$9,942,180	1,478	$7,741,790	32%	28%
Scorpionfish, California	2	$23,098	3	$28,399	–45%	–19%
Sharks & Skates	248	$204,975	172	$145,009	44%	41%
Thornyheads	989	$2,891,294	1,085	$3,114,120	–9%	–7%
Other Groundfish	61	$35,322	84	$68,466	–27%	–48%
Total Groundfish	6,603	$19,523,614	6,443	$17,382,320	2%	12%

*Petrale sole was declared overfished in 2009
Data Source: CFIS (CMASTR) Extraction Date: 04/28/2014

landings of 276 t worth an ex-vessel value of $455,998. Unlike high-volume, high-value species such as sablefish, nearshore rockfishes are generally a low-volume, high-value commodity in California—brown rockfish (*S. auriculatus*), gopher rockfish (*S. carnatus*), and grass rockfish (*S. rastrelliger*) were worth a combined ex-vessel value of $1,049,843 with landings of 26 t, 26 t and 11 t respectively. Restricted access and the live fish market are primarily responsible for the high market value of the nearshore fishery. In 2014 the top grossing nearshore species were grass rockfish, black-and-yellow rockfish (*S. chrysomelas*), and gopher rockfish; valued at approximately $21,100/t, $17,000/t and $17,000/t, respectively. By contrast, chilipepper (a non-nearshore rockfish) was valued at approximately $1,650/t.

Landings of overfished rockfish species, which accounted for <1% of the groundfish landings in 2014, decreased by 7.4% compared to 2013 (21.3 t versus 23 t). In both years the predominant species was bocaccio (*S. paucispinis*), which accounted for 71% and 73% of the total overfished rockfish species landings in 2014 and 2013, respectively. Management measures to protect overfished species have greatly reduced landings over the past decade.

Recreational Fishery. The Recreational Fisheries Information Network (RecFIN) Program stores recreational data from California, Oregon, and Washington. RecFIN incorporates data from two recreational fishery sampling programs in California—the Marine Recreational Fisheries Statistical Survey (MRFSS), which

TABLE 4
Comparison of recreational groundfish catch in California in 2014 and 2013 (does not include discards and only includes catch greater than 5 metric tons).

Species	2014 Harvest (mt)	2013 Harvest (mt)	% Change from 2013
Lingcod	572	433	32%
Black rockfish	340	363	–6%
Vermilion rockfish	206	211	–2%
Blue rockfish	134	106	26%
California scorpionfish	123	112	9%
Brown rockfish	120	82	48%
Pacific sanddab	107	86	25%
Copper rockfish	102	99	4%
Bocaccio	100	131	–24%
Yellowtail rockfish	60	56	7%
Gopher rockfish	55	41	34%
Cabezon	32	25	28%
Olive rockfish	32	20	56%
Squarespot rockfish	22	17	35%
Kelp rockfish	18	19	–8%
Widow rockfish	16	18	–8%
Canary rockfish	16	13	25%
Starry rockfish	15	24	–39%
Leopard shark	14	14	1%
Kelp greenling	13	14	–8%
Grass rockfish	12	10	26%
Chilipepper	11	7	46%
Black-and-yellow rockfish	10	6	68%
Greenspotted rockfish	10	11	–12%
China rockfish	10	10	3%
Speckled rockfish	9	16	–39%
Flag rockfish	9	14	–34%
Treefish	9	13	–28%
Honeycomb rockfish	6	9	–39%
Rosy rockfish	5	6	–18%
Other groundfish	31	27	15%
Total Groundfish	2,220	2,014	10%
Angler Trips			
Bottomfish Effort	950,801	925,682	3%

Data source: RecFIN
Date Extracted: 05/08/2015

operated from 1980 to 2003, and the California Recreational Fisheries Survey (CRFS) initiated by the Department in 2004. These data, which are available from 1980 to the present, represent the best available information on recreational catch in California. CRFS data indicate that California anglers targeting groundfish participated in an estimated 950,801 trips in 2014, a small increase (<3%) from 2013 (925,682 trips). The predominant gear type used in the California recreational groundfish fishery is hook and line.

An estimated 2,220 t of groundfish were taken by the recreational fishery in 2014 (table 4), which represents a 10% increase compared to 2013 (2,014 t). The top five species in 2014 were lingcod, black rockfish (*S. melanops*), vermilion rockfish (*S. miniatus*), blue rockfish (*S. mystinus*), and California scorpionfish (*Scorpaena guttata*), which accounted for approximately 62% of the groundfish catch by weight; in 2013, the same five species comprised 61% of the catch. In 2014, the majority (52%) of groundfish catches occurred in central California (Point Conception to Cape Mendocino), where lingcod was the most frequently encountered. In southern California (south of Point Conception), anglers took 36% of the groundfish catch, with vermilion rockfish being the most frequently encountered. Lastly, northern California (Cape Mendocino to the California-Oregon border) accounted for 12% percent of the catch, with black rockfish being the most frequent.

Commercial Nearshore Fishery Update. The state Nearshore Fishery Management Plan (NFMP) has been in place for more than twelve years, having been first adopted in October 2002 to meet the mandates of the Marine Life Management Act in addressing growing concerns regarding increasing participation in the nearshore fishery. The NFMP provides a framework for management of nineteen species including various rockfish and a number of species caught in association with them in nearshore habitat. A full review of steps taken to implement the NFMP since its inception is provided in a recently published paper by Wilson-Vandenberg et al. (2014).

To date, full stock assessments have been completed for half of the nearshore species, including blue, black, brown, China, copper, and gopher rockfish, as well as California scorpionfish and cabezon. The remaining species have been assessed with less intensive data methods (table 5). Many stocks are considered to be healthy while others are in the precautionary zone; none are considered overfished.

Regulations have been developed to prevent commercial harvest from exceeding the allowable limits. Season lengths, depth restrictions, gear restrictions, trip limits and a restricted access permit system have been implemented and have been successful at providing as much fishing opportunity as possible while keeping catches within allowable limits.

Commercial Nearshore Fishery. During development of the NFMP, a restricted access program was developed to address overcapitalization issues in the nearshore fishery and to keep catches within allowable limits. Three different species specific permits were developed for this fishery—a Nearshore Fishery Permit (NFP; also known as the shallow nearshore permit), a Deeper Nearshore Fishery Permit (DNSFP), and a Nearshore Fishery Bycatch Permit (bycatch permit). The NFP is divided into four regions (North Coast, North-Central Coast, South-Central Coast and South Coast) with area-specific capacity goals; capacity goals are North Coast = 14, North-Central Coast = 9, South-Central Coast = 20, and South Coast = 18. This permit can only be fished in the region for which it is issued. This permit is also transferrable, but two permits must

TABLE 5
The 19 nearshore species with relevant federal and state management and stock assessment information. Shallow and Deep permit types refer to the Nearshore Fishery Permit (NFP) and Deeper Nearshore Species Fishery Permit (DNSFP), respectively.

Species	Managed by	NFMP Species by Permit	Last Assessed	Status[a]
Black rockfish (RF)	Fed/State	Deep	2007	healthy
Black-and-yellow RF	Fed/State	Shallow		
Blue RF	Fed/State	Deep	2007	precautionary
Brown RF	Fed/State	Deep	2013	precautionary
Calico RF	Fed/State	Deep		
China RF	Fed/State	Shallow	2013	healthy[b]
Copper RF	Fed/State	Deep	2013	healthy[b]
Gopher RF	Fed/State	Shallow	2005	healthy[b]
Grass RF	Fed/State	Shallow		
Kelp RF	Fed/State	Shallow		
Olive RF	Fed/State	Deep		
Quillback RF	Fed/State	Deep		
Treefish	Fed/State	Deep		
Cabezon	Fed/State	Shallow	2009	healthy[b]
CA scorpionfish	Fed/State	Shallow	2005	healthy
Kelp greenling[c]	Fed/State	Shallow	2011	
Rock greenling	State	Shallow		
CA sheephead[c]	State	Shallow	2004	
Monkeyface prickleback[c]	State	—[d]		

[a] Status of the stock is based on the Nearshore Fishery Management Plan (NFMP) 60-20 Harvest Control Rule
[b] indicates the northern portion of the stock was precautionary; the southern portion was healthy
[c] Stock status was not determined or the assessments were deemed inadequate for management
[d] No permit required. A commercial fishing license is required as it is for all 19 species

be purchased and one retired. The DNSFP can be fished coast-wide and is nontransferrable. The bycatch permit was issued to allow incidental take of shallow nearshore species with trawl or gill net gear only. This permit is not transferrable.

The restricted access program has greatly reduced the number of participants in the fishery. Between 1999 and 2002, the number of permits issued decreased from 1,127 to 505. The number of NFPs purchased in 2003 totaled 220 but has been reduced through transfers or non-renewal, to 150 permits in 2014, for an attrition rate of 32%. Despite the reduction in the number of NFPs, each region remains above its capacity goal. In 2014 the number of permits issued by region is as follows: North Coast = 16; North-Central Coast = 26; South-Central Coast = 52; and South Coast = 56.

The DNSFP was intended to act as a moratorium to prevent any further entrants into the fishery and does not have gear restrictions or a capacity goal. In 2003, 294 DNSFPs were issued; through attrition the number has been reduced 36% to 188 permits in 2014. In addition, a bycatch permit was created allowing for the incidental take of the nine shallow nearshore species with trawl or gill net gear only. In 2003, 97 individuals qualified for a bycatch permit but only 26 permits were issued. By 2014, the number of bycatch permits was reduced to 11 permits, yet only 3 of these permit holders were active (i.e., making at least one landing of shallow nearshore species).

Summary and Geographic Distribution of Landings. In the early 1990s, prior to implementation of the NFMP and restricted access program, coast-wide nearshore landings (shallow and deeper combined) totaled 445 t, with an ex-vessel value of $1.7 million. After implementation of the restricted access program and the DNSFP in 2003 the coast-wide shallow and deeper nearshore species landings totaled 230 t, with an ex-vessel value of $2.0 million. Eleven years later, in 2014, coastwide nearshore landings (shallow and deeper combined) decreased (6%) to 212 t compared to 2003; however, the ex-vessel value increased (25%) to $2.5 million (fig. 9).

While the fishery originated in the South and South-Central regions in the 1980s, it expanded northward, and between 2003 and 2014 catch has been more evenly distributed over all regions (fig. 10). The composition of catch varies by area in part due to the geographic distribution of each species and availability of other target species (table 6).

Many of the nearshore species are underharvested, meaning they are harvested at levels lower than permissible. While economic factors can affect harvest, protective measures implemented in the early 2000s to protect overfished rockfish are likely having the greatest impact. Canary and yelloweye rockfish are frequently found to co-occur with many nearshore species; as a result large areas of allowable fishing area were closed, which eliminated and/or reduced access to productive fishing

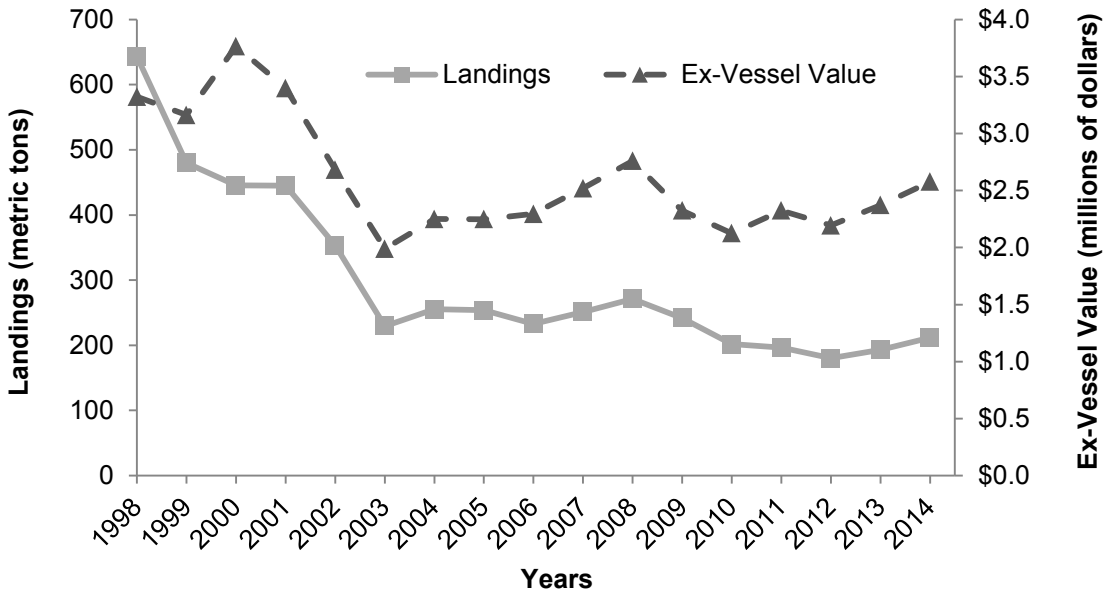

Figure 9. California commercial nearshore groundfish landings, 1998–2014.

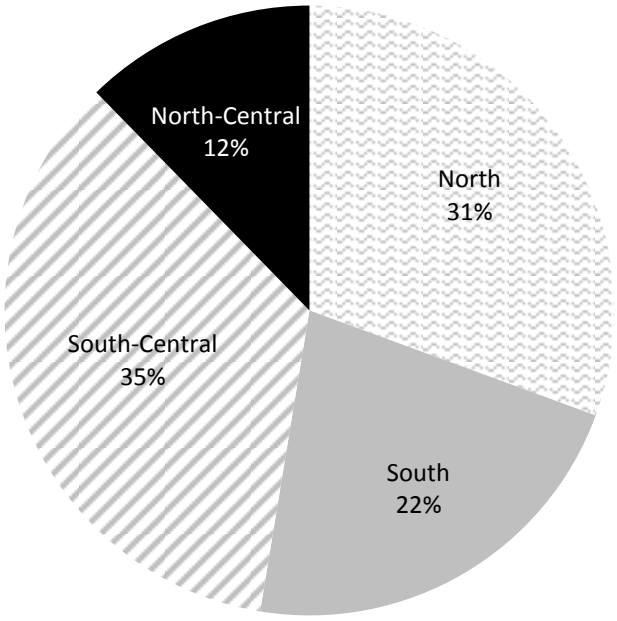

Figure 10. Commercial nearshore landings (shallow and deeper combined) by region, 2003–14.

TABLE 6
Nearshore species regional commercial landings composition, 2003–14. Data from California Department of Fish and Wildlife commercial landing receipts (CFIS).

Species/Group	North Coast Region	North-Central Coast Region	South-Central Coast Region	South Coast Region	Total All Regions
Deeper Nearshore Rockfish	94.80%	40.00%	32.80%	5.50%	46.70%
Shallow Nearshore Rockfish	1.60%	36.60%	42.30%	10.70%	22.20%
CA Sheephead	0.00%	0.00%	0.40%	69.70%	15.50%
Cabezon	3.10%	20.30%	22.50%	9.10%	13.30%
Greenlings	0.60%	3.00%	2.00%	0.00%	1.20%
CA Scorpionfish	0.00%	0.00%	0.00%	4.90%	1.10%
Monkeyface Prickleback	0.00%	0.00%	0.00%	0.00%	0.00%

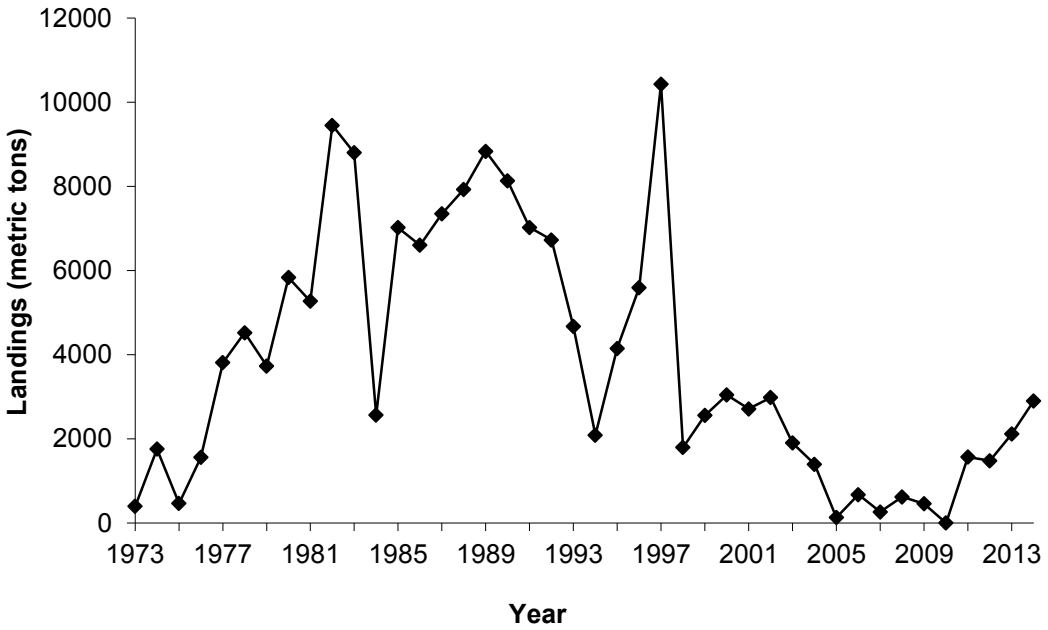

Figure 11. San Francisco Bay commercial Pacific herring (*Clupea pallasi*) sac roe, 1972–2014.

grounds. As canary and yelloweye rockfish continue to rebuild, additional opportunities such as higher trip limits or more access to deeper depths may be permitted.

Pacific Herring

Fishing effort for Pacific herring (*Clupea pallasi*) in 2014 continued at reduced levels when compared to historic landings for California. San Francisco Bay was the only active fishery during this reporting year. There has been no commercial fishing effort in Tomales Bay since 2007, Humboldt Bay since 2005, and Crescent City Harbor since 2002. During the 2014 sac roe season (January 2014–March 2014), the San Francisco Bay fleet landed 2,901.2 t, an increase over the 2013 landings (2,115.6 t) (fig. 11) and 93% of the 3,122.5 t quota.

The forecast base price for roe herring is a good indicator of the economic status of the fishery and determines whether fishermen will participate in the fishery. Ex-vessel prices for roe herring are set using a base price with an additional roe percentage point bonus. The base price is set per short ton of roe herring with a minimum roe percentage of 10%. Roe herring that are landed which exceed the minimum roe recovery level are given a bonus for each percentage point exceeding 10%. Ex-vessel prices in the herring sac roe fishery can vary greatly based on roe recovery rates. The 2014 base price for roe herring with 10% or greater roe recovery was $200/short ton landed ($220/t), with an additional $20 paid for each percentage point above the 10% baseline. The average roe count for the 2014 season was 13.4% resulting in an ex-vessel value of $268/short ton ($295/t). Due to a decrease in base price, the statewide ex-vessel value of the herring sac roe fishery fell from over $1.7 million in 2013 to $857,064 in 2014.

The San Francisco Bay herring-eggs-on-kelp (HEOK) fishery landed 0 t during the 2014 season, however the fishery was active during the 2013 season, landing 35.7 t of HEOK product. Price paid for HEOK typically ranges from $17.6–48.5/kg ($8–22/lb) depending on the quality of the product.

During the 2014 season, the Department conducted spawn deposition surveys in San Francisco Bay to estimate the spawning biomass of the herring stock. The spawning biomass estimate for San Francisco Bay was 54,999 t, a 23.8% decrease over the previous season's estimate of 72,130 t. However, 2014 was the fifth consecutive year of increased biomass since the historic low in the 2009/10 season of 4,394 t and was above the long-term average biomass for San Francisco Bay (1979–2014) of 47,445.8 t. There were no spawning biomass estimates conducted in Tomales Bay, Humboldt Bay, or Crescent City for 2014.

The commercial herring fishery is closely regulated through a catch-quota system to provide for adequate protection of this important forage species. The Department conducts annual assessments of the spawning herring population in San Francisco Bay as part of its ongoing monitoring and management of the fishery. The Department also examines age structure, growth, general condition, and biological aspects of the catch. These data serve as the basis for establishing fishing quotas for the following season. The quota range is based on the determination of the Department's assessment of the stock status, utilizing the best science available. This includes,

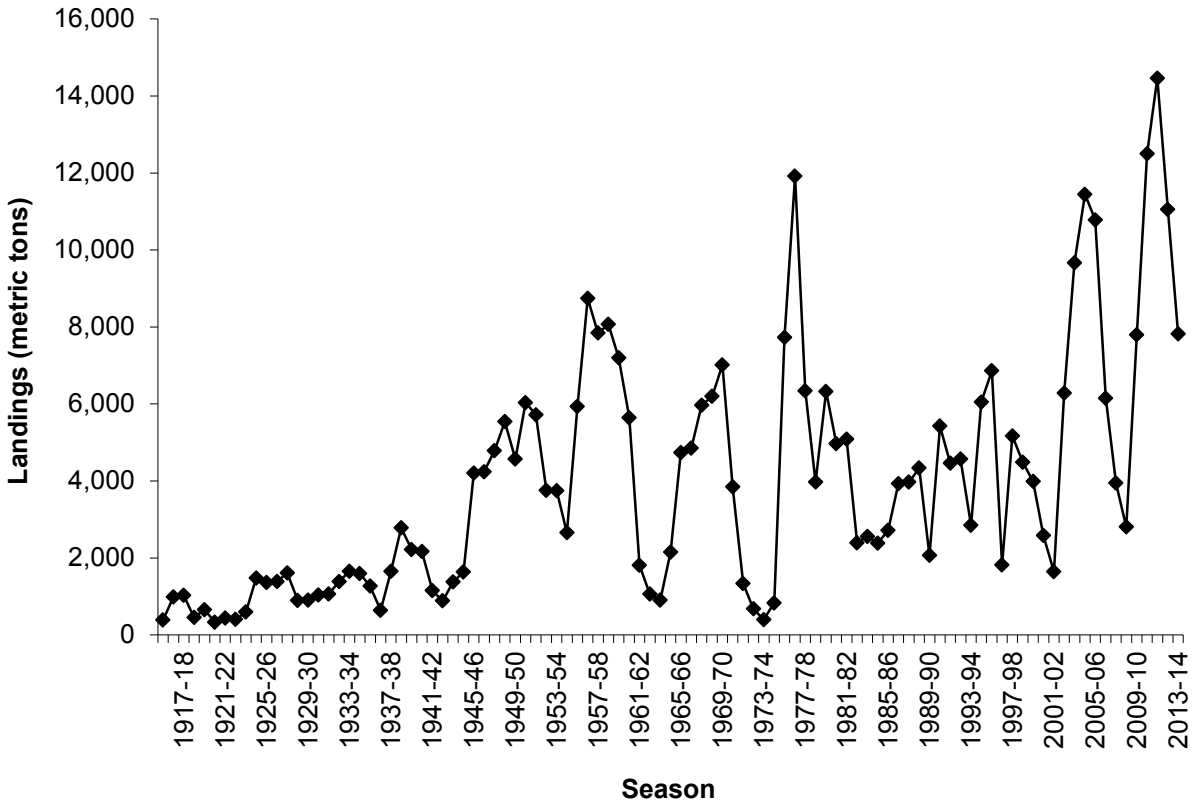

Figure 12. California commercial Dungeness crab (*Metacarcinus magister*) landings, 1915/16–2013/14.

but is not limited to, recent fishery-independent field surveys, commercial catch and age composition analysis, and environmental data. Quota recommendations for San Francisco Bay are primarily based on the most recent assessments by the Department of the size of the spawning population in San Francisco Bay. The recommendation also takes into account additional data collected each season, including ocean and bay conditions, growth rates of herring, strength of individual year-classes, and predicted size of incoming year-classes (i.e., recruitment).

In response to poor recruitment, indication of population stress, and/or unfavorable oceanographic conditions, harvest targets in recent years have been set at or below 10%. The San Francisco Bay fishery was closed during the 2009/10 season for the first time ever to allow for stock recovery following a record low biomass estimate of 4,394 t. After the one-year closure, harvest targets have been set at precautionary levels of approximately 5%. Since the 2004/05 season, harvest targets have allowed over 96% of the spawning biomass to return to the ocean after spawning in the bay. Based on accepted fishery management principles, these harvest targets are conservative and represent a precautionary approach to safeguard the population as forage and to provide a robust reproductive base to allow for stock rebuilding during years of low recruitment or abundance.

Dungeness Crab

The trap-based Dungeness crab (*Metacarcinus magister*, formerly *Cancer magister*) fishery spans the West Coast of North America from Alaska to central California. The California commercial fishery is regulated through the state legislature and is managed primarily on the basis of size, sex, and seasonal restrictions. Male crabs larger than 159 mm (6.25 in) carapace width (CW) are harvested commercially in California's two management areas, demarcated by the Sonoma/Mendocino county line. The commercial season in the central area, south of this line, begins November 15 and ends June 30, while it conditionally begins on December 1 and ends July 15 for the northern area, depending on the condition of the crab.

Mature males typically molt on an annual basis 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. Commencing with the 1995/96 season the state legislature authorized an industry-funded preseason crab quality test to ensure crab meat adequately fills 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 Coastal Dungeness Crab Tri-State Committee, on whether to delay the opening

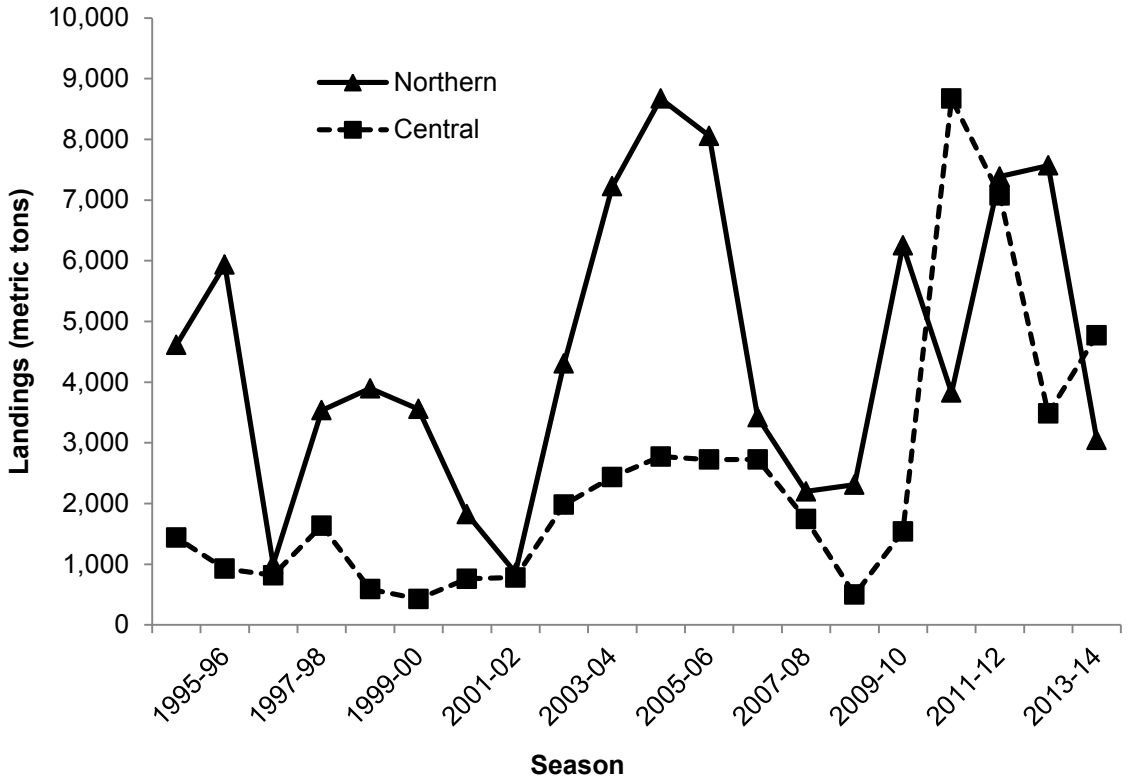

Figure 13. California commercial Dungeness crab (*Metacarcinus magister*) landings by management area, 1994/95–2013/14.

of the season in order to let the crabs reach a standard relative body weight. The 2013/14 season in the northern management area was not delayed and began on December 1 while the central management area is not subject to opening delays by statute.

The 2013/14 crab season brought in statewide landings of 7,822 t, resulting in $60.1 million in ex-vessel value received by the fishermen (fig. 12). The high value overall was in part due to the increasing average price per kilogram over the course of the season at $7.69/kg ($3.49/lb), compared to $6.29/kg ($2.85/lb) the previous season. Dungeness crab was California's second-most valuable fishery in ex-vessel value for the 2014 calendar year at $65.8 million, resulting from the high average price and high landings from the previous 2012/13 season (11,054 t). Typically, the northern area contributes the majority of total crab landed statewide, however for the 2013/14 season 61% of landings were reported from central area ports, between Bodega Bay and Morro Bay (fig. 13). This area has experienced a recent shift in higher than average landings for the past four seasons and set a record for the area in 2010/11 of 8,670 t, more than three times the current 20-year average of 2,390 t. Landings in the southern ports of the central management area, Santa Cruz to Morro Bay, set a record for the area during the 2013/14 season of 714 t, where landings have averaged 157 t for the past 20 seasons.

The recent 2013/14 season is the first to implement the Dungeness crab trap limit program, the primary goal of which is to cap the overall amount of traps that are fished in California. Vessels in the fleet are now subject to fish up to a maximum trap number dependent on their placement in one of seven trap allotment tiers. Placement was based on historical landings during a "window" period and vessels in the highest tier, Tier 1, are allowed a maximum of 500 traps while the lowest tier, Tier 7, is set at 175 traps. Tier 1 vessel permits contributed the most to the 2013/14 statewide total catch at 31%, and vessels in this tier landed on average 41 t, while Tier 7 vessels made up less than 6% of the total catch and averaged about 7 t.

Preliminary data from the 2014/15 season shows statewide landings exceeding 6,500 t (through February 2015), and like the preceding season the majority of these landings (80%) are reported from the central area. Although landings are trending lower than previous seasons, the record high average price of $7.99/kg ($3.63/lb) has contributed to over $50 million in ex-vessel value brought in by that date.

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. Of the approximately 563 vessels with a 2013 commercial

Dungeness Crab Vessel Permit, 453 vessels made at least one landing in the 2013/14 season. With about 20% of the total permits not actively participating in the fishery, there is concern that, even with trap limits in place, an influx of traps by these latent permits in future seasons could contribute to overfishing and intensify overcrowding on fishing grounds.

In 2008, legislation created the Dungeness Crab Task Force (task force), an advisory group comprised of Dungeness crab fishers from the major fishing ports in the state, members from the Department, and non-governmental organizations. The task force was reinstated in 2012 with SB 369 and one of their many objectives is to evaluate the trap limit program. An initial report was submitted to the Joint Committee on Fisheries and Aquaculture this past January 2015, with a final report of recommendations due on January 15, 2017. Further evaluation of the trap limit program continues as the fishing industry undergoes another fishing season with trap limits in place.

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 Fishery Management Council (PFMC) and 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 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 2014, California ocean salmon fisheries north of Point Arena were primarily constrained by the NMFS consultation standards for California Coastal Chinook which limits the KRFC age-4 ocean harvest rate to a maximum of 16%. California ocean salmon fisheries south of Point Arena were primarily constrained by the NMFS consultation standards for Sacramento River winter Chinook, which restricts season opening/closing dates, imposes minimum size limits, and sets an age-3 ocean impact rate cap (15.4% in 2014) based on the last three years of spawner escapement.

Commercial salmon fisheries south of Point Arena opened May 1 and closed south of Pigeon Point (Monterey-south management area) on August 13. All other areas south of Point Arena (San Francisco management area) closed on September 30, with the exception of an October 1–15 (Monday through Friday) fishery between Point Reyes and Point San Pedro. In the Fort Bragg management area between Horse Mountain and Point Arena, the fishery opened June 19 through September 30. The fishery was closed statewide during the first two weeks of July and during the last two days of August. The Klamath Management Zone (KMZ), including Crescent City and Eureka ports, opened on September 12 with a 4,000 Chinook quota and daily bag and possession limit of 20 Chinook.

Commercial fisheries in the four major port areas (KMZ, Fort Bragg, San Francisco and Monterey-south) had 342 combined days open to fishing in 2014 compared to 410 days open during the 2013 season. An estimated 166,500 Chinook salmon (1,011 t) were landed during the 2014 commercial season (fig. 14) in 14,200 days fished. The average weight per fish was 6.08 kg (13.4 lbs). The average price was $12.19/kg ($5.54/lb), with a total ex-vessel value of the fishery estimated at $12.3 million. Approximately 600 Chinook were landed out of the KMZ's 4,000 Chinook quota.

The 2014 recreational fishing season increased 14 days compared to 2013, for a season total of 743 days open in each of the four management areas combined. The recreational fishery opened in the Fort Bragg, San Francisco, and Monterey-south areas on April 5 while the KMZ opened on May 10. All fisheries remained open through the summer until closing on September 8 (KMZ), October 6 (Monterey-south), and November 10 (Fort Bragg and San Francisco).

In 2014, an estimated 74,700 Chinook were landed (fig. 15) in 120,300 angler days, a decrease in both catch and effort compared to 2013. Approximately 480 coho were landed illegally during 2014, presumably by anglers who misidentified their salmon as Chinook. The bag 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 possession limit regulation was changed for the 2014 season to state that no more than two daily bag limits may be possessed when on land. On a vessel in ocean waters, no person shall possess or bring ashore more than one daily bag limit. The minimum size limit ranged from 20–24 inches (508–610 mm) TL to protect the generally smaller-sized ESA-listed endangered Sacramento River winter Chinook.

In fall 2014, SRFC exceeded the conservation goal of 122,000–180,000 hatchery and natural area adult spawners for the fifth consecutive year. Nearly 211,700 SRFC adults and 25,400 jacks (age-2 fish) returned to spawn in the Sacramento River basin. Likewise, KRFC surpassed

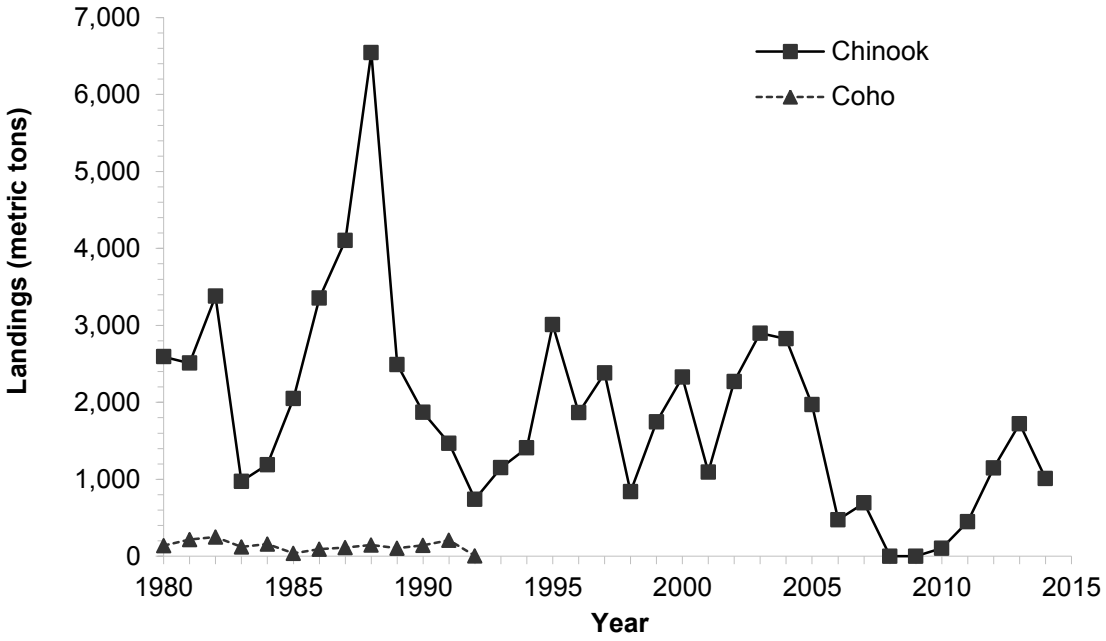

Figure 14. California commercial landings of ocean salmon, 1980–2014.
Note: Commercial fishery landings of coho salmon have been prohibited since 1993 to protect ESA-listed California coastal coho salmon stocks.

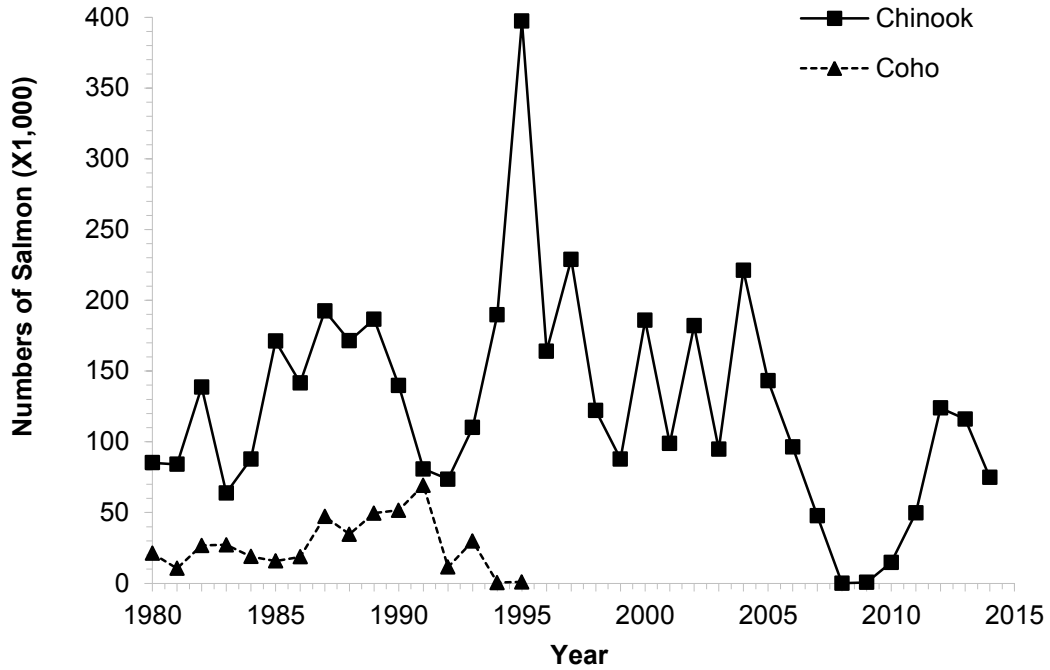

Figure 15. California recreational landings of ocean salmon, 1980–2014.
Note: Recreational fishery landings of coho salmon have been prohibited since 1996 to protect ESA-listed California coastal coho salmon stocks.

the conservation objective of at least 40,700 natural area adult spawners, with 95,300 returning to the Klamath-Trinity Basin in fall 2014.

The 2015 ocean abundance forecasts for SRFC and KRFC are higher than their respective 2014 projections. The Sacramento Index of ocean abundance forecast for 2015 is 652,000 SRFC, while the KRFC ocean abundance projection is 423,800 without additional ocean or in-river fishing. However, protections in addition to NMFS guidance for ESA-listed endangered SRWC were deemed prudent when developing the 2015 ocean salmon fishing seasons. As a result of the drought's continuing detrimental effects on SRWC and based on the best available data, the PFMC adopted more stringent

Figure 16. Surf smelt fisherman with throw net (Photo credit Ken Oda, CDFW).

Figure 17. Night smelt fisherman setting net (Photo credit Kristine Lesyna, CDFW).

Figure 18. A-frame dip net (Photo credit Kristine Lesyna, CDFW).

recreational and commercial management measures, such as higher minimum size limits, reduced days open, and a new sub-management area south of Pt. Sur. These restrictions are expected to provide additional protection to SRWC.

True Smelts

The family Osmeridae is comprised of approximately 11 genera and 30 species. These "true smelts" are small, soft-rayed, schooling fishes with an adipose fin and are found in marine, estuarine, and freshwater habitats in the Northern Hemisphere. They range from Pt. Arguello, California, to the Gulf of Alaska. The related family Atherinopsidae (silversides) includes jacksmelt, topsmelt, and grunion. Members of the true smelts occurring in California waters are delta smelt (*Hyposmesus transpacificus*), eulachon (*Thaleichthys pacificus*), longfin smelt (*Sprinichus thaleichthys*), night smelt (*Sprinchus starksi*), surf smelt (*Hypomesus pretiosus*), whitebait smelt (*Allosmerus elongatus*) and a nonnative, the Wakasagi (*Hypomesus nipponenisis*).

Historically, most of California's Osmerids contributed to sport, commercial, and tribal fisheries; however, only surf and night smelt support these fisheries today. Surf and night smelt, though small in size, are a popular local food fish. Surf smelt are typically headed, gutted, and pan fried due to their relative large size while night smelt are fried whole—"fries with eyes" flavor. Surf and night smelt are also sold by fish wholesalers to aquariums as food for fish, birds, and mammals. Anglers use Osmerids for bait targeting a range of gamefish including striped bass, California halibut, rockfish, lingcod, and redtail surfperch.

Most commercial and recreational Osmerid fishermen use cast nets (Hawaiian throw nets) and/or A-frame dip nets (figs. 16–18). Two-person beach seines ("jump nets") were once popular and are currently legal gear, but the use of beach seines has waned recently in favor of cast nets by recreational fishermen targeting surf smelt. Cast nets are most effective when thrown at visible schools of fish. Fishermen wait until they spot surf smelt appearing in the wash and immediately throw their nets at schooling fish. Cast nets are also readily available, relatively inexpensive, and with practice can be effective.

A-frame dip nets are still used for targeting night smelt throughout their range. The webbing, approximately 3/8 inch measured stretched, is sized to minimize gilling the catch. The net frame is placed seaward into the substrate then the net is tilted up and the catch is tumbled down the throat of the net into the bag. A-frame nets that are handmade have become increasingly difficult to source with ageing of fishery participants but are still widely used.

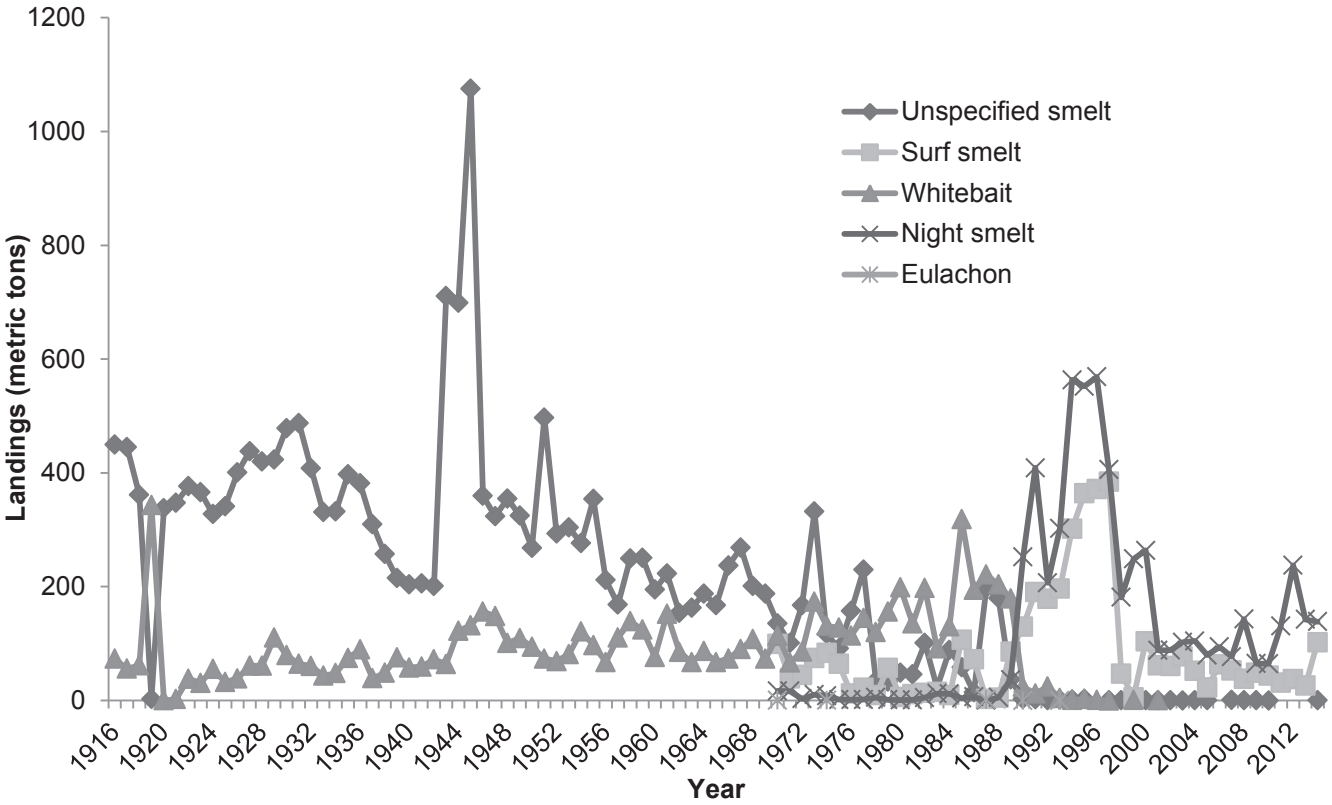

Figure 19. Annual commercial statewide smelt landings, 1916–2014.

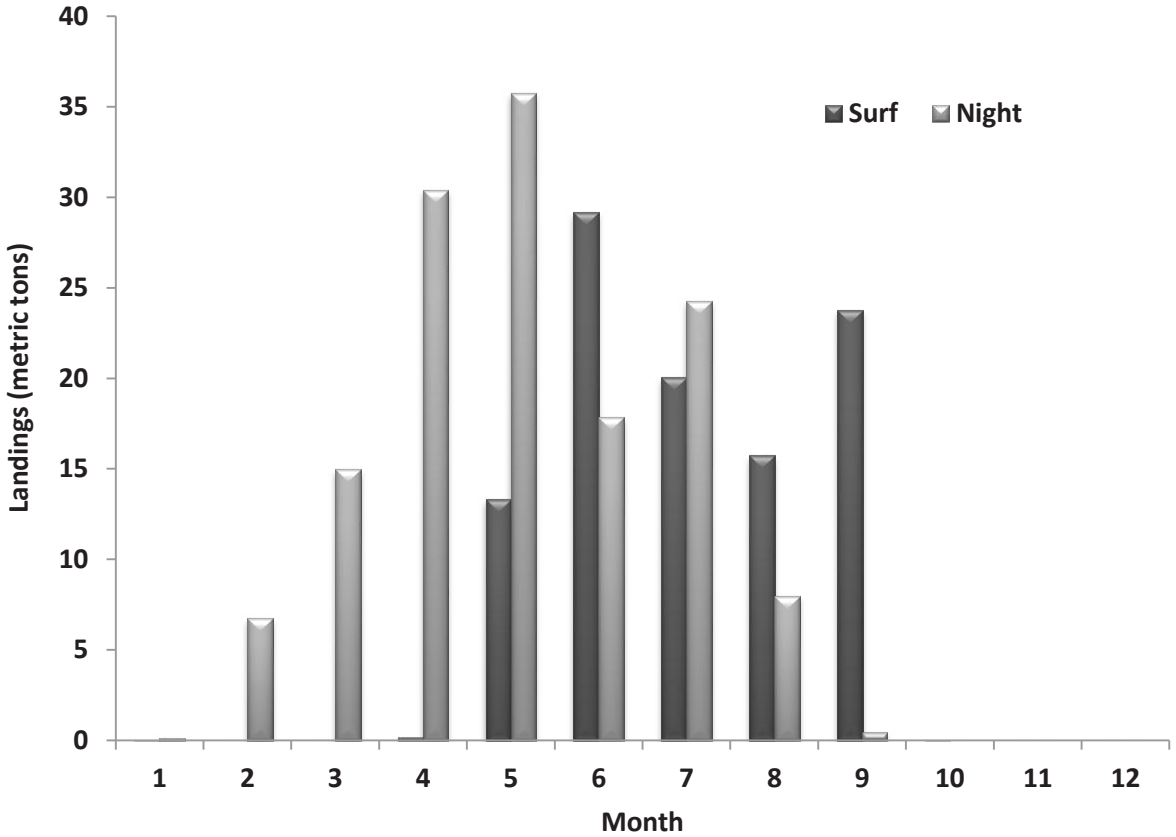

Figure 20. Commercial night smelt (*Sprinchus starksi*) and surf smelt (*Hypomesus pretiosus*) landings by month, 2014.

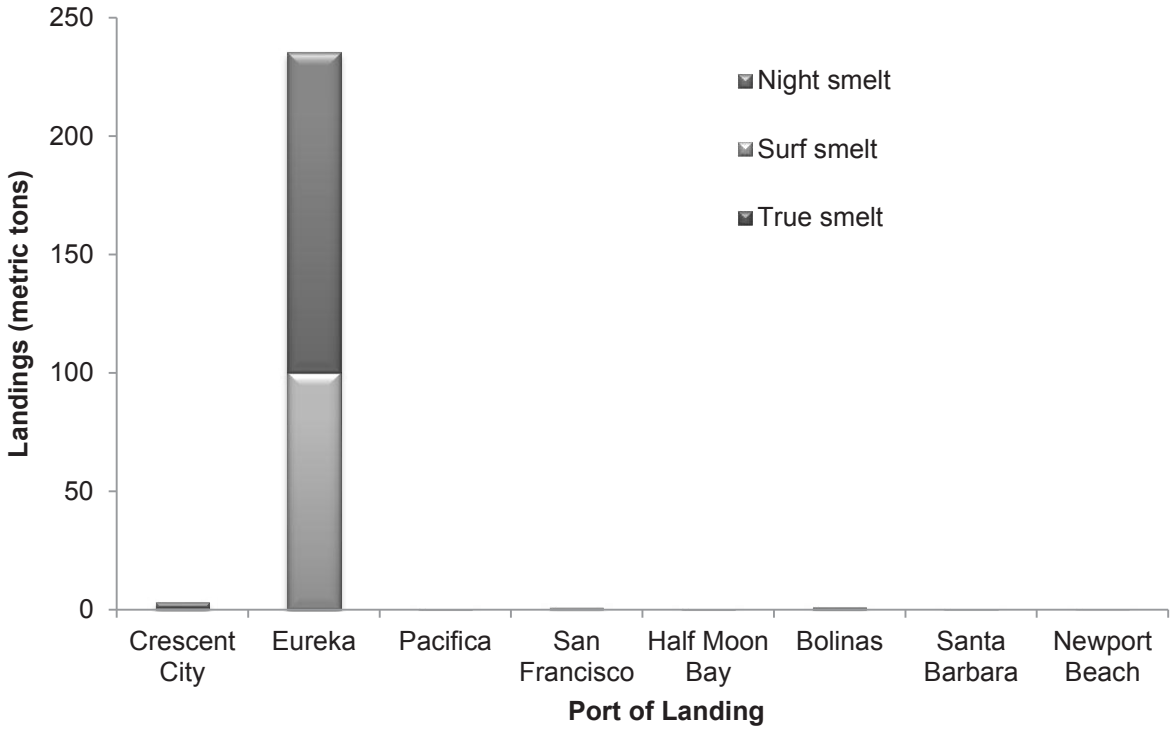

Figure 21. Statewide Osmerid landings by port, 2014.

Commercial landing records for all Osmerid and Atherinopsid species from 1916 through 1969 were recorded as "smelt" and "whitebait smelt." "Smelt" was comprised of surf smelt, but may have also included silversides—jacksmelt, topsmelt, and grunion, depending on the individual fish buyer and region. "Whitebait smelt" was primarily night smelt and similarly sized but less abundant Osmerids including whitebait, longfin smelt, and delta smelt.

After 1969, the "smelt" category was replaced by the "true smelt" and "silversides" market categories to capture Osmerids and Atherinopsids, respectively. True smelt included all Osmerids except whitebait and night smelt; however it is important to note that whitebait was the only Osmerid market category preprinted on receipt books provided to fish buyers to record catch. Therefore, it appears likely that whitebait included other Osmerid species including surf smelt and night smelt. Market categories were created for silversides (unspecified Atherinopsids) including jacksmelt, topsmelt, grunion, night smelt, and surf smelt.

Over time, true smelt and whitebait landings steadily declined as the use of night smelt and surf smelt market categories on fish receipts increased. The decline in true smelt and whitebait landings is attributed to phasing out these market categories as receipt books were replaced rather than changes in species abundances. Use of night smelt and surf smelt market categories was initiated in 1970. In 2014, the true smelt market category composed less than 0.07% of the total Osmerid landings and whitebait landings dropped to zero. Currently, receipt books have preprinted categories for night smelt and surf smelt as well as jacksmelt.

From 1977 to 2014, the combined commercial catch of the Osmerid market categories, primarily night smelt and surf smelt, ranged from 102.5 t in 2005 to 941.4 t in 1996 (fig. 19). Ex-vessel value of the landings ranged from $43,500 in 1971 to $608,000 in 1995. In 2014, night smelt landings totaled 138.5 t with an ex-vessel value of $169,000; surf smelt landings totaled 102.2 t with an ex-vessel value of $157,000. Fish processors paid an average of $1.37/kg ($0.62/lb) and $1.28/kg ($0.58/lb) for night smelt and surf smelt respectively, in 2014. The last commercial eulachon landing was recorded in 1974.

Commercial landings of night smelt and surf smelt indicate peaks in April–May and June–July, respectively (fig. 20). Night smelt begin spawning in late winter while surf smelt begin appearing in the spring. Both species are found on the same beaches but are fished at different times of the day—surf smelt are also called "day fish" or "day smelt" and are caught typically during daylight hours while night smelt are fished at dusk. Landings of both species are often caught on the same fishing trip.

Over 97% of the 2014 statewide commercial Osmerid harvest was landed in Eureka with the remainder landed in the ports of Crescent City, San Francisco, and Half Moon Bay (fig. 21). Landings reported from

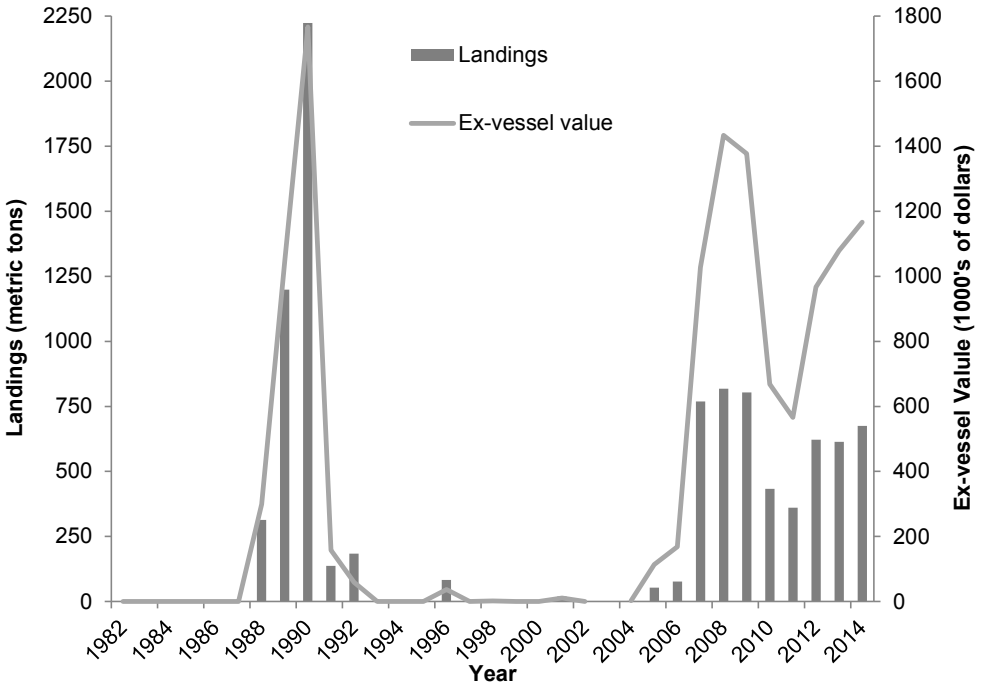

Figure 22. California commercial landings of Pacific hagfish (*Eptatretus stoutii*), 1982–2014

Santa Barbara and Newport Beach as Osmerids may be Atherinopsids.

Historical recreational landings data on Osmerids is extremely limited. An estimated 181 t of unspecified smelt were taken in 1958 based on the results of a Department of Fish and Game recreational fishing survey. Subsequent MRFSS and CRFS estimates ranged from 5 t in 2000 to 199 t in 1984 for surf smelt. Night smelt recreational landing estimates have been sporadic. Recent estimates are unavailable due to safety concerns and logistical issues related to night time data collection and assignment of the Osmerids as a low priority species. Results of the MRFSS ranged from 0.01 t in 1982 to 16 t in 1980. Recreational estimates of annual surf smelt take have varied widely, most likely because this species is rarely encountered in the Department's recreational fishery surveys. Eulachon was listed as a threatened and endangered species by NOAA in March 2010 resulting in the closure of California's sport fishery in 2012 to conform with federal regulations.

Hagfish

Pacific hagfish (*Eptatretus stoutii*) are a member of the Myxinidae (hagfishes) family. Members of this family are cartilaginous, lack eyes and jaws, and have a single nostril with several barbels. The most notable characteristic of hagfishes are the series of mucus-producing "slime" glands along each side of the fish's body. This thick, sticky, protein-based mucus, in the presence of water, converts into a jelly like slime. Produced when agitated, this slime may act as a defense mechanism. Pacific hagfish (hagfish) prefer muddy substrate in depths from 9–732 m. Considered scavengers, hagfish feed upon dead fish and marine mammals, or any other animal matter they can find. Knowledge of maturation and fecundity is limited although studies indicate that females attain sexual maturity between 325 and 340 mm TL, and are between 7 and 12 years. Hagfish fecundity is low with a female hagfish producing 20–30 eggs per reproductive cycle. Reproductive cycle length is unknown, since viable female hagfish may contain eggs that are of various stages of maturity.

Prior to 1988, hagfish landings in California were nonexistent. However, hagfish imports were in great demand by South Korea due to a localized depletion of two related species, brown hagfish (*Paramyxine atami*) and inshore hagfish (*Eptatretus burgeri*). In 1988, a Korean hagfish importer recruited San Francisco and Monterey fishermen to target hagfish for export to South Korea. Statewide landings and fishing effort expanded in 1989 leading to 1,199 t of landed hagfish (fig. 22). By 1990, hagfish landings from Eureka to San Diego resulted in a record high of 2,223.5 t. Hagfish were euthanized with the fish anesthetic MS222 to prevent captured fish from sliming and biting each other. Landed in fresh-dead condition, hagfish were then frozen, and shipped for use in the Korean leather goods market. Due to Korean processing laws and the use of MS222, imported hagfish were used for their skin only and the flesh was discarded. In the latter part of 1990, Korean demand for

California-caught hagfish decreased due to unexplained blemishes, holes, and marks on the skins. Due to these imperfections, hagfish from California became less desirable and South Korean importers took an interest in hagfish exported from British Columbia. Ex-vessel price declined in 1990, but fleet efficiency allowed for the continuation of the California fishery. Ex-vessel price continued to drop in subsequent years, leading to reduced effort and participation.

From 1993 to 2004, annual landings exceeded 20 t in only one year (1996) and averaged 8.9 t. Fishing effort and catch began to increase in 2005 as hagfish were exported in live condition for human food at a greater ex-vessel price, with 54 t landed and a rise again in 2006 with 77 t landed. In addition to resurgence in Korean demand, displaced commercial fishermen were looking for other sources of income, which by 2008 resulted in the highest landings since 1990 of 818 t, valued at $1.43 million. Landings remained high in 2009 with 803 t, valued at $1.38 million. In 2010, while some displaced fishermen returned to their respective fisheries, new fishermen began entering the fishery. From 2010 to 2014, landings were more consistent, averaging 541 t per year (range from 361 to 675 t).

As of 2015, California fishermen face heavy competition in the Korean import market. South Korean hagfish importers also purchase hagfish from Washington, Oregon, and from Korean-sponsored fishermen in Mexico. Hagfish from Washington and Oregon are on average larger than California hagfish and Mexican fishermen are selling hagfish at low market prices. Despite the adversity faced by California fishermen, South Korean import demand of hagfish remains consistent, resulting in regular landings by California fishermen. In 2014, five port complexes and 33 vessels contributed to a landings total of 675 t at an ex-vessel value of $1.17 million. The top three port complexes were Eureka, Morro Bay, and Bodega Bay.

Hagfish may be taken commercially using bucket traps or Korean traps primarily in the depth range of 55–185 m, although fishing occurs out to 370 m. A bucket trap consists of a 5-gallon bucket with a self-closing plastic cone fixed to the bucket lid. The plastic cone acts as a one-way entrance into the trap. Buckets have many drilled holes to allow water flow and possible escapement of small hagfish. Bucket traps are fished on a central ground line with a single vertical line and marker float. Korean traps (currently not used in California) are small, elongated plastic cylinders no greater than 15.24 cm (6 in) in diameter and no more than 60.96 cm (24 in) long. Korean traps employ the same type of plastic cone for an entrance; however, trap holes are smaller and prefabricated. Vessels are limited to 500 Korean traps or 200 bucket traps. No species other than hagfish may be possessed or sold when Korean or bucket traps, or hagfish, are on board the vessel. All traps must have a destruct device, and time-released buoys (pop-ups) are prohibited. Only a general trap permit is required to participate in this open access fishery. Traps are baited with fish, squid, or fish carcasses.

Prior to January 2015, there was no restriction in California on minimum trap hole diameter. In 2013, as part of a collaborative project between the Department and industry to determine the influence of hole diameter in bucket traps on average size of retained hagfish, fishery participants were interviewed to determine what hole diameters were being used. The two common hole diameters were 12.7 mm (1/2 in) and 14.3 mm (9/16 in). Based on this knowledge, the Department conducted a fishery-independent hagfish study in Monterey Bay in 2013, using bucket traps with four different hole diameters, including the two above. Traps with 14.3 mm holes saw a resource benefit of a 10% reduction in retained immature hagfish compared to traps with 12.7 mm holes. Because of this work, a new regulation was developed by the Department and adopted by the Fish and Game Commission (Commission). Effective in January 2015, it is required that all holes in hagfish traps, except for the entrance, be no less than 14.3 mm in diameter.

In 2013, two commercial fishermen requested Experimental Gear Permits from the Commission to use individually floated, 151.4 L (40 gal) barrel traps. The fishermen suggested that the proposed gear might reduce negative gear interactions with other benthic fisheries and reduce dead loss of hagfish from crowding. Pending favorable evaluation, this gear could offer hagfish fishermen a third alternative for the take of hagfish. In addition to onboard observations, Department staff evaluated this gear through logbooks and laboratory dissection of hagfish retained from observed trips. Evaluation of this experimental gear concluded in April 2015 with a regulation proposal expected for August 2015.

Since late 2007, the Department's Northern/Central Finfish Research and Management Project (Project), formerly the State Finfish Management Project, has monitored hagfish fishing activity through dock sampling and laboratory dissection. Due to the difficulty in measuring live hagfish, Project staff use average count per kg from sampled landings to document changes in average size of hagfish. Specimens are collected and examined for length, weight, sex, and maturity.

Deep Water Visual ROV Surveys of MPAs and Surrounding Nearshore Habitat

In December 2012, California implemented the largest scientifically designed network of Marine Protected Areas (MPAs) in the United States, following an MPA

Figure 23. The ROV *Beagle* being launched off Campus Point State Marine Conservation Area.

design and siting process led by the California Department of Fish and Wildlife (Department). This design process spanned eight years across four coastal regions, including the central coast region (2004–07), north central coast region (2007–10), south coast region (2008–12), and the north coast region (2009–12). Regional MPA baseline monitoring programs began in each of the four coastal regions shortly after each implementation. These programs are administered through a partnership among the Ocean Science Trust, Ocean Protection Council, California Sea Grant, and the Department. The research is conducted by scientists from various research institutions, agencies, and nongovernment organizations. Deep water visual surveys have been an important component of each of these regional programs. The purpose of this report is to highlight the Department's work conducting deep water (20–300 m) visual surveys along California's coast inside and outside MPAs using a remotely operated vehicle (ROV). These Department led surveys are separate but complimentary to the regional baseline monitoring programs (including other ROV surveys) and substantially increase the geographic coverage of deep water monitoring throughout the statewide network.

Even before the Marine Life Protection Act and the implementation of California's redesigned MPA network, the Department has been at the forefront of efforts to use ROVs for subtidal ecosystem monitoring. In 1999, Department scientists began developing techniques for using ROVs for MPA monitoring and in 2001 completed the first extensive baseline survey of an MPA in California using an ROV at Punta Gorda Ecological Reserve on the remote rugged coast near Cape Mendocino. Since then, the Department has successfully completed substantial surveys in all four of California's MPA regions. Data gathered from these surveys, on the abundance and distribution of fish and invertebrates, have provided much needed characterization of the baseline ecological condition of California's vast deep water habitats.

In January 2014, the Department initiated new ROV expeditions to explore deep water habitats in each of the four MPA regions. These quantitative surveys occur both inside and outside California's MPAs, at locations previously identified using bathymetric data collected by the California Seafloor Mapping project (CSMP). The CSMP created high resolution maps of predicted rocky habitat which has provided the information necessary to identify index sites for continued monitoring. Within these index sites the project characterizes ecological conditions by quantifying and describing the abundance and distribution of fish and invertebrate species. For these expeditions the Department is contracting with its longtime partner Marine Applied Research and Exploration (MARE) who is providing the ROV *Beagle* (fig. 23) as well as extensive operational and data processing expertise.

Three deployments were successfully completed in 2014 beginning a three year statewide survey. In January 2014, surveys were completed between Point Conception and Santa Barbara with additional survey sites at Anacapa and Santa Cruz Islands. In June 2014, the sec-

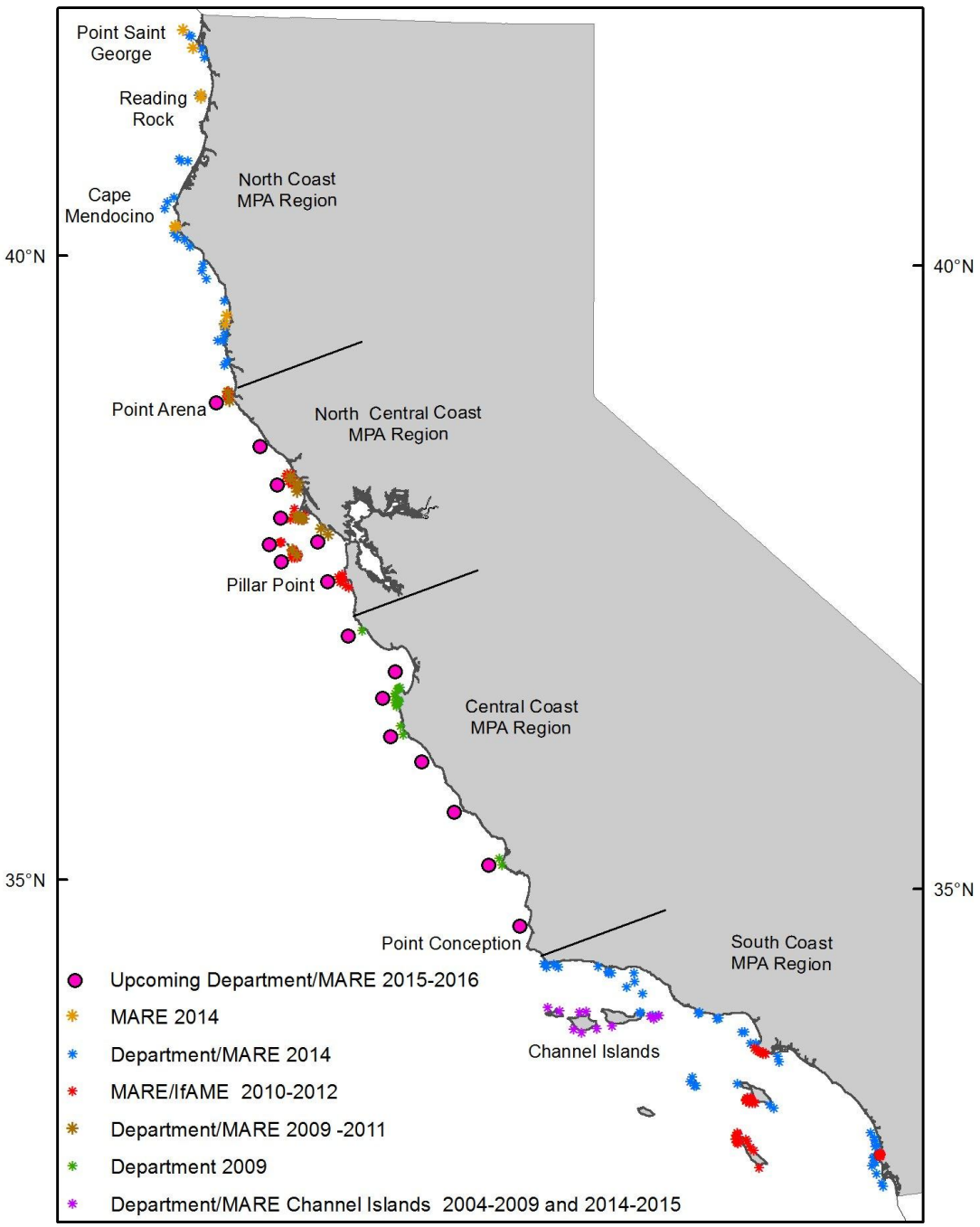

Figure 24. Map of ROV survey areas visited during 2014, historic survey sites (Department, MARE, and IfAME), and sites planned for 2015–16.

ond deployment surveyed the remainder of the south coast region from Point Dume to San Diego, including sites at Santa Barbara and Catalina Islands. In September and October 2014, a third deployment surveyed deep habitat within the north coast MPA region from Crescent City to Albion. Throughout all 2014 ROV surveys, additional sites outside MPAs were also visited. These sites allow the Department to further expand on ROV data for habitat characterization and species distributions, while also providing reference sites to allow comparisons to MPA sites over time (fig. 24).

Surveys completed in 2014 collected video and still imagery from 81 distinct sites. Twenty MPAs were visited including eleven state marine reserves (SMRs) and nine state marine conservation areas (SMCAs), two of which are designated as no-take. Over 200 km of video strip transects were performed resulting in 108 hours of video. Along these transects over 15,000 high resolution still

Figure 25. Selected photos taken during surveys of the South Coast MPA region: a) vermilion and copper rockfish (*Sebastes miniatus, S. caurinus*) aggregations at Campus Point SMCA, b) warty sea cucumbers (*Parastichopus parvimensis*) at Anacapa Island SMR, c) brittle stars and dying gorgonian coral at Anacapa SMR, and d) natural tar deposits at Point Conception SMR.

images were captured. At the date of this writing much of this imagery is still being processed for habitat classification, species identification, and spatial referencing.

The first two deployments of 2014 revealed interesting features of southern California MPAs. In Point Conception SMR, areas that were thought to be rocky habitat (as characterized by the CSMP) were found to be natural tar deposits (fig. 25d). Subsequent examination of the ROV imagery and bathymetric maps indicate that these tar deposits (also called tar mounds or tar volcanoes) may cover over 3 km^2 of seafloor within and near the SMR. Scattered throughout these tar mounds, small areas of less viscous tar were observed oozing from the seafloor along with bubbles of methane gas. Fish and invertebrates were less abundant in and around these deposits and biodiversity appears to be lower compared to nearby sites with rocky habitat.

Dense aggregations of rockfish, predominantly vermillion, copper, and flag rockfish (*Sebastes miniatus*, *S. carinus*, and *S. rubrivinctus,* respectively) were observed at several locations inside and outside of Campus Point SMCA and Point Conception SMR (fig. 25a). We suspect these aggregations may be spawning related as multiple fish were observed with bulging abdomens which may indicate gravid females.

An undocumented bed of geoduck clams (*Panopea generosa*) was discovered inside Naples SMCA. Using the location identified by the ROV, Department divers later confirmed this by collecting geoducks from the area and other nearby areas. A handful of locations in southern California waters were known to have beds of subtidal geoduck clams and recent explorations by Department divers continue to find more locations. This bed is one of the first documented on the mainland coast and appears to extend deeper (>40 m) and contains densities higher than beds observed in other areas.

A portion of the first southern California deployment was focused on exploring areas of sea cucumber trawl

TABLE 7
Preliminary densitities (number of individuals/100 m² of overall ROV survey transect area without taking into account habitat type) of giant red and warty sea cucumbers (*Parastichopus californicus* and *P. parvimensis*) observed at Anacapa Island, mainland sites (Campus Point and Santa Barbara), and trawl ground sites. No surveys were performed in study area and depth combinations without values.

Study Area—Species	Density (Number of Individuals / 100 m²)										
Anacapa Is.—Warty	16.4	5.5	4	0.7	0	0	0	0			
Anacapa Is.—Giant Red	0	0	0	0	0.3	4.6	9.4	1.7			
Mainland—Giant Red	0	0.1	0.4	0.7	0.8	19.3	6	2.3			
Trawl Grounds—Giant Red									1.9	0.1	0.3
Depth Range (meters)	42297	20–30	30–40	40–50	50–60	60–70	70–80	80–90	90–100	100–110	110–120

grounds to examine densities and habitat of the giant red sea cucumber (*Parastichopus californicus*) in areas where there is high fishery effort. Giant red sea cucumbers were observed in high densities in Campus Point SMCA and in deep areas of Anacapa SMR (table 7). Densities in the deeper (90–120 m) trawled areas were lower than in the mainland sites and deep (40–80 m) portions of Anacapa. Rocky habitats in shallower waters of Anacapa Island sites were also surveyed for the warty sea cucumber, *P. parvimensis* (fig. 25b), which is the target of a commercial dive fishery. Warty sea cucumbers were found in high densities in the shallower (10–40 m) areas of the Anacapa Island SMR and SMCA. These surveys documented sea cucumber densities during the winter period which is generally a period of very low catch rates for the trawl and dive fisheries. These surveys are the first to try to document seasonal changes of abundance in deep areas (40–100 m) of MPAs where abundance is not affected by fishing. Distribution and abundance data collected on these commercially fished sea cucumbers are providing much needed information that will aid the Department's management of these expanding and valuable fisheries.

In and around the Anacapa SMR and SMCA dense beds of brittle stars (Ophiouroids) cover vast areas of sandy and rocky habitats forming mats up to 10 cm thick over the substrate in depths from roughly 15–40 m. A noticeable increase in area covered and density was observed in the January surveys compared to Department surveys in 2004–09. In the same areas many gorgonian corals appear to be dead or dying compared to what was seen in previous surveys (fig. 25c). The Department is working with MARE to further investigate these findings and quantify the increase of brittle stars and decrease of gorgonian corals.

The second deployment in southern California looked at mainland areas between San Diego and Point Dume as well as sites at Santa Catalina Island and Santa Barbara Island. Some of these sites targeted low-relief, sparse rocky areas that are surrounded by vast areas of sandy habitat along the mainland coast. Although scattered across large areas, these low-relief habitat patches may be important to fish populations in nearshore waters of southern California where rocky habitat is less prominent than in central and northern California.

Rockfish abundance and size was greater in north coast areas than southern California. Juvenile and adult lingcod (*Ophiodon elongates*) were abundant in both north and south surveys, although increased size and abundance was evident in the north (fig. 26b). Patchy distributions of fish were observed with some areas surprisingly devoid of common species. This patchiness was most common in areas with large, expansive low-relief, rocky reef areas. The north coast's complex and dynamic habitats that are swept by strong ocean currents, large waves, and receive increased sedimentation from rivers, may be influencing these patchy distributions. For example, greater fish abundance and more invertebrates were observed on the northern side of Reading Rock offshore of Orick, (fig. 26b). Inside Reading Rock SMR, on the south side of the actual sea stack, very few fish and sparse invertebrate growth was observed in rocky habitats covered with fine sediment (fig. 26a). River mouths adjacent to Reading Rock (Klamath River and Redwood Creek) deposit large volumes of sediment into the surrounding waters during winter storms. Local winds and currents may be washing away this sediment from the north side of Reading Rock creating the differences observed. Similar areas of sediment impacted reefs were observed at sites around Point Saint George Reef and Crescent City.

The Department's efforts compliment other deep water ROV survey efforts in California waters using the same or similar equipment and methods. Researchers at MARE and Institute for Applied Marine Ecology (IfAME) at California State University, Monterey Bay collaborated to examine the deep habitats of several MPAs as part of the baseline monitoring projects in the north central (2010–11) and south coast (2011–12) MPA regions. The current Department survey builds off these surveys and fills in data gaps by visiting MPAs and outside reference areas that have not been surveyed, as well as revisiting some MARE/IfAME sites.

In the south coast, Department surveys coincided with a MARE-led project focused on revisiting the Channel

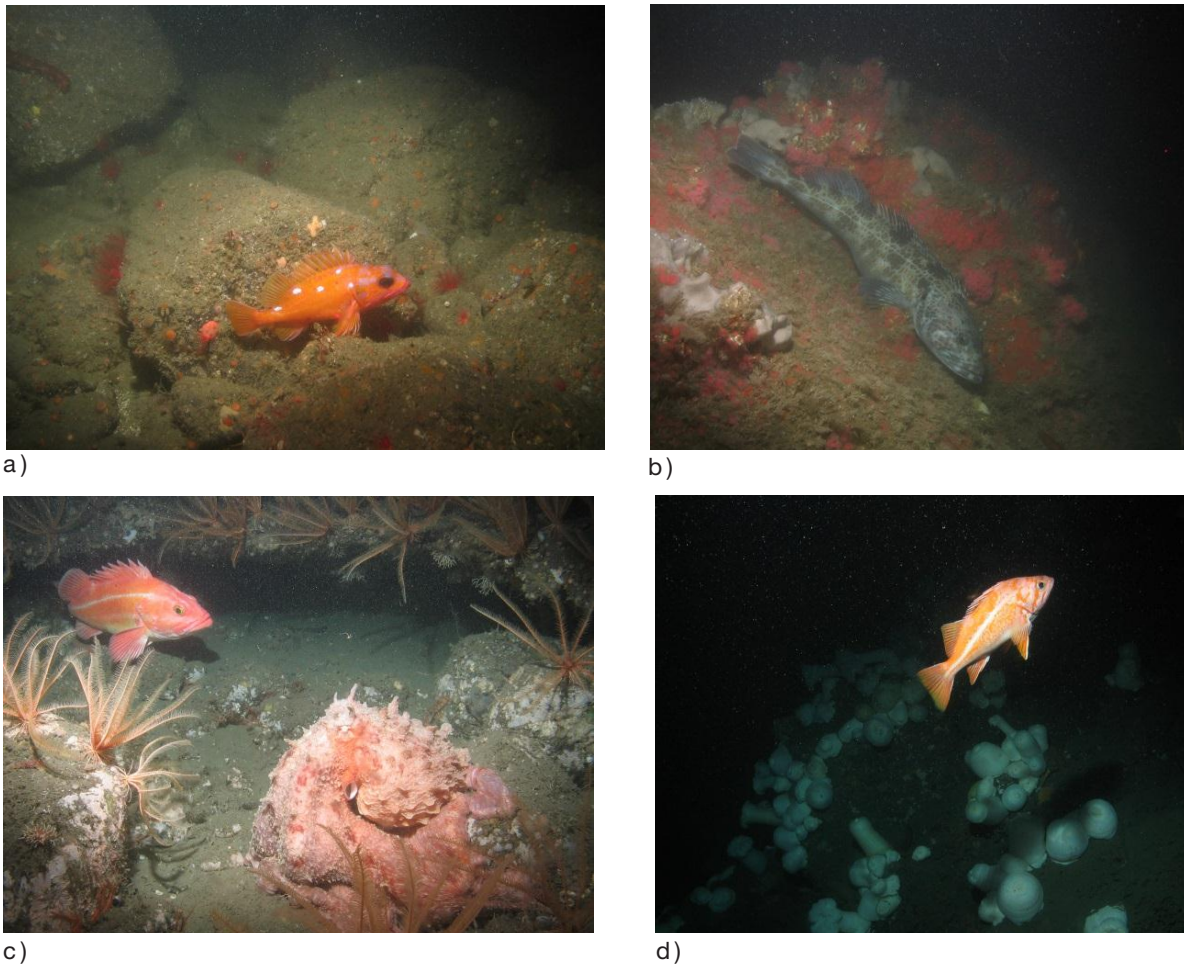

Figure 26. Selected photos taken during surveys of the North Coast MPA region: a) rosy rockfish (*Sebastes rosaceus*) in sediment impacted rocky habitat of Reading Rock SMR, b) lingcod (*Ophiodon elongates*) in rocky habitat less impacted by sediment outside of Reading Rock SMR, c) yelloweye rockfish (*Sebastes ruberrimus*) and giant Pacific octopus (*Enteroctopus dofleini*) at Sea Lion Gulch SMR, and d) a canary rockfish (*Sebastes pinniger*) at Sea Lion Gulch SMR.

Islands sites previously surveyed from 2004-09. These surveys are looking for potential ecological changes that arose 10 years after MPA implementation. Similarly, in 2014 the Department combined its statewide survey project with MAREs north coast MPA baseline project. During this four week long joint research cruise aboard the RV *Miss Linda*, MARE and the Department each visited four MPAs completing 52 km and 58 km of transects, respectively. Additionally, the Department surveyed another seven locations within the region, focusing on prominent rocky habitat areas. This collaborative partnership provided much greater coverage of deep water habitats than was possible in any of the previous regional baseline monitoring programs.

In 2015 and 2016, researchers will revisit MPAs in the north central coast MPA region where both MARE/IfAME and the Department surveyed in 2009–11. Similarly, researchers will revisit sites in the central coast region, originally surveyed by the Department in 2007–09, and fill in data gaps while visiting additional MPAs and reference sites that were not part of the first surveys. When complete this effort will result in unprecedented coverage of nearshore deep water habitats across the entire coastline of California (fig. 24).

After completion of data processing and summary analysis, technical reports of each ROV deployment will be made available. Each report will summarize the abundance of fish and invertebrates, and will provide a characterization of habitats and stereographic sizing of select fish species. An in-depth analysis of the statewide data set by Department scientists may include investigations on distributions of managed species inside and outside MPAs, size structure of select fish species, descriptions of unexplored deep water habitats, and other findings that emerge from this extensive data set. Particular attention has been placed on directing survey effort both inside and outside MPAs, and in rockfish conservation areas where rocky habitats important to the overfished

yelloweye and canary rockfish (*Sebastes ruberrimus* and *S. pinniger*) are found (figs. 26c–26d). Analysis of survey data will examine distribution, habitat preference, and size structure of these protected species. Analyses will also focus on areas within the north coast region where frequent encounters of these protected species by recreational anglers impose restrictive fishing seasons, depth restrictions and catch limits. Department scientists are also exploring collaborative partnerships to analyze the extensive data set that will result from these surveys. The data sets will be made available to researchers, and will likely provide opportunities to study many species of fish and invertebrates in relation to MPA effectiveness and fishery management.

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