



## History and status of commercial live fish fisheries in California and the United States West Coast

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The coastal waters of the state of California, on the west coast of the United States, support a diverse range of substrates and depths, including deep submarine canyons, offshore islands and an extended shallow water shelf. Below 34°N the coastline takes on a more east–west orientation, creating a recognized biogeographical break in the coastline at Point Conception (Fig. 1). It is at Point Conception that the colder California Current from the north and the warmer California Countercurrent from the south meet. Although there are some cosmopolitan bottom-associated species, such as some rockfish and cabezon, for the most part, the composition of commercially targeted fish species differs greatly north and south of Point Conception. The part of the state north of Point Conception is referred to here as “northern California”, and the part to the south, “southern California”.

Since its emergence in the late 1980s, California’s live fish commercial fishery continues to make up a small but significant portion of the state’s total commercial finfish catch. Live landed commercial fishing evolved from the demand for specialty foods in Asian restaurants and markets in southern California (McKee 1993). What started out as an alternative fishery quickly expanded into a multimillion dollar industry by the early 1990s (Table 1). Part of the reason for this boom was the willingness of consumers to pay a much higher price for live fish than dead fish of certain species, particularly plate-sized fish. That premium was passed on to fishermen in the form of higher ex-vessel prices (price per unit of weight paid to fishermen upon landing of catch) for live fish. Many establishments offered consumers the opportunity to pick out a fish of their choice from tanks right in the restaurant. In general, a mar-



**Figure 1.** The west coast of the United States and the northeast Pacific Ocean, showing Point Conception as the boundary between northern and southern California.

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ket developed for fish that live in shallow waters close to shore and did not necessarily require a large boat to capture. In many cases there was no need for fishermen to bring fish to market at all; the buyer would meet a fisherman right at the dock to transport catch directly to the restaurant or market in a live state. Among other evolving issues, it was the rapid expansion and mobile nature of the fishery and the small target size of certain species that began to concern fishery managers.

**Table 1.** Approximate landings, ex-vessel value, and average ex-vessel prices in California of the 10 most commonly landed commercial live fish categories, 1994–2005 (values and prices have been adjusted for inflation and are expressed in 2005 US dollars, USD).

Year	No. of fishermen with at least one live landing	Catch weight (t)	Ex-vessel value (USD)	Average price (USD/kg)
1994	822	738.0	4 804 114	6.51
1995	690	928.9	6 099 216	6.57
1996	885	888.0	5 942 269	6.69
1997	870	619.0	4 946 402	7.99
1998	774	666.7	5 274 173	7.91
1999	712	690.0	5 790 128	8.39
2000	709	688.5	6 363 915	9.24
2001	583	533.3	4 995 232	9.37
2002	545	562.0	4 954 629	8.82
2003	461	541.8	4 598 976	8.49
2004	408	612.3	5 317 027	8.68
2005	376	574.2	4 912 218	8.56
Average	653	670.2	5 333 192	8.10

Ten major groups of fish are included in this article: rockfish (family Scorpaenidae, comprising 45 different species), California sheephead (called “sheephead” hereafter, *Semicossyphus pulcher*), halibut (*Paralichthys californicus*), thornyheads (genus *Sebastolobus*), sablefish (*Anaplopoma fimbria*), cabezon (*Scorpaenichthys marmoratus*), lingcod (*Ophiodon elongatus*), eels (*Gymnothorax mordax*, *Anarrhichthys ocellatus*), surfperch (family Embiotocidae), and greenlings (genus *Hexagrammos*) (Table 2). Most live on or near the bottom and are considered groundfish or are nearshore species with limited migration. The majority are both — that is nearshore groundfish — making them good candidates for live harvesting with trap or hook-and-line. These groups represent the species most commonly targeted by live fish fishermen in California; live catches from other species groups are negligible. With the exception of halibut, thornyheads and sablefish, all are targeted in size for individual meal portions (i.e. plate-sized). Halibut, thornyheads and sablefish are landed live for the

fresh fish market and are usually not targeted in size for individual restaurant portions. Although there are many species in California’s commercial live fish fisheries, for the purpose of this article, live fish refers to finfish (vertebrates) only.

Data from the California Department of Fish and Game’s (CDFG) California Fisheries Information System (CFIS) landing receipt database were used for all analyses presented in this article. The database includes receipt data from transactions at the first point of sale. Buyers are required to complete and submit to the CDFG receipts for all such transactions that take place in the state. Although these landing receipts indicate whether a given landing comprised live or dead fish, those indications are not reliable. In order to estimate quantities of live fish landings from the landings data, prices were used to differentiate between the two products. Since the prices paid for live fish tended to be substantially greater than for dead fish (from two-fold to many-fold, depending on species, condition and size), the price distributions from landing receipt data were analyzed to determine a threshold price that could be used to distinguish live from dead catch for each of the ten harvest groups examined here. Landing weight, gear types and personal communication with the fishing industry were also considered in

order to characterize live catch. Due to complexities involved in determining live landings, including variability in prices, all numbers reported here should be viewed as approximate.

**Table 2.** Average annual commercial landings in California of the top live fish species groups, 1994–2005.

Harvest group	Average annual landings (t)
Rockfish	269
Flatfish	100
Thornyheads	82
Sheephead	67
Cabezon	54
Sablefish	39
Lingcod	36
Perch	17
Greenlings	6
Eels	1

Southern California's live fish fishery is dominated by rockfish, halibut, thornyheads and sheephead (Table 3). One of the few members of the wrasse family (Labridae) on the Pacific coast of North America, sheephead (Fig. 2), is a protogynous hermaphrodite (Love 1996). Sheephead begin their lives as females and after maturing, most, if not all, change sex and become males. These are very colourful and unique looking fish that, according to one high-volume dealer from southern California, resemble a food fish favoured in parts of Asia (Palmer-Zwahlen et al. 1993). This resemblance probably explains why California's live fish fishery started with trap-caught sheephead bound for California's ethnic Asian market.

One of the major concerns with sheephead and other species targeted in live-fish fisheries has been that the market demand is for single serving-sized



**Figure 2.** Male (top) and female morphs of California sheephead (Photo: David Ventresca, CDFG).

fish, approximately 0.5–1.0 kilograms (kg) in size (McKee 1993). It is likely that most, if not all, sheephead of this size are females, including some that are reproductively immature (Tegner and Dayton 1997). The repercussions of such a fishery are that targeting the female reproductive potential could lead to depletion over a much shorter time than for fish without such life history characteristics. Similar concerns about overfishing have been expressed on the other side of the Pacific Ocean for another member of the Labridae family, the humphead wrasse or Maori wrasse (*Cheilinus undulatus*), a large coral reef-associated fish with similarities in sexual development.

Regulations that limit the total allowable annual commercial catch of sheephead went into effect in 2001 and may partially explain the decline in catch in recent years, but there is evidence that the average size and availability of this species were on the decline prior to 2000 (Alonzo et al. 2004). The catch of live sheephead has diminished nearly every year since its peak of 112 metric tonnes (t) in 1997. In addition to total allowable catch restrictions, sheephead (regardless of whether landed dead or alive) are managed by CDFG through minimum size limits and by limiting the number of participants allowed in the commercial fishery. CDFG has also considered various slot size limits (i.e. both minimum and maximum size limits) and different seasonal options for the fishery.

In 2004 the first ever stock assessment was completed for sheephead and the stock size was found to likely be less than 50% of its unfished size (Alonzo et al. 2004). Consequently, stepwise reductions in the allowable annual state-wide commercial catch have been established, starting with 34.1 t

**Table 3.** Commercial landings in southern California of the top 10 live-landed harvest groups, 1994–2005.

Year	Cabezon		Halibut		Lingcod		Rockfish		Sheephead		Total
	Eels		Greenlings		Perch		Sablefish		Thornyheads		
1994	4.9	3.7	43.3	trace	1.3	0.1	194.2	33.5	83.8	21.2	386.0
1995	3.5	3.1	74.2	trace	1.1	0.0	180.3	1.5	86.3	21.6	371.7
1996	7.9	2.2	78.9	0.4	1.9	0.1	142.0	0.0	84.3	22.5	340.2
1997	9.6	1.6	77.1	0.1	2.3	0.3	80.8	0.1	112.2	30.0	314.1
1998	14.1	1.4	64.3	0.0	3.7	0.3	106.1	0.1	95.3	25.8	310.9
1999	11.1	0.3	101.2	trace	2.0	0.3	84.2	1.5	51.7	36.6	288.9
2000	17.4	0.9	96.6	trace	1.1	1.2	58.9	0.8	64.3	54.3	295.5
2001	9.5	0.1	86.8	trace	1.5	0.2	54.7	1.4	52.5	65.8	272.4
2002	5.0	0.5	100.3	trace	1.8	0.8	48.9	6.9	46.0	82.6	292.9
2003	4.3	0.4	74.5	trace	2.8	1.4	32.1	5.3	43.5	126.4	290.7
2004	3.9	0.4	99.4	trace	3.1	4.9	39.5	6.5	37.1	131.5	326.2
2005	1.5	0.3	66.6	trace	1.8	2.6	29.2	10.8	38.1	134.6	285.5
Average	7.7	1.2	80.3	trace	2.0	1.0	87.6	5.7	66.3	62.7	314.6

Note: "trace" indicates landings of less than 0.05 t.

in 2005 and leading to an allowable catch of 12.8 t in 2008. The 2004 stock assessment results will be used as a baseline for comparison with future stock assessments and will be valuable in gauging the success of current rebuilding efforts.

California halibut is in high demand by sushi restaurants and is worth more when landed live. In 1999, halibut overtook rockfish and sheephead as the group with the greatest amount of live-catch for southern California. However, from 2002 onward, thornyheads has been the dominant group in the catch south of Point Conception. The thornyheads catch has increased in nine of the last ten years, going from approximately 21 t in 1994 to 135 t in 2005 (Table 3). The top five (by weight) harvest groups landed by weight in southern California in 2005 were, in descending order, thornyheads, halibut, sheephead, rockfish and sablefish.

In northern California the live fish catch has been traditionally dominated by rockfishes (Fig. 3), cabezon, and lingcod (Table 4). Sheephead are uncommon north of Point Conception. As with sheephead, the life history characteristics of rockfish also play a major role in the sustainability of the fishery, although in a much different way than for sheephead. In general, rockfish are relatively slow to mature and have a closed type of swim bladder (in which air cannot escape from the bladder through the mouth) that aids in swimming and energy conservation. The evolutionary advantage provided by having a closed swim bladder becomes a disadvantage to rockfish when they are brought to the surface from any depth greater than approximately 10–15 metres. The decrease in pressure in bringing a fish from deeper to shallower

water can cause over-expansion of the swim bladder and has a suffocating effect on the fish. Because the survival rate of released fish is consequently low, minimum size limits on rockfish would be relatively ineffective as a management strategy.

Some species of rockfish live to an age of more than 100 years, although California's nearshore species have a shorter life expectancy. Studies of some nearshore rockfish species have shown that reproductive success increases with age and size (Berkeley et al. 2004) and rockfish are capable of reproducing throughout their adult lives. As with the sheephead fishery in southern California, removal of too many immature rockfish from a population before they have a chance to spawn can have a lasting effect.

The top five rockfish species landed live in northern California, by weight, in 2005 were, in descending order: black, brown (*Sebastes auriculatus*), gopher (*Sebastes carnatus*), grass (*Sebastes rastrelliger*) and black-and-yellow (*Sebastes chrysomelas*) rockfish, with combined landings of 113 t. The top five rockfish species landed live in northern California, by value, in 2005 were, in descending order: brown, gopher, black, grass and black-and-yellow rockfish, with a combined ex-vessel value of USD 1.1 million. In 1995, the top live-caught harvest groups from northern California, by weight, were rockfish, sablefish, cabezon, halibut and lingcod (Table 4). By 2005 the top groups had changed to rockfish, lingcod, halibut, sablefish and thornyheads.

Although seven species of rockfish have been declared overfished by the US federal government

**Table 4.** Commercial landings in northern California of the top 10 live-landed harvest groups, 1994–2005.

Year	Cabezon	Eels	Halibut	Greenlings	Lingcod	Perch	Rockfish	Sablefish	Sheephead	Thornyheads	Total
1994	18.2	1.3	32.7	0.7	19.6	36.5	212.6	28.5	1.2	0.6	351.9
1995	45.0	0.3	29.1	0.4	26.2	19.8	270.4	162.2	1.5	2.2	557.2
1996	62.6	0.3	26.0	1.4	33.8	14.9	293.2	113.4	1.2	1.2	547.8
1997	57.3	0.1	22.9	1.8	33.8	15.2	166.3	6.1	1.1	0.2	304.8
1998	95.5	0.1	12.4	5.5	40.6	20.2	168.7	1.3	0.7	10.8	355.8
1999	71.8	trace	16.0	12.5	55.8	6.6	187.5	1.9	1.1	48.0	401.1
2000	69.3	0.1	25.6	21.5	46.7	10.0	176.8	18.3	0.7	24.1	393.0
2001	37.4	0.1	10.2	9.2	20.7	9.3	145.2	9.2	0.6	18.8	260.8
2002	23.3	0.1	3.4	7.0	31.8	12.5	160.0	7.3	0.5	23.2	269.1
2003	23.6	trace	8.4	4.7	30.7	17.6	108.2	13.4	0.2	44.3	251.1
2004	28.4	0.1	25.3	1.8	35.9	20.1	136.3	5.8	0.2	32.3	286.0
2005	18.0	trace	29.8	1.6	31.8	9.8	146.4	26.2	0.3	24.7	288.6
Average	45.9	0.2	20.2	5.7	33.9	16.0	181.0	32.8	0.8	19.2	355.6

Note: "trace" indicates landings of less than 0.05 t.



**Figure 3.** Black (*Sebastes melanops*, upper left), blue (*Sebastes mystinus*, bottom left, middle and upper right) and copper (*Sebastes caurinus*, center) rockfish aggregation (Photo: Scot Lucas, CDFG).

(National Marine Fisheries Service), none of the most commonly live-caught rockfish species are among those. Of the top five live-landed rockfish species only gopher rockfish has been assessed within the last two years; it was found to have a healthy population (Key et al. 2005).

In 2002, as required by California's Marine Life Management Act, the CDFG drafted and the Fish and Game Commission adopted the Nearshore Fishery Management Plan (NFMP). One goal of this plan is to sustainably manage 19 of the nearshore finfish species, including 13 rockfish, found in California waters. Other goals include resource conservation, adaptive management, coordinated and cooperative approaches to management, incorporating socioeconomic dimensions into management, fair resource allocation, and evaluation of costs for management (California Department of Fish and Game 2002). An underlying principle of the NFMP is for CDFG to use a scientific approach to better understand and manage California's marine ecosystems through collaboration and coordination with fellow agencies and stakeholders. Due to increasing concern over diminishing fishery resources, the plan takes a conservative approach that reduces the overall take of the 19 nearshore species until sufficient scientific information became available to allow managers to set more informed catch limits. To implement the plan and meet total allowable annual catch limits for the state, as set by the federal government,

CDFG developed a restricted access program. This program limits the number of participants allowed to fish commercially for nearshore species by issuing a limited number of permits. Seasons and depth restrictions may also be set to limit commercial take. California commercial permit holders are also subject to limits on the amount of catch allowed to be landed over a specified time period. An example might be 250 kg of cabezon over a two-month period per permit holder. This last management measure helps spread the catch between smaller and larger boats and was designed to help keep the season open longer. Catches over the course of a year are monitored using the CFIS landing receipt database (as well as other datasets). If the total allowable catch is met before the end of the year (or season), the fishery is closed until the next year or season. Much time is spent fine-tuning the number of permits and individual catch limits to achieve the goal of allowing fishing all year (or for the entire season if it is not a year-round fishery). As understanding of the resource status improves, a more liberal management strategy will be possible if stock assessments show healthy fish populations.

These management measures do not differentiate between the fisheries for live and dead product. However, to enable improved monitoring of the emerging live fish fishery, new commercial landing reports were introduced in 1994 that required differentiation between live and dead catch. Problems



with monitoring live catches have persisted for various reasons, including: miscoding or non-recording of live versus dead fish, unreported landings, misidentification of species landed, and difficulties in ensuring the accuracy of information recorded on landing receipts by buyers. Consequently, data on live landings entered into the CFIS database probably underestimate actual landings (which is why an alternative method of identifying live fish catches was used here), despite efforts at making landing receipt integrity a priority.

Eventually, the live fish fishery spread northward into the state of Oregon. The first significant live fish landings in Oregon occurred in 1997, with a reported total live fish catch of 42 t. By 2000, that number had almost doubled to 82 t (Bacon 2001), at least in part due to tighter restrictions in California's commercial fisheries. In 2002 an interim fishery management plan for Oregon's nearshore commercial fisheries was adopted and, similar to California's plan, reductions in commercial harvest were being achieved through trip limits and limited entry commercial permits (Oregon Department of Fish and Wildlife 2002). On 1 January 2000, the state of Washington, to the north of Oregon, adopted legislation to prevent a live fish fishery from developing in its waters (Washington Administrative Code). The legislation bans the transport of live fish. The state of Alaska, also seeing the live fish fishery expansion in states to the south (and to a lesser extent in British Columbia, Canada), took pre-emptive measures to stop the fishery from developing by enacting a state regulation barring commercial capture of groundfish that are intended to be kept alive (Alaska Administrative Code). This measure was undertaken for reasons of stock conservation. A lack of state personnel and other resources to monitor such a fishery also played a key role in the decisions to deter live fish fisheries in Washington and Alaska.

Other concerns related to live fish fisheries include some of the gear used to capture fish. In California, trap fishing for finfish evolved from market demand for live fish; this method also allowed fishermen to make use of lobster gear when the lobster season was closed. These traps are very efficient at catching fish but are not necessarily efficient at selecting target fish (Palmer-Zwahlen et al. 1993), and some species are heartier than others when it comes to surviving the rigors of being trapped and released. Therefore, there can be significant non-commercial and invertebrate bycatch in the live fish trap fishery, along with associated stress- and injury-related mortality of such bycatch. Also, abandoned or lost traps may continue to catch fish for extended periods of time until they decay and break down. Fish captured in these "ghost traps"

may die from starvation or from injury sustained from attempting to escape. They in turn become bait, attracting other predators that get trapped. To alleviate the problem of ghost traps CDFG has put into its regulations a requirement that all traps used in any fishery must contain self-destruct devices designed to break the trap down rapidly enough to allow the escape of a substantial proportion of any fish that are trapped inside (California Code of Regulations, Title 14, Section 180.2).

Some of the initial concerns with the live fish fishery have been addressed through limits on both allowable take and number of participants. Trap design regulations have helped solve the problem of ghost trap fishing. However, issues that still persist include monitoring of bycatch, small target sizes and difficulties in monitoring landings. Small target size and bycatch are both characteristic of this type of fishery and any solutions, aside from shutting the fishery down completely, are complex and expensive from a management standpoint. Accurate information on condition (live or dead) of fish from landing receipts continues to be a problem as well. For example, in 2005, for the harvest groups examined in this article, more than 12,000 landings were made with unknown condition codes, totalling nearly 7000 t.

Overall, live fish fishing in California seems to have reached a modicum of stability, primarily through reducing the total allowable take. However, by most accounts it is still a data-poor fishery, especially with respect to bycatch and its mortality. Although most of the most commonly caught live rockfish are not considered overfished, they live in aggregations containing a complex of species. Therefore, there is the potential of bycatch mortality of some of the overfished rockfish species. Depth closures have been used most recently to offset this potential as the species of concern generally live in deeper water than the rockfish targeted in the live fish fishery. Future strategies for management in California include continued stock assessments and development of a coast-wide system of marine protected areas. Marine protected areas allow for a more ecosystem-based management approach as opposed to the species-by-species management approach that has been used most often in the past. Such protected areas may have a spill-over effect that helps to replenish areas that have been fished out.

With respect to the economics of California's live fish fishery, two patterns are clear: the overall number of fishermen participating in live-catch fisheries has dropped by a little over half since 1994, while the average price of live product has increased (Table 1). High demand for live fish persists.

## References

- Alaska Administrative Code. 05 AAC 28.180. [<http://touchngo.com/lglcntr/akstats/AAC/Title05/Chapter028/Section180.htm>]
- Alonzo H., Key M., Ish T. and MacCall A. 2004. Status of the California sheephead (*Semicossyphus pulcher*) stock (2004). [<http://www.dfg.ca.gov/mrd/sheephead2004/index.html>]
- Bacon L. 2001. Fishermen bring 'em back alive: Selecting fish while they're still swimming provides a hot new market. Eugene, Oregon: The Register-Guard, May 5, 2001. [<http://www.californiafish.org/orelivefishery.html>]
- Berkeley S.A., Hixon M.A., Larson R.J. and Love M.S. 2004. Fisheries sustainability via protection of age structure and spatial distribution of fish populations. *Fisheries* 29(8):23–32.
- California Department of Fish and Game. 2002. Nearshore fishery management plan. August 2002. [<http://www.dfg.ca.gov/mrd/nfmp/>]
- Key M., MacCall A., Bishop T. and Leos R. 2005. Stock assessment of the gopher rockfish (*Sebastes carnatus*). [<http://www.pcouncil.org/groundfish/gfsafe0406/gfsafe0406.html>]
- Love M.S. 1996. Probably more than you wanted to know about the fishes of the Pacific Coast. Santa Barbara, California: Really Big Press.
- McKee K. 1993. Live-fish fishery. California Cooperative Oceanic Fisheries Investigations Reports 34:17–18.
- Oregon Department of Fish and Wildlife. 2002. An interim management plan for Oregon's nearshore commercial fisheries. October 11, 2002. [[http://www.dfw.state.or.us/MRP/publications/northshore\\_comm\\_fisheries.pdf](http://www.dfw.state.or.us/MRP/publications/northshore_comm_fisheries.pdf)]
- Palmer-Zwahlen M., O'Brien J. and Laughlin L. 1993. Live-fish trap fishery in southern California (1989-1992) and recommendations for management. Unpublished report. California Department of Fish and Game, Marine Region. 23 p. [[http://www.californiafish.org/1993\\_TrapAnalysis\\_DFG.html](http://www.californiafish.org/1993_TrapAnalysis_DFG.html)]
- Tegner M.J. and Dayton P.K. 1997. The live-fish fishery of California. SPC Live Reef Fish Information Bulletin 2:25–26. [<http://www.spc.org.nc/coastfish/News/LRF/2/7California.htm>]
- Washington Administrative Code. WAC 220-20-039. [<http://apps.leg.wa.gov/WAC/default.aspx?cite=220-20-039>]