3 Pacific Hagfish, *Eptatretus stoutii*

Pacific hagfish*, Eptatretus stoutii*. Photo credit: Andrew Clark.

History of the Fishery

Pacific hagfish, *Eptatretus stoutii*, are the target of a robust, statewide re-emerging fishery. Prior to 1982, hagfish were not landed or targeted by California fishers. Most fishers targeting deep water species viewed hagfish as a nuisance, eating bait or destroying catch. Hagfish were noted for ruining hooked or netted sharks as well as hooked shelf and slope rockfish. Hagfish would burrow into the fish, eat the internal organs and, if time allowed, the rest of the fish. Pacific hagfish would also interfere with various trap fisheries, such as Dungeness crab, by eating the bait. In Korean waters, two related species, inshore hagfish, *E. burgeri*, and brown hagfish, *Paramyxine atami*, were being pursued for food and an eel skin leather trade.

In 1983, eel skin leather products were gaining popularity and fishing effort for hagfish increased in Korea. By 1985, 400 vessels were landing up to 3000 short tons (2722 metric tons) annually. From 1986 to 1987 there were approximately 600 vessels and up to 35 processors in the Korean port of Pusan. Due to fishery depletion, Korean hagfish processors began to look for outside sources of hagfish.

By late 1987, Korean processors began to solicit California fishers, mostly from the San Francisco and Monterey port areas, to target hagfish. After one year of fishing, 8 vessels had landed 345 short tons (313 metric tons) (Figure 3-1). The hagfish were frozen and shipped to Korea for processing. All hagfish meat was discarded due to Korean importation laws and due to the use of the anesthetic MS222. California fishers would apply MS222 to the hagfish catch to reduce activity and to prevent hagfish from biting each other. MS222 is highly toxic and made the flesh unfit for human consumption.

Shortly thereafter, interest in hagfish increased and California fishing activity surged. In 1989, statewide landings reached 1321 short tons (1200 metric tons) from 80 participating vessels. The ports with the greatest activity were Ventura, Santa Barbara, Oxnard and San Francisco. Landings reached the highest on record in 1990 with 2490 tons (2260 metric tons) from 56 participating vessels. Ironically, during this time, Korean interest in hagfish from California declined along with the price. During the 1990 fishing season, skins of hagfish from California became less desirable due to holes from bites from other hagfish and unexplained pinholes commonly occurring in the dorsal part of the skin. During the curing process, these holes and bite marks would stretch and make the skin piece unusable. Hagfish demand decreased in 1991, and

total landings fell to 151 short tons (137 metric tons). From 1992 to 2004, annual landings ranged from 0 to 202 short tons (0 to 183 metric tons) and averaged 34 short tons (31 metric tons).

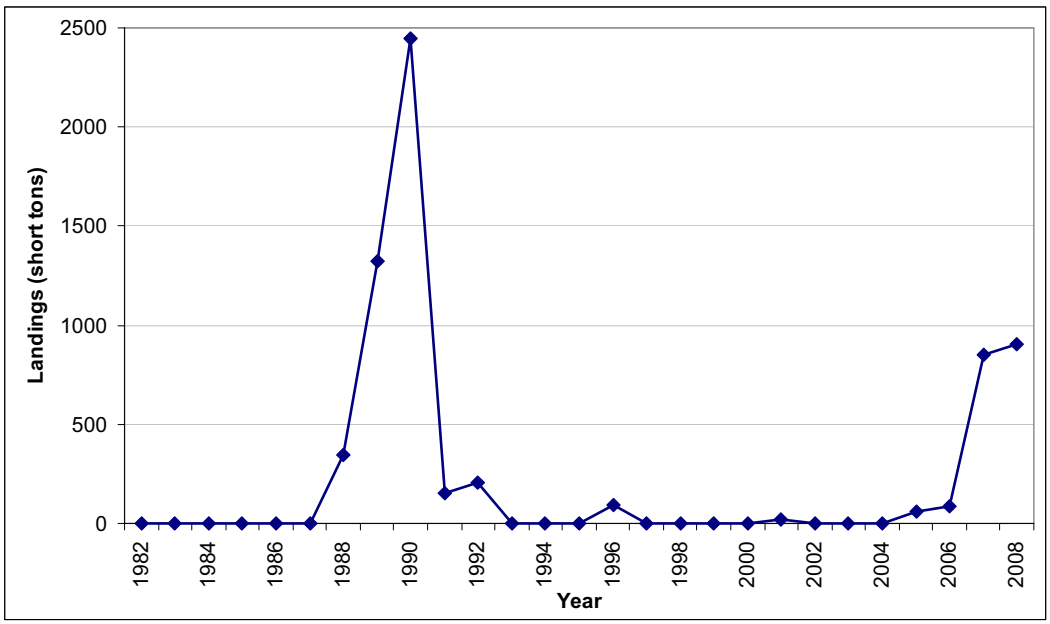

Figure 3-1. Pacific hagfish commercial landings, 1982-2008. Data source: CFIS data, all gear types combined.

Fishing effort and landings increased again in 2005 with a renewed interest in Pacific hagfish from California. This time the species was sought primarily for human consumption in Asia, mostly in Korea. Most hagfish were caught and sold live to local fish receivers, and this practice continues today. Typically, hagfish are placed in holding tanks owned by fish receivers for a few days for several reasons: 1) to allow emptying of the hagfish' digestive tract; and 2) to allow receivers to build their inventory before sale. A hagfish buyer then purchases the fish from the receiver and exports them live to Korea. Once in Korea, the hagfish are processed for human consumption. In addition, any large hagfish in good condition are still processed for their skins.

California landings in 2005 and 2006 were minimal, but sharply increased in 2007 to 852 short tons (773 metric tons) (Figure 3-1). Ex-vessel ranged from $0.25 to $2.00 per pound ($40.55 to $4.41 per kilogram), averaging $0.78 per pound ($1.72 per kilogram). In 2008, landings reached 901 short tons (818 metric tons), and ex-vessel price ranged from $0.01 to $1.75 per pound ($0.02 to $3.86 per kilogram), averaging $0.95 per pound ($2.09 per kilogram). This renewed fishing effort for hagfish was also a result of an increased number of displaced fishers, either from fisheries that had seasonal reductions or emergency closures, or who were seeking an additional income source. Buyers were also recruiting fishers by offering traps and equipment to those who would sell hagfish to them.

There is no recreational fishery for Pacific hagfish.

Status of Biological Knowledge

The Pacific hagfish is a member of the Myxinidae (hagfishes) family. Hagfish are cartilaginous fish that lack eyes, jaws, scales and paired fins. Hagfish also have a single nostril and a mouth that contains two parallel rows of pointed, keratinous teeth. These teeth are secured to rasping dental plates. The oral/nasal cavity is surrounded by eight barbells. Considered scavengers, hagfish will feed upon dead fish and marine mammals, or any other animal matter they can find. Hagfish identify food sources through their excellent sense of smell and touch. After identification, hagfish will protract/retract their plates until the food source is secured and consumption begins by entering an existing hole or making one using their dental plates. The hagfish will then enter its food item, if possible, consuming it from the inside. Hagfish were once thought of as parasites due to this behavior. Members of the hagfish family also have mucous producing "slime" glands along each side of the fish's body. When agitated, the hagfish will produce a protein-based mucous that, when mixed with water, produces a thick, viscous slime. This behavior is the reason hagfish are commonly called "slime eels".

Pacific hagfish occur in depths from 30 to 2402 feet (9 to 732 meters) on muddy substrate, but most are caught in depths less than 1800 feet (549 meters). Knowledge of maturation and fecundity is limited, but improving. Studies indicate that females attain sexual maturity around 13 inches (33 centimeters) when they are between 7 and 12 years old. Male sexual maturity knowledge is limited, but males are sexually identifiable at 11 inches (28 centimeters). Males typically will grow to a larger size than females. Females are sexually identifiable at 8 inches (20 centimeters). Hagfish fecundity is low with female hagfish producing 20-30 eggs per reproductive cycle. Female hagfish may contain eggs of various stages of maturity. Reproductive cycle length is not known; however, a female's eggs must come to full term before the next batch of eggs will begin to mature. There is no specific spawning season and female hagfish may have viable eggs at any time during the year. Viable eggs have been observed more frequently in sampled hagfish during fall and winter months.

Larger Pacific hagfish may show characteristics of hermaphroditism or bisexuality. In these rare cases, the hagfish gonad will contain both developing eggs and active spermatogenic follicles.

Status of the Population

Little is known about the status or biomass of Pacific hagfish stocks. Based on landings from the first surge of fishing activity from 1989 to 1991 and the current pulse, which began in 2007, the biomass must be large. A tagging study performed by Nakamura in 1991 suggests that the population density could range from approximately 484,000 to 714,000 hagfish per square mile (1870 to 2760 hagfish per hectare) in suitable habitats and in water depths less than 1200 feet (366 meters), although the estimates were based on samples primarily in the 600 foot (183 meter) depth regime. Recent California Department of Fish and Game (Department) sampling of the fishery has shown hagfish to average about four to five individuals per pound, which would

equate to density estimates ranging from approximately 48 to 89 short tons of hagfish per square mile (168 to 311 kilograms per hectare), using Nakamura's data.

Management Considerations

In 1991, at the end of the first surge in fishing activity, the Department enacted several regulatory measures (FGC §8397). In addition to normal licensing, fishers were required to purchase a nontransferable hagfish permit to take hagfish. With the hagfish permit, a general trap permit was not required. Fishers were also required to submit logs documenting their fishing activities. Vessels were limited to 1200 Korean traps or 300 of any other type of trap. Korean and bucket traps are fished in a string and are secured to an anchored, central ground line. The Fish and Game Code was later amended to specify non-Korean traps as the 5-gallon bucket type trap. The requirement for the hagfish permit and associated fee, and the logbook requirement, were repealed in April 1998. Beginning in 1999, vessels were limited to 500 Korean traps or 200 bucket traps (FGC §9001.6).

Currently hagfish fishers and crewmen are required to possess a valid general trap permit. A logbook is required again. Vessels are limited to a maximum of 500 Korean traps or 200 five-gallon bucket style traps. No other fish, other than hagfish, may be possessed or targeted while fishing for hagfish or if hagfish are onboard (FGC §9001.6).

In December 2008, the California Fish and Game Commission authorized the Department to issue experimental gear permits for the use of 40-gallon barrel traps to take hagfish commercially. No more than 40 barrel traps, each with its own float and line, may be used by an individual. This type of gear may reduce potential gear conflicts with trawlers fishing in federal waters and with the Dungeness crab trap fishery. In addition, this gear may produce a better, more marketable catch. As a condition of the permit qualified fishers are required to submit logs of their fishing activity, pay a permit fee and have at least three days of observer coverage to assess the gear. As of March 2009, three permits have been issued.

Travis Tanaka
California Department of Fish and Game
TTanaka@dfg.ca.gov

Further Reading

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Pacific hagfish commercial landings, 1982-2008.

Year	Pounds	Year	Pounds	Year	Pounds
1982	126	**1991**	303,228	**2000**	69
1983	45	**1992**	405,374	**2001**	44,256
1984	170	**1993**	473	**2002**	109
1985	0	**1994**	1,206	**2003**	0
1986	0	**1995**	72	**2004**	4,466
1987	0	**1996**	182,445	**2005**	119,036
1988	690,655	**1997**	86	**2006**	169,045
1989	2,642,540	**1998**	523	**2007**	1,699,723
1990	4,900,596	**1999**	206	**2008**	1,802,935

Data source: CFIS data, all gear types combined.