



State of California – Natural Resources Agency  
DEPARTMENT OF FISH AND WILDLIFE  
Marine Region  
20 Lower Ragsdale Drive, ste 100  
Monterey, CA 93940  
[www.wildlife.ca.gov](http://www.wildlife.ca.gov)

*EDMUND G. BROWN JR., Governor*  
*CHARLTON H. BONHAM, Director*



## **Final Report: Evaluation of the Use of 40-gallon Barrel Traps for the Take of Hagfish**



**Travis Tanaka  
California Department of Fish and Wildlife  
Marine Region  
North-Central Finfish Research and Management Project**

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## INTRODUCTION

In February 2013, the Fish and Game Commission (Commission) was petitioned by two Bodega Bay commercial fishermen requesting Experimental Gear Permits to use individually floated, 40-gallon barrels as a method of take for Pacific hagfish. Under statute, hagfish may be taken in either 5-gallon bucket traps or Korean-style hagfish traps. While legal in other states, the use of barrels to take hagfish in California is prohibited. The 40-gallon barrel is a standard readily available to the fishing industry and currently in use in other jurisdictions such as Oregon. They suggested that the use of this gear was a way to decrease potential for negative gear interactions with other commercial benthic fisheries (e.g. Dungeness crab) and to improve catch quality by reducing dead loss or damage to captured fish through crowding.

The Commission accepted the Department's recommendations and approved the Experimental Gear Permits with the conditions including that the use of the gear be observed by the Department. The Department, working with the permitted fishermen, sought to evaluate the proposed method as possible legal gear to take hagfish. At the time of the application, while there were no requirements of the fishery to have a minimum hole diameter on hagfish traps, a 1/2-in. diameter minimum was a requirement identified in the permit. The permittees were allowed to design their traps in any fashion, provided Department regulations regarding destruct devices were followed. As the study progressed, minimum hole diameter was increased to 9/16 in. to comply with a regulatory requirement which became effective January 1, 2015.

## METHODS

The proposal to the Commission stated that barrel traps would minimize negative gear interactions with other fisheries, improve the quality of trapped hagfish and reduce dead loss due to crowding. To evaluate this gear, the Department required both permit holders to submit accurate logs documenting gear interactions, number of traps, soak duration, total catch per trip, and bycatch by species. Onboard observation trips (minimum of 3 days per permit) performed by Department staff were required to verify logbook information and to document any interaction with wildlife or other fisheries. Each permit holder was allowed to fish up to 40 traps (Fig. 1), with all traps having a minimum hole diameter of 1/2 in. The minimum hole diameter was increased to 9/16 in. in January 2015 and the permit holders modified their experimental barrel traps accordingly. The period of evaluation began September 2013 and ended April 2015.



Figure 1. 40-gallon barrel trap in the intended orientation as fished on the bottom

#### **ONBOARD OBSERVATIONS**

Staff observed fishing activities documenting any interactions with either marine mammals or other commercial fisheries, and species caught as bycatch. Staff evaluated average size of catch by taking a bucket sample per barrel or sampling the entire barrel. In the former case, a 5-gallon bucket was filled about halfway with fish from each barrel. The bucket was weighed and fish were counted to calculate the average count-per-pound (CPP). If the entire barrel was sampled, all fish were weighed in aggregate and counted. Randomly selected hagfish were retained for laboratory dissection to establish sex ratio, spawning status, and average length and weight per fish by sex.

#### **FISHERMEN LOGBOOKS**

Using trap logs supplied by the Department, both permitted fishermen were required to maintain accurate records of their fishing activity. Information requested included: fishing date, number of traps fished, soak duration, number of traps lost, hagfish dead loss quantity, gear interactions with other fisheries or marine mammals, incidental species, and total estimated catch.

#### **LABORATORY DISSECTION**

A random sample was retained from each on-board observation to obtain representative information regarding length, weight, sex, and spawning status for fish caught during the trip.

## DEAD LOSS

In a separate but related fishery independent study to evaluate dead loss in bucket traps, in 2014 Department staff deployed 80 baited 5-gallon bucket traps (1/2 and 9/16-in. diameter holes, 40 each) in Monterey Bay for an overnight soak. Traps were baited with the same amounts used in the commercial fishery. Traps were retrieved the following day. Captured hagfish were counted, weighed, and assessed for condition. Live hagfish were released and dead hagfish were retained for laboratory dissection. The percentage of dead loss due to crowding in each bucket trap was determined.

## RESULTS

### ONBOARD OBSERVATIONS

*1/2-in. diameter holes*- Three fishing trips were observed documenting the use of 1/2-in holes in 40-gallon barrel traps in 2014. On two of the three trips, the catch per barrel was sampled by taking a random bucket sample. These samples were taken after a short soak. The entire content of selected barrels was accounted for during the trip in August because traps were pulled after a short soak and there were small catch quantities in each trap. The primary incidental catch was *Octopus spp.* One *Cancer spp* crab was also observed.

Associated data for observed trips:

Month	Year	Hole diameter(in.)	Barrels pulled	Sample unit	# samples	Mean (CPP)	Range (CPP)
February	2014	1/2	32	bucket	32	4.99	3.93-6.31
August	2014	1/2	32	barrel	14	4.41	2.35-5.89
September	2014	1/2	28	bucket	28	4.07	3.39-4.97

*9/16-in. diameter holes*- Three additional fishing trips were observed documenting the use of 9/16-in holes in 40-gallon barrel traps in 2015. On all three trips, traps were soaked overnight. During the trip in March, six of the 28 traps were pulled after a short soak (3.5 hr). The average weight of fish captured per barrel relative to the total number during this short soak was less than the average weight for the barrels soaked overnight, thus increasing the average mean CPP for the entire trip. The primary incidental catch was *Octopus spp.* No finfish or finfish remains were observed.

Associated data for observed trips:

Month	Year	Hole diameter(in.)	Barrels pulled	Sample unit	# samples	Mean (CPP)	Range (CPP)
March	2015	9/16	33	bucket	33	4.72	4.00-6.50
April	2015	9/16	33	bucket	33	4.61	3.56-6.25
April	2015	9/16	28	bucket	28	4.52	3.95-5.45

For all barrels, regardless of hole diameter, no negative gear interactions with other commercial fisheries or marine mammals were observed. No incidental finfish or finfish remains were observed.

### FISHERMEN LOGBOOKS

*1/2-in. diameter holes-* A total of 118 fishing days for both permittees combined were reported for traps with 1/2-in holes. Average catch per barrel was 33.9 lb, with a range of 17.9 - 57.1 lb per barrel. The average number of traps used per fishing trip was 33. Traps were pulled between 1 and 4 times per fishing day with an average pull rate of 1.8. One trap was reported as lost due to a bottom snag. Reported incidental catch were small *Octopus spp.* No negative gear interactions were reported.

*9/16-in. diameter holes-* A total of 63 fishing days for both permittees combined were reported for traps with 9/16-in holes. Average catch per barrel was 34.5 lb, with a range of 17.9-77.8 lb per barrel. The average number of traps used per fishing trip was 31.5. Traps were pulled between 1 and 3 times per fishing day with an average pull rate of 1.8. Reported incidental catch were small *Octopus spp.* No negative gear interactions were reported.

Both fishermen noted a better average size of hagfish with the increased hole diameter.

### LABORATORY DISSECTION

Randomly selected hagfish were retained from each observation trip. These fish were later dissected in fresh condition.

#### *1/2-in diameter holes-*

Sex	Number	Average weight (g)	Weight range (g)	Average length (mm)	Length range (mm)
Female	100	79.5	12.6-172.2	368.5	210-500
Male	102	97.5	37.1-255.9	396.4	295-527
Unknown	33	51.3	21.9-132.5	316.0	252-447

*9/16-in diameter holes-*

Sex	Number	Average weight (g)	Weight range (g)	Average length (mm)	Length range (mm)
Female	82	108.2	46.2-262.7	411.6	326-527
Male	108	122.1	53.9-207.4	429.3	310-556
Unknown	12	63.1	47.8-81.0	342.7	304-380

**DEAD LOSS IN SEPARATE DEPARTMENT STUDY**

Two strings of 40 5-gallon bucket traps (20 each of 1/2 and 9/16-in. diameter holes) were deployed.

Hole Diameter (inch)	Total Live	Total Dead	Total Weight (lbs)(Live and Dead)	CPP (Live and Dead)	# of Traps w/ Dead Loss	Average weigh per bucket (lbs)	Weight range (lbs)	Buckets with zero catch
1/2	1,484	61	449.0	3.44	5	14.0	1.0-41.0	7
9/16	1,297	7	402.5	3.24	7	11.2	0.5-23.5	4

Dead hagfish comprised 2% by count of the total catch. Of the 61 dead hagfish found in the 1/2-in traps, 56 came from one trap which was filled to capacity. Incidental catch included one sablefish (*Anoplopoma fimbria*) and *Octopus spp.* All incidental catch was released alive with no evidence of dead incidentals.

**DISCUSSION****ONBOARD OBSERVATION**

After observing fishing activities of both vessels over the course of six trips, staff concluded the following regarding the use of this gear. Individually floated barrel traps may be fished in high traffic areas with minimal chance of interacting negatively with gear from other fisheries. Both permitted fishermen were able to set their traps on the same grounds fished by the Dungeness crab fleet. Traps were set far enough apart such that salmon trollers could fish the bottom in the same proximity of these traps with minimal chance of snagging them.

The hagfish trap fishery (bucket or barrel) is a clean finfish trap fishery, with very little to no capture of incidental species. Two fishery-independent Department bucket trap

surveys, one performed as part of this evaluation, confirmed this. It is thought that any incidental species would be consumed by retained hagfish given enough time in the trap. The remains of octopus and one cancer crab were present. No skeletal remains of finfish were encountered.

A 5-gallon bucket trap at capacity, without bait or a bait jar can hold approximately 40 lb of hagfish. Using this metric, a 40-gallon barrel trap could theoretically hold up to 320 lb of hagfish. Log data indicate that after an overnight soak, barrel traps would average over 30 lb. The observation trip in August 2014 corroborated this data. Barrels pulled on a short soak were filled to similar capacities; however, average size of individual fish was noticeably smaller. Korean hagfish importers desire a minimum of eight-nine hagfish/kg (Tanaka and Crane 2014). Small hagfish (CPP of 10 hagfish/kg or greater) typically are undesirable by Korean importers and fishermen are encouraged to cull these from their catch prior to landing. This market-driven requirement could force fishermen to soak their traps longer, allowing more immature hagfish to escape, and providing an ecological benefit while improving the quality of their catch (Tanaka and Crane 2014).

#### **FISHERMEN LOGBOOKS**

Both fishermen documented total catch for each trip, gear interactions, incidental catch, and number of sets per trip. The information provided by both fishermen was corroborated through fishing trips observed by Department staff. If traps could not be serviced within 24 hours due to expected inclement weather, all traps were pulled and brought to shore.

Traps were typically pulled after an overnight soak or after 8-10 hr of deployment which allowed smaller hagfish to escape through the holes. At the beginning of the evaluation period, both fishermen conducted more short soaks to get the total landing weight required to meet expenses per trip. They confided that their culling efforts of small hagfish at the dock were greater due to this practice. With longer soaks, including overnight, the average size increased, thus reducing the need to cull immature hagfish at the dock. Once all the barrels were modified to accommodate the 9/16-in hole diameter requirement, dockside culling was eliminated.

Both fishermen reported no incidents of negative gear interaction with other fisheries or marine mammals. Only one trap was lost throughout the entire evaluation period. This trap was stuck on the bottom and the vertical line snapped. Since logs are not required for the hagfish trap fishery, the Department has limited logbook data, mostly submitted on a voluntary basis. This log data show that during the barrel trap evaluation period (September 2013-April 2015), the bucket trap fishery lost 141 buckets. The reasons cited for trap loss included cut ground line, lost trap string, or traps cut off by another

vessel. The Department has video stills of a lost bucket trap taken during a Department ROV survey (Fig 2).



Figure 2. Lost bucket trap documented by DFW's ROV project off the coast of San Diego. Note intact snap and attached trap lid. The attached lid could indicate failure or lack of the required destruct device.

### **LABORATORY DISSECTION**

The random samples collected during observation trips show the direct relationship and effect that changing the minimum trap hole diameter has on average fish weight. When using the 9/16-in. diameter, average weight and length for males and females increased indicating that smaller hagfish were able to escape the trap. There was also a decrease in the number of hagfish with unknown sex. Typically, fish of unknown sex are smaller and sexually immature.

When compared with samples from the 2015 bucket trap fishery, dissected hagfish sampled from barrel traps show that barrel caught fish are slightly larger. This could be the result of the consistently long soak time employed by the permit holders.

Laboratory dissection data from Department samples (all fish combined) taken from the 2015 bucket trap fishery (Morro Bay and Eureka) and barrel trap observation trips (hole diameter for all traps is 9/16 inch):



Fishery	Length range (mm)	Length average (+/- s.d.) (mm)	Weight range (mm)	Average weight (+/- s.d.)(g)	Average CPP (+/- s.d.)
Bucket	310-500	396.8 +/- 43.3	43.4-109.2	95.7 +/- 64.5	4.66 +/-0.79
Barrel	304-556	417 +/- 49.5	46.2-262.7	113.0 +/-39.0	4.67 +/- 0.17

## DEAD LOSS

In their petition to the Commission, both permittees stated that catch quality may be better in barrel traps due to reduction in crowding which sometimes occurs in bucket traps. Other hagfish fishermen also claimed to have lost catch due to crowding in buckets, especially after an extended soak time beyond 24 hr. After soaking bucket traps provided by the permittees and those constructed by the Department and examining the resulting catch, staff could not replicate the amount of dead loss experienced by both fishermen. Staff did note however that there was a higher percentage of dead loss in buckets that were filled to capacity. On the observed trips with barrel traps, no traps were filled to capacity and no dead loss observed. However, the greater trap volume and large number of holes allows for better water circulation, which may improve survivorship.

## CONCLUSION

Department staff consider that allowing barrels as a legal method of take will allow the sustainable use of the Pacific hagfish resource, especially when limitations on their deployment are implemented.

An existing regulation (Title 14, §180.6) requires that all trap holes, which would include barrels, be at least 9/16-in. diameter. This requirement reduces the take of immature hagfish.

Another existing regulation (FGC §9003) requires the use of a destruct device in all traps. The larger barrel surface area, depending upon the design used by the fisherman, could allow a more effective destruct device. Bucket trap lids are typically secured with cotton and rubber strapping; however in the event the lid snaps to the bucket, it will never open. Due to the nature of the entrance funnel, the bucket trap fishery and barrel trap fishery have approximately the same type of incidental catch. During the Department's dead loss study, other researchers were able to record on camera finfish and Dungeness crabs attempting to interact with a baited bucket trap. Fish and crabs were seen approaching the funnel, but none were observed entering.

A barrel trap limit would ensure resource sustainability by lessening the theoretical impact of increasing trap size and therefore overall catch weight. The states of Washington and Oregon have trap limits of 100 and 200, respectively, for any legal type of trap (WAC 2015, OAR 2015). Fishermen in Oregon and Washington have the option as to the size of their traps; however the majority utilizes 40 to 55-gallon barrels fished on a ground line.

The Department recommends that California commercial hagfish vessels be allowed to fish 25 or fewer barrels (25 barrels equates to 200 buckets in volume) at the discretion of the operator, as an alternative to buckets or Korean traps. This study focused on the experimental use of a single line/single trap format, but multiple barrels may be fished on a ground line. Whether using one barrel with a single vertical line or several barrels on a ground line, this gear would fish the same and yield similar catch results. Barrels could be an efficient, alternative for fishermen that would reduce the number of traps and length of ground line on the seafloor.

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