An Assessment of the Use of Light-touch California Halibut Trawl Gear within Historic Monterey Bay Trawl Grounds: Seafloor Interactions, Catch Composition, and Economic Feasibility

Photo Credit: NOAA Fisheries

Final Report
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INTRODUCTION

In 2004, California state legislation (SB 1459) was introduced to close Monterey Bay to bottom trawling but the closure was not enforced until 2006. Prior to that, trawling had occurred for at least 75 years in this area. In May 2009, the California Fish and Game Commission established criteria for "light-touch" trawl gear (as defined in California Code of Regulations Title 14, Section 124, see Figure 1) and required that only this type of trawl gear could be used within the California Halibut (*Paralichthys californicus*) (halibut) Trawl Grounds off Santa Barbara County and Ventura County in southern California. Light-touch trawl gear has a lighter net and cod end, longer wing length, no rollers or bobbins, and lighter doors than traditional trawl gear. Because of interest expressed by the fishing industry about using light-touch halibut trawl gear within the historic Monterey Bay trawl grounds, a research study was developed among California Department of Fish and Wildlife (CDFW), the National Marine Fisheries Service-West Coast Region-Sustainable Fisheries Division (NOAA Fisheries), and industry. This study was undertaken to determine the environmental and economic implications of using light-touch trawl gear to target halibut in Monterey Bay.

OBJECTIVES

The objectives of the study were to conduct a fishery-independent survey to document seafloor interactions and species catch composition by use of light-touch trawl gear and to investigate the economic feasibility of using this gear in the former trawl grounds of Monterey Bay:

1. Attach remote cameras to the trawl doors and headrope to document seafloor interactions and degree of contact.

2. Measure, weigh (when possible) and assess condition of all species caught.

3. Measure, tag, and release all live, legal-sized (22 inches or greater) halibut, the target species of this survey.

4. Retain sublegal-sized halibut for life history studies.

5. Obtain economic information from the captain of the F/V *Cecelia* on fishing operations during the survey.

6. Monitor and record any protected species interactions.

METHODS

Permits

The nature and location of this study required obtaining a permit and meeting the requirements of federal regulations and laws. The survey was conducted in Monterey Bay, within the boundaries of the National Oceanic and Atmospheric Administration's, Monterey Bay National Marine Sanctuary (MBNMS). The MBNMS required issuance of a research permit for CDFW and NOAA Fisheries to conduct the survey within its boundaries. The lead action agency for the survey was NOAA Fisheries, and the CDFW was considered a non-Federal representative which conducted some of the at-sea research and carried out many aspects of the survey. Further, since the NOAA Fisheries contributed equipment and had an at-sea biologist performing duties on-board the survey vessel, the action was considered a major Federal action requiring National Environmental Policy Act (NEPA), Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultations.

NOAA Fisheries initiated the EFH consultation (Appendix A) on January 9, 2013, the section 7 ESA consultation with a Biological Assessment (Appendix B) on February 4, 2013, and the NEPA consultation (Appendix C) on May 30, 2013. The EFH consultation was finalized on February 5, 2013 (Appendix A), the Categorical Exclusion Memo and checklist to satisfy NEPA requirements were approved on April 22, 2013 (Appendix C), the section 7 ESA consultation concurrence letter (Appendix D) and accompanying Monitoring and Mitigation Protocol (Appendix E) were finalized on May 28, 2013. NOAA Fisheries and CDFW originally applied for a permit (Appendix F; MBNMS Permit #MBNMS-2013-015) with the MBNMS on September 7, 2012, which was approved on June 4, 2013, allowing the survey to take place.

Vessel and Gear

The F/V *Cecelia* was contracted to conduct the survey tows with operations originating from Moss Landing Harbor, Monterey County. The F/V *Cecelia* is a 49-foot wooden vessel with a 19-foot beam, and weighs 13 gross tons. The light-touch trawl net used a different setup compared to the traditional trawl nets used in CDFW's 2007 and 2010 fishery-independent halibut trawl surveys in the same area. In those studies, conventional groundfish bottom trawl gear (including a 4.5-inch cod-end mesh) was used. The light-touch trawl net used a 60–foot long footrope, had a body mesh of 5 inches, and a cod end mesh of 7.5 inches (Figure 1). Additionally the light-touch trawl did not have floats attached to the headrope and therefore had a "low-rise" configuration making the net height from the headrope to footrope opening smaller (4¯foot opening) compared to that of a traditional trawl net (10-to-15 foot opening; M. McCorkle, personal communication, July 20, 2012). The capacity of the light-touch trawl net is hard to quantify but it is unlikely that the net would catch over 1,000 pounds of fish on any one haul (M. McCorkle, personal communication, July 20, 2012). The light-touch trawl net is not designed to be a high capacity trawl net.

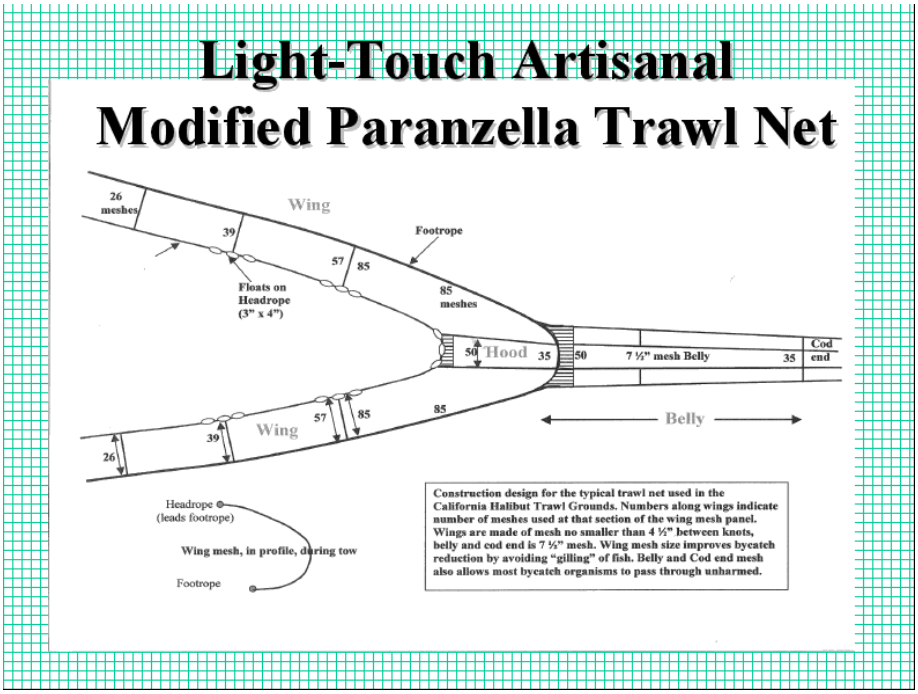

Figure 1. Diagram of light-touch trawl net gear with design specifics. Gear specifics as required by the California Code of Regulations Title 14. Specific description per CCR Title 14 § 124. Halibut Trawling Gears. Special gear requirements apply while trawling for California halibut in the California Halibut Trawl grounds. Each trawl net, including trawl doors and footrope chain, shall meet the following requirements: (1) Each trawl net shall have a headrope not exceeding 90 feet in length. The headrope is defined as a chain, rope, or wire attached to the trawl webbing forming the leading edge of the top panel of the trawl net. Headrope shall be measured from where it intersects the bridle on the left side of the net to where it intersects the bridle on the right side of the net. (2) The thickness of the webbing of any portion of the trawl net shall not exceed 7 millimeters in diameter. (3) Each trawl door shall not exceed 500 pounds in weight. (4) Any chain attached to the footrope shall not exceed one quarter inch in diameter of the link material. The footrope is defined as a rope or wire attached to the trawl webbing forming the leading edge of the bottom panel of the trawl net. (5) The trawl shall have no rollers or bobbins on any part of the net or footrope. Rollers or bobbins are devices made of wood, steel, rubber, plastic, or other hard material that encircle the trawl footrope. These devices are commonly used to either bounce or pivot over seabed obstructions, in order to prevent the trawl footrope and net from snagging on the seabed. (Figure courtesy of Mike McCorkle, 2012.)

Study Area

The study took place within the historic Monterey Bay trawl grounds along the similar trawl lines used by CDFW in the 2007 and 2010 fishery-independent halibut trawl surveys (Figure 2). Tow depths in the previous two surveys ranged from 12 to 41 fathoms. The 2013 survey design intended to tow within the same depth range and at the same speed, performing twenty tows at 30 minutes per tow, over a 4-day period. Typically commercial halibut trawlers tow for one to three hours, depending upon whether they are fishing for the live or fresh fish markets. The purpose of the shorter tow time for this survey was to document gear interactions with the seafloor by video camera, to increase the survivability of released organisms, and to reduce the chance of interactions with threatened, endangered, or other protected species.

Using the contracted fisherman's knowledge and data from previous CDFW trawl surveys, the F/V *Cecelia* conducted 30-minute tows using light-touch trawl gear (Figure 1). All tows followed a pre-determined bottom contour or followed the best possible course given tide and current direction. Prior to each tow, NOAA Fisheries staff would scan the immediate area for signs of threatened, endangered and other protected species in the planned fishing area.

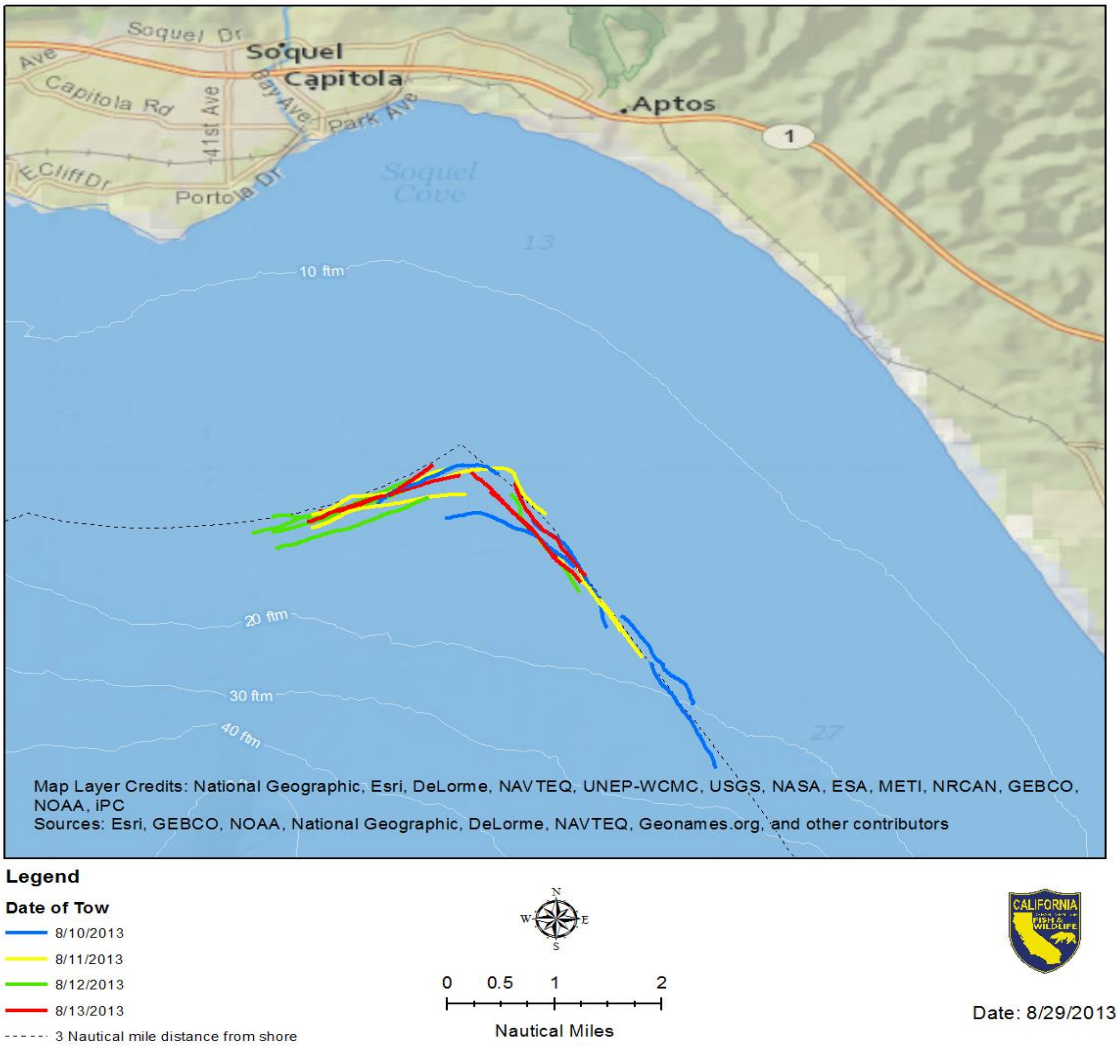

Figure 2. Trawl area for the 2013 Light-touch trawl survey, including tow track-lines and depth contours in fathoms.

Data Collected

Catch Data

Legal-sized (legal) halibut collected in the trawl were measured and, sexed by gently squeezing the abdomen and looking for milt or hydrated eggs. The halibut were then tagged and released alive. Sublegal-sized (sublegal) halibut were to be retained for life history studies. All halibut and any other finfish species not weighed on site had weights estimated from historic CDFW data and/or established length-weight estimates for that species. All finfish and invertebrates were placed into separate bins with fresh seawater to increase survivorship. All non-halibut organisms were identified to species, measured individually (except for some invertebrates), and weighed as species aggregates. In past surveys, Pacific sea nettles (*Chrysaora fuscescens*) were only observed and not weighted or counted. For the 2013 survey, every

attempt was made to identify, weigh and count Pacific sea nettles as they are considered primary prey for the Pacific leatherback sea turtle (*Dermochelys coriacea*). The condition of all species, including halibut, were noted before release. Condition status was based on a 1 through 4 rating (1: lively with no wounds, 2: minor wounds or bleeding, 3: severe wounds or bleeding, and 4: dead).

Video Data Collected

A NOAA Fisheries biologist was present to supervise the use of an underwater video camera which was attached to the trawl doors and headrope to document seafloor interactions and the degree of contact. NOAA Fisheries used GoPro Hero 2 cameras with 960p-30fps resolution, 170 degree field-of-view and a 1-second time lapse interval. Video data were processed using standard techniques developed by NOAA Fisheries personnel. The CDFW prepared a summary report and tables relative to halibut captured as well as associated species (Appendix G), enabling the NOAA Fisheries biologist to ground-truth the video data.

Economic Data and Analysis

Economic data were collected for the purposes of analyzing the economic feasibility of using the modified gear in Monterey Bay. Data included the cost earnings survey information completed by the contracted fisherman (Appendix H), and information from another fisherman with a long history of involvement in the California halibut fishery. Additional information obtained by the cost earnings survey included an estimation of anticipated monthly distribution of trips, potential expected number of trips in Monterey Bay if it were to re-open, potential expected revenue, and potential fleet size. To assess the economic feasibility of using the modified trawl gear in the Monterey Bay area, the economic profits were estimated using a standard economic approach (used in economic profit estimation where both explicit and implicit costs of resources used in the production process are accounted for) after deducting all variable and fixed costs from the gross revenue (Appendix I). The initial economic estimates from the experimental results were adjusted to enable comparison with existing commercial fisheries. Trip level estimates were extrapolated to the fleet level for one season. Monthly catch rates and distribution of fishing effort both in the Monterey Bay area and outside the area were also taken into account. The analysis only considered the catches of the primary target and any other marketable species caught in the trawls and not any income from other fisheries.

Protected Species Data Collected

To fulfill the requirements of the ESA consultation, the survey was designed to reduce potential interactions with marine mammals and other protected species. Marine mammal, sea turtle, green sturgeon (*Acipenser medirostris*), and Pacific sea nettle jellyfish monitoring and mitigation protocols were put in place to minimize potential interactions with these organisms (Appendix E). The surveys included one dedicated NOAA Fisheries biologist to perform the at-sea protocols, in combination with additional assistance from other crew members.

Prior to each tow, the NOAA Fisheries biologist would scan the immediate area for signs of protected resources in the fishing area. During transit to each station, and for a period of at least 30 minutes before the tow, the captain, deckhands, and all available scientists visually scanned the sea surface for marine mammals, turtles, and jellyfish. If marine mammals, other protected species, or jellyfish were sighted during this period, or upon arrival at the station, scientific staff would determine if trawling operations could commence without the likelihood of the gear interacting with the sighted animals.

During each tow, the captain and scientific crew kept continuous watch for protected resources and jellyfish. The observations focused within a radius of about 650 feet to approximate the distance between the trawl and the vessel on any given tow (see Appendix J: Protected Species Observing Distances). If animals were sighted while the net was in the water, the scientific crew would document the observation using a protected species sighting record (Appendix K) and determine the best strategy to avoid potential takes based on the species and number of animals sighted, their behavior, their positions, vectors relative to the path of the vessel, and other factors.

RESULTS

Haul Data

The 2013 survey took place over a 4-day period from August 10, 2013, to August 13, 2013, at depths from approximately 10 to 35 fathoms on soft-bottom substrate between approximately 36° 56' North latitude to 36° 48' North latitude (Figure 2). The average tow speed was approximately 2.3 to 2.7 knots. Twenty daylight tows at 30 minutes per tow were completed (Table 1). Most tows were performed in the northern part of the bay due to better water clarity for filming and to avoid the larger quantities of Pacific sea nettle jellyfish that were present elsewhere in the bay. Weather for the cruise was excellent with little wind or swell.

Table 1. Haul specifics including haul date, haul start and end time, and haul position data.

Haul Number	Haul Date	Start Haul Time	End Haul Time	Start Haul Latitude	End Haul Latitude	Start Haul Longitude	End Haul Longitude
1	08/10/2013	0700	0730	36.51.730	36.52.835	121.53.343	121.53.944
2	08/10/2013	0754	0826	36.53.203	36.54.332	121.54.360	121.55.058
3	08/10/2013	0857	0927	36.54.80	36.54.463	121.55.378	121.56.522
4	08/10/2013	0950	1020	36.54.341	36.53.836	121.55.867	121.54.653
5	08/10/2013	1043	1112	36.53.326	36.52.378	121.54.224	121.53.559
6	08/11/2013	0720	0750	36.52.895	36.53.917	121.54.035	121.54.680
7	08/11/2013	0811	0841	36.54.399	36.54.754	121.54.933	121.55.892
8	08/11/2013	0906	0936	36.54.876	36.54.375	121.55.795	121.57.115
9	08/11/2013	0955	1025	36.54.242	36.54.593	121.57.121	121.55.673
10	08/11/2013	1044	1114	36.54.140	36.53.164	121.55.003	121.54.229
11	08/12/2013	0741	0811	36.54.638	36.54.187	121.56.229	121.57.670

12	08/12/2013	0836	0906	36.54.196	36.54.748	121.57.494	121.56.177
13	08/12/2013	0924	0954	36.54.559	36.54.028	121.56.027	121.57.450
14	08/12/2013	1017	1047	36.54.348	36.54.712	121.57.486	121.56.067
15	08/12/2013	1105	1135	36.54.597	36.53.568	12155.264	121.54.620
16	08/13/2013	0726	0756	36.53.93	36.54.84	121.54.83	121.55.64
17	08/13/2013	0821	0851	36.54.89	36.54.30	121.55.98	121.57.15
18	08/13/2013	0918	0948	36.54.41	36.54.79	121.57.04	121.55.72
19	08/13/2013	1015	1045	36.54.63	36.53.67	121.55.45	121.54.60
20	08/13/2013	1106	1135	36.53.73	36.54.70	121.54.55	121.55.22

Life History & Bycatch Data

A total of 55 legal halibut were caught during the tows, all of which were tagged and released in good condition. All halibut had some degree of split caudal fins and minor bruising to their ventral side. Most of the halibut, despite minor bruising and split fins, were very lively and swam away immediately upon release. The total estimated weight for the halibut was 761.3 pounds (345.3 kilograms) with total length measurements ranging from 578 to 975 millimeters (22.8 to 38.4 inches). The estimated average halibut weight derived from length-weight relationships was 13.84 pounds (6.28 kilograms). No sublegal halibut were caught.

In addition to halibut, there were 33 incidentally-caught fish and invertebrate species (Table 2). The top three vertebrate species by number were California skate (*Raja inornata*, 302), shortbelly rockfish (*Sebastes jordani*, 287), and Pacific sanddab (*Citharichthys sordidus*, 241). The most abundant invertebrate species was Dungeness crab (*Metacarcinus magister*, 656). Pacific sea nettle jellyfish were present in small amounts in 16 of the 20 tows. All rockfish captured were juvenile and averaged 89 millimeters fork length in size. No groundfish designated as “overfished” by the federal government were captured. By number, 85.9 percent of all finfish were considered to be in good or excellent condition prior to release. Additionally, 14.1 percent (88.9 pounds) of finfish were considered dead or near death. When compared to halibut, the rate of loss for incidentals was approximately 11.7 percent. For the invertebrates, all jellyfish were assessed to be in poor or dead condition after capture. All the remaining individual invertebrates (n=739), except for two market squid (*Doryteuthis opalescens)* and one octopus (*Octopus* sp.), were released in good or excellent condition.

While the data is not directly comparable due to the difference of tow time and fishing season, two previous trawl surveys conducted by the CDFW using conventional trawl gear saw a 27.7 percent (2007) and 9.8 percent (2010) of catch that were dead or near death. The 2007 survey was conducted after the peak of the halibut season, while the 2010 and 2013 surveys were conducted during the peak. The 2010 survey caught 1,120 pounds (508 kilograms) of halibut.

Table 2. Total catch, by scientific name and common name, from the California halibut light-touch trawl survey in Monterey Bay, August 2013, including individual numbers and weight (pounds or lbs.).

Scientific Name	Common Name	Number	Weight (lbs.)
Metacarcinus magister	Dungeness crab	656	659.0
Raja inornata	California skate	302	557.25
Sebastes jordani	shortbelly rockfish	287	4.75**
Citharichthys sordidus	Pacific sanddab	241	56.3
Sebastes goodie	chilipepper rockfish (juvenile)	179	3.25**
Genyonemus lineatus	white croaker	163	24.25
Parophrys vetulus	English sole	152	34.8
Zaniolepis latipinnis	longspine combfish	141	11.0**
Raja binoculata	big skate	112	966.25
Chrysaora fuscescens	brown sea nettle	91	499.5**
Peprilus simillimus	Pacific butterfish	84	7.0**
Eopsetta jordani	petrale sole	79	88.75
Platichthys stellatus	starry flounder	72	240.5
Paralichthys californicus (legal-size)	California halibut	55	761.3*
Doryteuthis opalescens	California market squid	45	5.0
Pleuronichthys decurrens	curlfin turbot	35	11.45
Psettichthys melanostictus	sand sole	34	31.5
Ophiodon elongates	lingcod (juv)	33	0
Octopus spp.	Octopus	23	0
Leptocottus armatus	staghorn sculpin	15	6.75
Squalus acanthias	spiny dogfish	9	60.5**
Chitonotus pugetensis	roughback sculpin	8	0
Lunatia lewisii	moon snail	6	0
Pisaster brevispinus	giant pink seastar	4	0
	sea star spp.	4	
Pycnopodia helianthoides	sunflower star	4	4
Metacarcinus gracilis	slender crab	3	
Hyperprosopon anale	spotfin surfperch	3	
Synodus lucioceps	California lizardfish	2	0
Zalembius rosaceus	pink sea perch	2	0
Myliobatis californica	bat ray	1	11.5
Pleuronichthys verticalis	hornyhead turbot	1	0.5
Clupea pallasi	Pacific herring	1	0
Cancer productus	red rock crab	1	0

*= calculated weights based on Department sample data
**=Total weight calculated from on-board weights and established length/weight relationship data
0=No weight due to small size, lack of length/weight relationship data, or unable to calculate average weight due to low catch

Video Data

NOAA Fisheries staff analyzed all video footage to assess performance of the light-touch halibut trawl net and to help researchers understand the extent to which light-touch trawl gear minimizes contact with the seafloor. NOAA Fisheries personnel collected video footage on 15 of the 20 tows performed during the survey (Table 3). The quality of the video was dependent

on light and depth of the tow. Of the 18 videos collected (the last three tows had two cameras), seven were considered good quality video and were analyzed for seafloor contact and net performance by a NOAA Fisheries biologist.

Table 3. Video data collected by haul, camera (GoPro Hero 2) placement, video quality and whether it was used in the analysis.

Haul Number	Haul Date	Camera mounted on Headrope	Quality of Video from Headrope Camera	Headrope Video Used for Analysis	Camera mounted on Trawl Door	Quality of Video from Trawl Door Camera	Trawl Door Video Used for Analysis
1	08/10/2013	NONE	NA	NA	NONE	NA	NA
2	08/10/2013	NONE	NA	NA	NONE	NA	NA
3	08/10/2013	NONE	NA	NA	NONE	NA	NA
4	08/10/2013	NONE	NA	NA	YES	POOR	NO
5	08/10/2013	NONE	NA	NA	YES	POOR	NO
6	08/11/2013	YES	POOR	NO	NONE	NA	NA
7	08/11/2013	YES	GOOD	YES	NONE	NA	NA
8	08/11/2013	YES	GOOD	YES	NONE	NA	NA
9	08/11/2013	YES	GOOD	YES	NONE	NA	NA
10	08/11/2013	YES	GOOD	YES	NONE	NA	NA
11	08/12/2013	NONE	NA	NA	NONE	NA	NA
12	08/12/2013	NONE	NA	NA	YES	POOR	NO
13	08/12/2013	NONE	NA	NA	YES	POOR	NO
14	08/12/2013	NONE	NA	NA	YES	POOR	NO
15	08/12/2013	YES	FAIR	YES	NONE	NA	NA
16	08/13/2013	NONE	NA	NA	NONE	NA	NA
17	08/13/2013	YES	POOR	NO	NONE	NA	NA
18	08/13/2013	YES	POOR	NO	YES	POOR	NO
19	08/13/2013	YES	POOR	NO	YES	GOOD	YES
20	08/13/2013	YES	POOR	NO	YES	GOOD	YES

Review of the trawl footrope video showed that the footrope made minimal contact with the seafloor (Figure 3). The footrope skimmed above the seafloor while the chain loops hanging below the footrope did make bottom contact. These chain loops are intended to drive fish up and over the footrope and into the net. Many flatfish and crabs were observed passing under the footrope and chains thus avoid being captured in the trawl net.

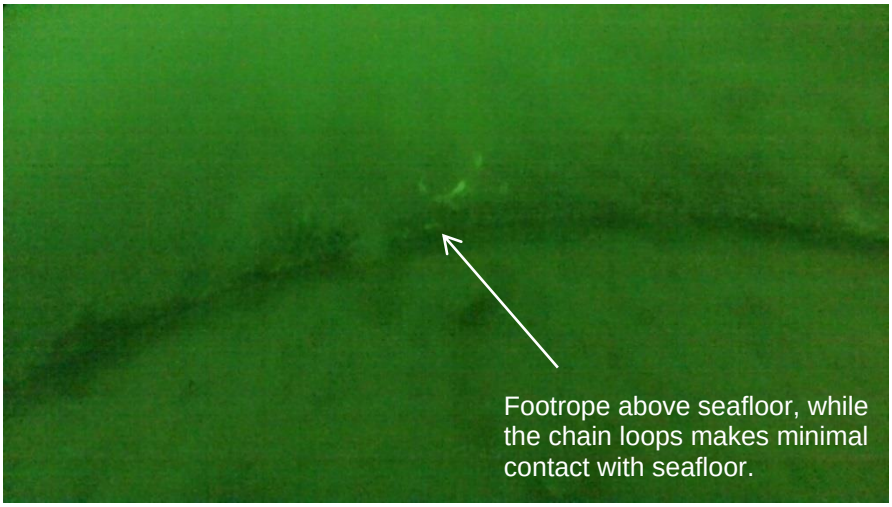

Figure 3. A still-frame picture taken from the video showing the footrope making minimal contact with seafloor. **Photo Credit: NOAA Fisheries**

Review of the trawl door video indicated that the door was not in constant contact with the seafloor during each trawl. The door traveled at an angle and skimmed above the bottom, while the leading edge made contact only when the seafloor had a corrugated surface (Figure 4). The door did pass through raised ripples in the seafloor, leaving a furrow approximately one inch deep into the soft sediment. This observation was supported by the condition of the trawl doors when examined onboard after trawling. The bottom surface of the doors was mostly covered with rust prior to the first trawl of the study. After a period of trawling on a sandy seafloor, a portion of the door had been scoured and appeared shiny (Figure 5). This rust-free area corresponded to the area seen making seafloor contact in the video.

Figure 4. Trawl door skimming the seafloor. **Photo Credit: NOAA Fisheries**

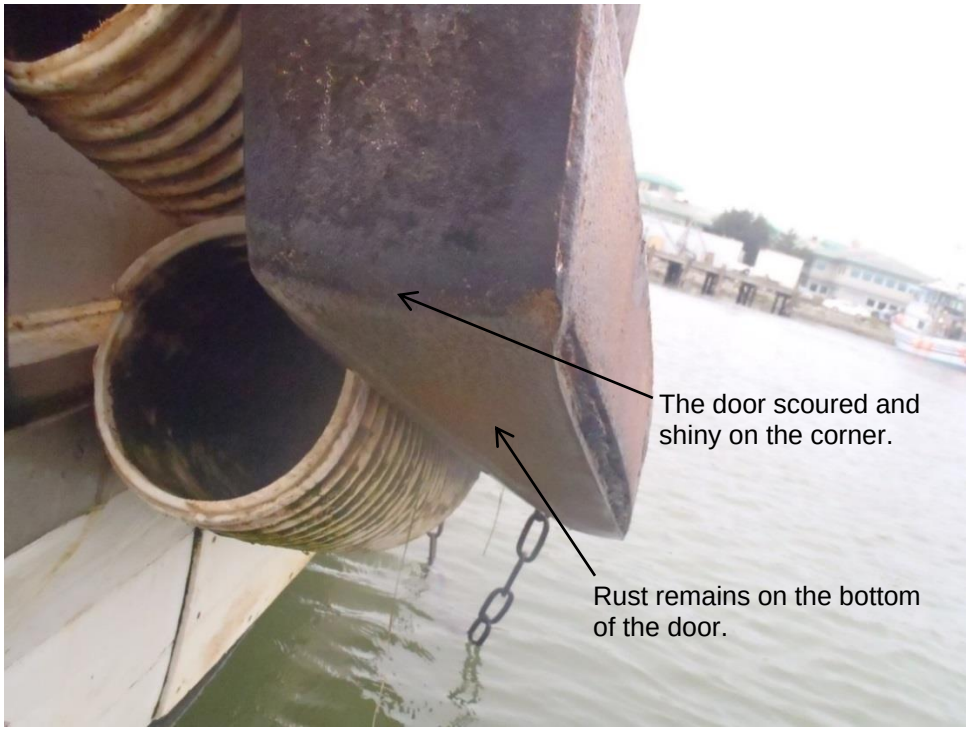

Figure 5. Picture of trawl door with rust on the bottom of the door, and scoured and shiny on the corner which corresponds to the area seen making seafloor contact in the video. **Photo Credit: NOAA Fisheries**

Economic Analysis

Returns at Trip Level

The results of the economic analysis show that targeting California halibut in the Monterey Bay area generates an economic profit of about $972 per trip during the halibut season (Appendix I). This profit level is substantially higher than the economic profit of $241 in the other fishing zones (i.e., Ventura and Santa Barbara) for the same target species and season. The economic return or profit after paying for the opportunity costs of all resources including the owner-operator's estimated value of labor constitutes about 47 percent of the fishing revenues in the Monterey Bay area, but only about 18 percent of revenue in the Ventura and Santa Barbara fishing grounds.

The owner operator's wage represents about 25 percent of the fishing revenue in the Monterey Bay area, but about 38 percent of the fishing revenue goes as wage to the owner operator when fishing outside the area, indicating that the Monterey Bay area offers higher potential entrepreneurial incentives and income to fishermen if this area were open. The lower profit margin in other fishing zones primarily reflect that bottom trawlers in other fishing zones catch less halibut and other marketable species there; catching only about 70 percent of halibut relative to the catch rate in the Monterey Bay area. In other words, the average catch rate per trip is about 180 pounds of California halibut during June-August as compared to the catch rate of 258 pounds in the Monterey Bay area. Further, the revenues from marketable, non-targeted species are also lower outside the Monterey Bay area. A good-valued, marketable incidental catch such as Starry flounders are largely caught in the in Monterey Bay area, but they are

uncommon or not available in other fishing grounds. The revenue from marketable incidental species is about $382 per trip (or 19 percent of the total revenue) in Monterey Bay area, but it is about $157 (or 12 percent of the total revenue) in other fishing zones (Table 4).

Table 4. Summary of Costs and Earnings (trip and fleet level) of a "Light-Touch" Trawl Gear for California Halibut in and Outside of the Monterey Bay Area, August 2013. (Appendix I).

Fishing Zones and Efforts	No. of Fishes		Catch (lbs.)		Revenue $			*Fixed Costs*	Variable Costs $		*Total Costs $*		Gross Profits $	
	CA Halibut	Bycatch	CA Halibut	Bycatch	CA Halibut (75:25 Live:Dead)	Bycatch	Total		w/o Owner's wage	w/ Owner's wage	w/o Owner's wage	w/ Owner's wage	Accounting Profit	Economic Profit
	A	B	C	D	E	F	G	H	I	J	K=H+I	L=H+J	M=G-K	N=G-L
In the Monterey Bay Area:														
***Catch Experiment (Unadjusted)*:**														
4-days trip	55	454	644	409	$4,188	$954	$5,142	$200	$1,841	$3,841	$2,041	$4,041	$3,101	$1,101
Per trip	14	114	161	102	$1,047	$239	$1,286	$50	$460	$960	$510	$1,010	$775	$275
***Normal Fishing (Adjusted)*:**														
4-days trip	88	726	1031	655	$6,701	$1,527	$8,228	$200	$2,141	$4,141	$2,341	$4,341	$5,887	$3,887
Per trip	22	182	258	164	$1,675	$382	$2,057	$50	$535	$1,035	$585	$1,085	$1,472	$972
Off the Monterey Bay Area:														
***Normal Fishing*:**														
Per trip	< 22 or ~ 14	154*	180	67*	$1,170	$157	$1,327	$50	$535	$1,035	$585	$1,085	$741	$241

* Bycatch is adjusted for Starry flounder, as the species is not caught off the Monterey Bay area.

Returns at Fleet Level

Trip level economic data was aggregated to a potential fleet level for the fishing season (June-August) in the Monterey Bay area and other fishing zones. It is assumed that possibly seven fishermen could be expected to trawl the Monterey Bay area should it be opened for California halibut trawl fishing. These fishermen would most likely be originating from Ventura, Santa Barbara, Moss Landing, and Monterey Bay area ports. It is expected that each vessel would, on average, take about five trips per week or 20 trips per month targeting California halibut in the area. There would be no incentive for these vessels to fish lesser trips after making the effort to travel to Monterey Bay. However, weekly number of fishing trips during the halibut season at the other fishing grounds is variable ranging from two to five trips per week or 10 to 20 trips per month depending upon sea conditions favorable for targeting halibut (M. McCorkle, personal communication, January 22, 2014).

Fleetwide revenue and gross profits for a potential halibut season (June-August) were estimated for both Monterey Bay area and other fishing grounds by using the information derived from the trip level analysis. The fleetwide revenue in the Monterey Bay area is expected to be about $863,906 with an economic profit of about $408,101 during the halibut season. The fleetwide economic profit in the Monterey Bay area is expected to be about $332,103 higher compared to fishing for halibut in other fishing grounds.

The incremental revenues for halibut fishing in the Monterey Bay relative to other fishing grounds are estimated to be about $585,338 for a low effort level; $446,054 for median level of effort; and $306,770 for the high level of effort in other fishing grounds. The resulting incremental return per vessel for halibut fishing in the Monterey Bay area is expected to be about $47,443 in economic profit in one halibut season for a median level of fishing effort in other fishing grounds.

Economic Impact

The additional economic contribution to the California economy through backward linked economic activities due to halibut fishing in the Monterey Bay area was estimated using the secondary data from an economic study by CDFW in 2009 (Hackette et al., 2009). The economic output multipliers for the trawlers operating in northern and southern California were used to assess the economic impact of halibut fishing in the Monterey Bay area. It is expected that the value-added from the incremental catches associated with fishing activities in the area would add to California's economy by the multiple of 1.67 on the incremental revenues. The halibut fishery in the Monterey Bay area is estimated to contribute an additional economic output to the California economy in the range of half million dollars to one million dollars depending upon the level of effort for halibut in other fishing grounds during the halibut season. The economic contribution from the forward linked economic activities at the restaurant or consumer's end will be an additional contribution to the economic impacts of backward linked activities. The economic analysis suggests that the economic return from the halibut fishery in the Monterey Bay area using the modified trawl gear is quite attractive to fishermen relative to same fishery in other fishing zones.

Protected Species Monitoring

In order to satisfy the requirements of the ESA consultation, NOAA Fisheries provided one dedicated scientific crew member to perform all the ESA monitoring and mitigating protocol at-sea duties. No ESA threatened or endangered species, or other protected species were encountered while transiting to the fishing grounds, during trawl fishing, or any other part of the survey. However, the survey team did observe large quantities of Pacific sea nettle jellyfish in the southern portion of Monterey Bay, therefore most of the tows were performed in the northern part of the bay as they are the primary prey of leatherback sea turtles which effectively categorizes them as critical habitat under the ESA.

DISCUSSION AND CONCLUSIONS

This research partnership, among CDFW, NOAA Fisheries, and industry, was successful in collecting an additional set of relative abundance, life history, and bycatch data to assist in the analysis of halibut stock health. The survey also analyzed the feasibility of using light-touch halibut trawl gear within the historic Monterey Bay trawl grounds. Video footage taken from cameras mounted on the headrope of the trawl showed that the light-touch trawl successfully caught fish with minimal disturbance to the seafloor while minimizing bycatch. The gear is economically feasible to provide a lucrative alternative source of income to fishermen in this fishery. In addition, the profit margin is attractive for halibut fishing in the Monterey Bay area relative to other fishing zones. The associated economic analyses indicated the use of light-

touch trawl in the Monterey Bay area could be profitable and may generate almost a million dollars in ex-vessel revenues and other positive impacts in Monterey Bay and throughout the California economy.

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