The Prevention of Marine Entanglement Using Autonomous Underwater Fishing Gear Through Designed Simulation

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Abstract

With the demand for seafood climbing, fisheries in the United States have limitations on time and type of gear which fishermen can place in the water. From the 1970s to present, environmental groups and government organizations have put forth aggressive efforts to protect whales. These efforts include lawsuits and state bills that incur large expenses and further limit the fishermen's ability to meet rising demand for shellfish. This study investigates the issue of entanglements of whales by fishing gear and proposes a new solution to protect marine life while simultaneously increasing affected fishermen's productivity through the use of autonomous fishing trap recovery systems. A simulated autonomous underwater fishing trap (ATRS - Autonomous Trap Recovery System) was developed in virtual reality software to help understand and communicate the proposed approach. The simulation could be used by fishermen to understand the technology and reduce risks to marine life from fishing activities.

Introduction

Bycatch is defined as "the portion of a commercial fishing catch that consists of marine animals caught unintentionally" (The Merriam-Webster Dictionary, 2018) (fig. 1).

Figure 1: Humpback Whale breaches from surface with ghost gear (NOAA, 2016)

A major goal of the Marine Mammal Protection Act, stated in section 118, is to reduce "the incidental mortality or serious injury of marine mammals occurring in the course of commercial fishing operations to insignificant levels approaching a zero mortality and serious injury rate" (2007). Within the fishing industries in the Pacific Ocean, specifically the West Coast Fisheries, recent legislation has influenced factors contributing to ghost gear entanglement, such as: location, gear, time, and seasons. Three main fisheries that use traps and pots located on the West Coast of the United States are Spot Prawn, Dungeness Crab, and Spiny Lobster. The designed simulation shows the cause and effect of whale entanglements with current fishing gear and the new proposed autonomous fishing gear.

Research Questions

1. Can autonomous fishing traps be simulated with minimal or no use of lines and buoys?
2. Will introducing autonomous fishing gear reduce whale entanglements?

Methods

Step 1: Virtual simulation was designed

Figure 2: Designed simulation of traditional versus autonomous traps

Step 2: Gathered data from three separate categories

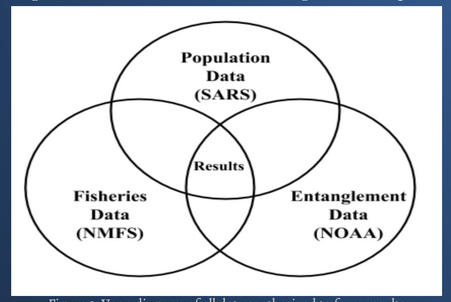

Figure 3: Venn diagram of all data synthesized to form results

Step 3: Own Calculated Mortality (OCM)

$((Nt^*E)/S)-(Nt^*E)$

My three OCM's calculated from the three different studies are:
#1 OCM1 = 3.7% from scar based study
#2 OCM2 = 4.5% from rope strength based study
#3 OCM3 = 3.3% calculated from West Coast entanglements

The Mean and Standard Deviation for these OCM's are:

Mean = 0.038

Standard Deviation = 0.0087

Purpose

Explore whether new commercial fishing techniques utilizing autonomous traps and recovery systems can reduce whale mortality from entanglements.

Results

Year	Fishery	# of pots	Species	Population	Observered Entanglements	Total Entanglements	OCM	PBR	Deaths	Tonnage	$ value of harvest	Tons harvested per whales killed
2016	crab	100,000	grey	20,125	3	30	3.8	624	1.14	64,166,220	222,640,176	56286157.89
2016	crab	100,000	humpback	1,876	54	540	3.8	11	20.52	64,166,220	222,640,176	3127008.77
2016	shrimp	108,000	grey	20,125	3	30	3.8	624	1.14	875,374	9,759,569	767871.93
2016	shrimp	108,000	humpback	1,876	54	540	3.8	11	20.52	875,374	9,759,569	42659.55
2016	lobster	45,000	grey	20,125	0	0	3.8	624	0	679,995	13,730,988	
2016	lobster	45,000	humpback	1,876	0	0	3.8	11	0	679,995	13,730,988	
2015	crab	100,000	grey	20,125	12	120	3.8	624	4.56	24,007,473	112,270,382	5264796.71
2015	crab	100,000	humpback	1,855	35	350	3.8	11	13.3	24,007,473	112,270,382	1805073.16
2015	shrimp	108,000	grey	20,125	12	120	3.8	624	4.56	877,214	9,247,445	192371.49
2015	shrimp	108,000	humpback	1,855	35	350	3.8	11	13.3	877,214	9,247,445	65955.94
2015	lobster	45,000	grey	20,125	12	120	3.8	624	4.56	767,810	15,806,408	168379.39
2015	lobster	45,000	humpback	1,855	35	350	3.8	11	13.3	767,810	15,806,408	57730.08
2014	crab	100,000	grey	20,125	7	70	3.8	624	2.66	55,028,879	211,607,127	20687548.5
2014	crab	100,000	humpback	1,855	20	200	3.8	11	7.6	55,028,879	211,607,127	7240641.97
2014	shrimp	108,000	grey	20,125	7	70	3.8	624	2.66	792,068	8,310,742	297769.92
2014	shrimp	108,000	humpback	1,855	20	200	3.8	11	7.6	792,068	8,310,742	104219.47
2014	lobster	45,000	grey	20,125	0	0	3.8	624	0	951,435	18,238,492	
2014	lobster	45,000	humpback	1,855	0	0	3.8	11	0	951,435	18,238,492	
2013	crab	100,000	grey	20,125	13	130	3.8	624	4.94	87,868,545	253,462,248	17787154.86
2013	crab	100,000	humpback	1,855	15	150	3.8	11	5.7	87,868,545	253,462,248	15415534.21
2013	shrimp	108,000	grey	20,125	13	130	3.8	624	4.94	741,186	7,114,974	150037.65
2013	shrimp	108,000	humpback	1,855	15	150	3.8	11	5.7	741,186	7,114,974	130032.63
2013	lobster	45,000	grey	20,125	13	130	3.8	624	4.94	764,302	13,842,204	154717
2013	lobster	45,000	humpback	1,855	15	150	3.8	11	5.7	764,302	13,842,204	134088.07

In table 9, the results reveal the shrimp industry had the least catch for the estimated number of whales killed. Using the OCM1, OCM2, and OCM3 overall mean from the calculations in *Step 5*, the amount of whale deaths was computed. This was done by using the observed entanglements from the data previously gathered. 10% was added to those numbers to obtain an estimate of all entanglements within that specific industry. From that, all of the entanglements was multiplied by 0.038 or the mean of all three OCM's to obtain the estimated number of whale deaths. The tonnage per year was divided by whale deaths to show the number of approximated whales being killed to satisfy increasing consumer demand for seafood.

Discussion

Based on the results, shrimp industry is potentially killing more whales per ton of shrimp harvested as a repercussion of bycatch. This indicates that the shrimp fishery would be a good place to focus industry attention first on the Autonomous Trap Recovery System (ATRS). In particular, understanding which fishery potentially harms the most whales could make the largest impact in terms of consumed seafood if it began utilizing ATRS. In order to accomplish this, an understanding of what the mortality of whales was that resulted from an entanglement and understanding how that entanglement related to Potential Biological Removal was conducted. If any of the fisheries embraced ATRS, the mortality rates would be decreased. While this may seem obvious, this study also attempted to outline a possible way to prioritize the use of incentive investment to create the necessary support for the technology to succeed. I have endeavored to identify the fisheries which could make the greatest impact towards a public consumption of seafood that will no longer kill whales. With the use of ATRS, fishermen would be able to differentiate themselves from those who use the current trapping mechanisms.

Conclusion

The simulation can show the fishermen how the traps will work and allow them to gain confidence in the new trapping systems which could result in the fishermen's support with the new technology. The data collected proved that the fishing industry is a major threat to the whales and other marine life but since nothing is currently being undertaken, further animals are in danger. ATRS can be used by all fishermen which will open up areas for new fishing, discriminate whales based on their swimming patterns, and detect and locate the crab, shrimp, and lobster. The overall goal of this project was to explore whether new commercial fishing techniques utilizing autonomous traps and recovery systems can reduce whale mortality from entanglements. ATRS provides a safe understanding of the future and how we can save our oceans from further endangerments.

Further Work

- The potential for a realistic simulation could be performed in the future that could have accurate predictions of whale migration and population anywhere in the world to provide assurance to the fishermen when placing their traps in the waters.
- The United States Department of Fish and Game could help subsidize the cost of ATRS implementation for fishermen. Legislative and litigation expenditures could be redirected to fund the new technology for the fishermen and their industries. The Department of Fish and Game could subsequently issue new permit types to the fishermen which require the use of ATRS but also open up new areas of water and seasons to continually feed the demand of growing consumers.
- In the future, when fishermen use ATRS they will be selling "Rope/Whale Free" shrimp, crab, and lobster. This is similar to the idea of "dolphin free" tuna where fishermen do not deliberately catch dolphins and if one does become entangled within the tuna nets, they set all dolphins and tuna caught with those nets free and start over in a new area. It is not a far reach to believe that shrimp, crab, and lobster will be sold with the words "whale free" on the label if ATRS is embraced and used to prevent entanglements and mortalities

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