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Monitoring of Fish Biomass to Comprehend and Manage Marine Ecosystems

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Abstract

Long-term monitoring of fish biomass is required to comprehend and manage marine ecosystems. Using sampling nets to estimate fish biomass is difficult due to the fact that catchability varies depending on habitat, weather, or vessel traffic. A non-lethal, cost-effective, and efficient way to observe and measure fish in areas that cannot be sampled otherwise has been demonstrated by underwater stereo cameras. However, these techniques have not yet been tested on mid-water pelagic or semi-pelagic fish. A stereo camera was designed, constructed, and tested with the intention of enhancing survey assessments of pelagic fish biomass in locations where trawl net samples cannot be collected. The stereo camera was used in a pilot test to identify and measure fish length, depth, tilt, and yaw. During an acoustic survey in the Strait of Georgia, British Columbia, five paired stereo camera deployments and pelagic midwater trawl hauls were compared.

Introduction

The deployment of the stereo camera occasionally caused fish to move, but they quickly adjusted to its presence at depth. In both midwater trawl haul catches and stereo camera images, Pacific hake, Merluccius productus, and walleye pollock, Gadus chalcogrammus, were the most common species. However, stereo camera images typically showed fish that were significantly larger than trawl haul catches. When yaw angles were 30°, fish length measurements were most accurate [1]. The midwater trawl catch-per-unit-effort values were correlated with higher fish abundances in the stereo camera images. The orientation of the fish was nearly horizontal for pollock and slightly downward for hake, which may have an impact on estimates of biomass based on acoustics. The use of stereo cameras in acoustic surveys presents a number of difficulties, including the time required for image processing, the identification of small fish, and smaller sample sizes than those found in midwater trawl catches. However, stereo cameras have the advantage of providing additional information on specific fish depth, tilt, and yaw, making them useful tools for acoustic target verification of fish species and measurements of fish lengths. In areas where trawling is either prohibited or logistically impossible, such as shipping lanes or marine protected areas, cameras can also sample non-lethally. Based on our findings, it appears that stereo camera technology can be used to study fish in the water column.

For sustainable ecosystem management to be supported, integrated research and long-term monitoring are necessary. Acoustic-trawl surveys, which provide biomass time series for targeted fish species, are one example of a variety of assessment methods that can be used to monitor marine fish populations. These abundance time series are frequently incorporated into species-specific stock assessments or ecosystem reports for the purpose of determining the species' total allowable catch or evaluating the state of ecosystems [2]. As a result, improving these estimates through the development of new technologies and methods could have a wide range of applications for decision-making in ecosystem-based fisheries management.

Acoustic-trawl surveys require fish species and size information from trawl catches in addition to acoustic volume backscattering data to estimate fish biomass. When habitat, weather, or vessel traffic changes the catchability or availability of fish for the survey gear, it is difficult to estimate fish biomass. A midwater trawl cannot be used in pelagic surveys in certain circumstances, such as vessel traffic lanes in fog or marine protected areas. Additionally, trawl samples are costly due to the time and effort required to deploy the net and process the catch as well as the large vessel size required to tow a midwater trawl net [2]. Elective non-deadly strategies to get length and species recognizable proof information might be more appropriate in certain circumstances.

A non-lethal, cost-effective, and effective method for observing and measuring fish in areas that cannot be sampled otherwise is provided by underwater stereo cameras. In habitats that can't be trawled, stereo camera technology has been used to estimate the biomass of rockfish near the bottom. The species composition as well as the lengths of demersal and pelagic fish has been gathered using baited and moored stereo video cameras in the middle of the water. The benefits of this technology could be used to monitor resources for pelagic and semi-pelagic fish; however, large-scale acoustic surveys of the water column have yet to test these methods [3]. The success of incorporating stereo camera technology to complement trawl sampling will need to be tested in the field.

Before stereo camera sampling efforts can be fully implemented in acoustic surveys, a number of significant issues must be resolved. The behavioural effects of underwater survey vehicles on benthic fishes have been the subject of several recent studies; however, the impact of stereo camera devices on pelagic fish behavior is largely unknown and likely significant. The number of samples required to accurately determining the size and species structure of acoustic targets encountered during an acoustic survey is another concern [4]. Lastly, biases in estimates of size and species composition must be addressed and taken into account, as with any sampling device.

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The assessment of pelagic fish biomass was carried out in this study using stereo camera technologies. This was a pilot test to decide whether sound system cameras could be valuable devices in confirming fish species and sizes [5]. The following were some of the study's goals: 1.) build a stereo camera system that won't affect how fish behave in the pelagic environment much; 2.) examine how this camera system works to identify the lengths and species of pelagic fish; 3.) assess the impact of fish direction on sound system camera-based fish estimations; and 4.) Compare the species composition and size of fish taken with a stereo camera and a midwater trawl net using a first-order approximation.

Discussion

Various studies examining the use of habitat and the abundance of ground fish close to the seafloor have successfully utilized stereo cameras. A stereo camera that can be used to identify fish and measure their lengths in the water column has been successfully designed, constructed, and implemented here. The stereo camera was looked at to see if it could help survey assessments of pelagic fish biomass in places like vessel traffic lanes where trawl net samples can't be collected [6]. This study's findings demonstrated that an effective instrument for acoustic target verification of fish species, length, depth, tilt, and yaw can be a stereo camera. Acoustic surveys can benefit from this information, as can other scientific surveys in general.

This study's Slycam stereo camera was able to capture images of fish that could be categorized by species and measured. Slycam images and midwater trawl net samples shared similar species composition and the main acoustic target species. The stereo camera faced the following difficulties: Due to the fact that the volume of water sampled by the Slycam was significantly smaller than that of the midwater trawl, the smaller sample sizes in backscatter were characterized as loosely aggregated acoustic targets. However, higher fish counts in Slycam deployments were linked to higher midwater trawl net catches. Slycam images of fish had sample sizes that were less than 11 percent of the number of fish in trawl collections. However, trawl collections frequently exceeded the required size for biological samples; only about 250 subsamples of trawl-caught fish were sufficient [7]. The proportion of hake and pollock counted in Slycam images compared to trawl catch subsamples was, on average, 20%. These findings have the repercussions of requiring approximately five times as many camera deployments as trawl hauls to collect the same number of fish identifications and fish lengths.

The amount of time required to set up equipment and process images or catches is an important factor. Slycam took only minutes to deploy and retrieve, with an entire deployment time of approximately 30 minutes between breaking and resuming survey transect operations. A midwater trawl took approximately 1–2 hours. Additionally, while trawl operations required a number of people, equipment operation only required two scientific personnel [8]. Depending on the size of the catch, it took anywhere from two to four people up to two hours to process the catch for length samples. Handling of Slycam pictures was finished by one individual and expected 2-6 h for each arrangement to handle the picture information, contingent upon the span and number of fish noticed. However, recent advancements in automated image processing and fish measurement will speed up image analyses. When compared to trawling operations, Slycam deployments require a shorter amount of ship time, allowing for larger Slycam sample sizes with fewer scientific personnel and the same amount of vessel time.

Slycam images occasionally made it difficult to distinguish species from smaller fish. Schools of age-0 herring were easily observed and identified with the camera during the initial field trials of Slycam in shallow areas close to the shore. However, Slycam could not be tested on a herring school because large herring aggregations were not acoustically observed during the Strait of Georgia survey [9]. Differences in the behavioural responses of the smaller fish to the camera system could also be the reason why there are no positively identified smaller fish in the images. Slycam may have approached a herring more like a predator than a larger pollock or hake. In other studies utilizing a wide range of underwater survey equipment, it was discovered that fish sizes and species have different responses to stimuli from underwater vehicles and cameras.

Although studies have demonstrated that spectral sensitivity for some marine fishes is reduced at wavelengths greater than 600 nm, fish vision is generally sensitive to light wavelengths in the blue to far-red range. Additionally, field experiments have demonstrated that fish exhibit a diminished response to lighting at higher wavelengths close to the extremes of their sensitivity. For instance, when red lights were used instead of white lights, rockfish and sablefish densities were found to be higher, and behavioural responses to red lights were also found to be lower. Therefore, despite the fact that the specific responses of Pacific hake and walleye pollock to red light at a wavelength of 660 nm are unknown, based on the behavioural responses of other fishes, we would anticipate that using red lighting rather than white lighting would have a minimal or reduced effect on these species' behavior. Almost certainly, the size of the unit or the presence of a tow link might have gotten a reaction in more modest fishes like herring [10]. Although the stereo camera's design in this study had a low profile, the pressure wave or camera movement probably caused the avoidance observed during deployment and retrieval. The image analyses did not reveal individual fish avoidance behavior, and even though there was only a small amount of sea swell (less than 1 m) during all camera deployments, it appeared that fish were accustomed to the camera by keeping it at depth.

Slycam images yielded estimates of mean fish lengths that were longer than those obtained from midwater trawl samples; however, the length ranges of the two kinds of gear were comparable. It's possible that smaller fish avoided the camera more than larger fish did, or that smaller fish were not always as easy to positively identify to a species and measure in Slycam images as larger fish were. Slycam could be used multiple times or for longer periods to increase sample sizes of smaller fish, as suggested by van Rooij and Videler as the most effective method for increasing the accuracy of stereo camera length measurements, to address the latter issue. However, midwater trawls can also select by size [11]. Numerous studies have demonstrated that trawl meshes in the middle of the water can result in the loss of a significant number of smaller fish. Despite the fact that selectivity for bigger fish doesn't make sense of the outcomes found in this review, selectivity against bigger fish has been recently seen in fishes.

Acoustic surveys can benefit from Slycam measurements of fish tilt and yaw. The fish's yaw angle in relation to the stereo camera has an effect on the length measurements. Similar to what Harvey, Shortis, and Williams found, this study found that when the yaw was less than 30 degrees, the most accurate length measurements were taken. One of the largest sources of uncertainty in biomass estimates derived from acoustic data is the tilt angle of fish, which has an effect on their target strength. Fish's tilt angles change how strong their targets are. Survey image tilt measurements in this study show that hake were tilted downward and pollock were oriented horizontally in the water column on average. The fish in this study did not have tilt angles because diel vertical migration can increase tilt angles; between 08:00 and 14:00 for hake and 08:00 and 18:00 for pollock, all samples were taken during daylight hours [12]. If the downward tilt angle of hake observed here is representative of the population and significantly different from that of individuals used to estimate target strength, it could be a potential source of bias.

Compared to the midwater trawl, the stereo camera provided additional advantages. For instance, when compared to the midwater trawl, the stereo camera was able to accurately record the depth-or depth layer, in the case of multiple fish layers at which fish were being observed and did not result in fish mortality. The water column was integrated on the "downcast" and "upcast" during deployment and retrieval with net tows, which resulted in fish mortality and sample sizes that were frequently larger than necessary [13]. Alternately, by matching fish observations to the camera depth, a lowered camera system can provide species identification and sizes specific to depth.

Conclusion

Stereo camera technology is improving and proving to be a useful tool for studying fish in the water column as well as ground fish and habitat studies. It offers the advantage of a quick tool for estimating fish lengths and species composition. The acquisition of the appropriate sample sizes and the identification and measurement of small fish are still obstacles to overcome. However, the benefits are compelling, including the ability to verify targets in untrawlable areas, lower fish sampling mortality, depth-specific fish identification, measurements of length, tilt, and yaw, time and cost savings, and more.

Conflict of Interest

The author declares has no conflict of interest.

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