RESEARCH NOTE

Patterns in the Local Distribution of the Sea Whip, *Halipteris willemoesi*, in an Area Impacted by Mobile Fishing Gear

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ABSTRACT

While conducting a larger project along the continental shelf off central California in June 2006, we encountered a large patch of sea whips (*Halipteris willemoesi*) in an area that was actively fished by vessels using otter trawls. A total of 10 transects were conducted using a remotely operated vehicle (ROV) to collect video imagery of seafloor communities. Video records allowed us to quantify sea whip density and to calculate the densities of upright and damaged or broken sea whips. Though the transects were sited within a dense aggregation of trawl tracks, we recorded significant variability in sea whip densities across transects. While subtle differences in water depth among transects may have contributed to the variability in sea whip density, we suggest that the distribution of trawling effort is a more likely explanation.

Introduction

The general effects of fishing with mobile, bottom-contact fishing gear (such as otter trawls) are increasingly well established (see reviews in Jennings and Kaiser, 1998; Auster and Langton, 1999; Hall, 1999; Collie et al., 2000; National Research Council, 2002; Kaiser et al., 2006). Trawling removes or damages structure-forming invertebrate organisms (such as sponges and corals), removes structure-producing organisms (such as rays and crustaceans), and smooths bedforms (such as sand waves; Auster et al., 1996; Lindholm et al., 2004). However, there continues to be a paucity of data on the specific impacts of trawling activity on particular organisms and on the rates of recovery following the cessation of fishing activity.

The sea whip, *Halipteris willemoesi* (Octocorallia: Pennatulacea) is a sessile macro-invertebrate common on the continental shelf and slope of western North America. It is an erect, colonial organism that is anchored to the seafloor by a burrowing peduncle (Wilson et al., 2002). Members of the family have been reported at water depths ranging from 50 to 6200 m (Williams, 1999; Stone, 2003). Along the central coast of California (USA) sea whips are frequently observed along the outer continental shelf in low densities (< 1 m $^{-2}$) and are periodically found in dense patches (>2 m $^{-2}$). The factors contributing to observed sea whip densities have not yet been explained.

A variety of organisms, including rockfish (Kreiger, 1993; Brodeur, 2001), sea horses (Choo and Liew, 2003), weathervane scallops (Masuda and Stone, 2003) and basket stars (de Marignac et al., in review) have been observed to associate with *H. willemoesi* or other pennatulid species. As attributes of animal habitat, sea whips may provide cover from predation and facilitate animal feeding higher in the water column.

The vulnerability of the *H. willemosi* to impacts from trawling activity remains unclear. Studies of age and growth indicate that sea whip life spans may exceed 50 yrs (Wilson et al., 2002), indicating that any impacts from trawling could persist for decades. Troffe et al. (2005) found differential impacts to *H. willemosi* from beam trawls and prawn traps. They theorized that sea whips may be able to withstand impacts from mobile fishing gear by bending and/or re-attaching to the sediment following disruption. Both bending and reattachment have been observed in other pennatulid species in the presence of fishing activity (Eno et al., 2001). However, in the Gulf of Alaska, 55% of individual sea whips (*Stylea spp.*) were either broken or had been extracted from the sediment following a single pass of a trawl (Freese et al., 1999). Im-

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portant questions remain with respect to the vulnerability of *H. willemosi* to damage from otter trawling specifically, where the heavy otter doors and trawl foot-rope gear exert a greater force on the organisms they encounter.

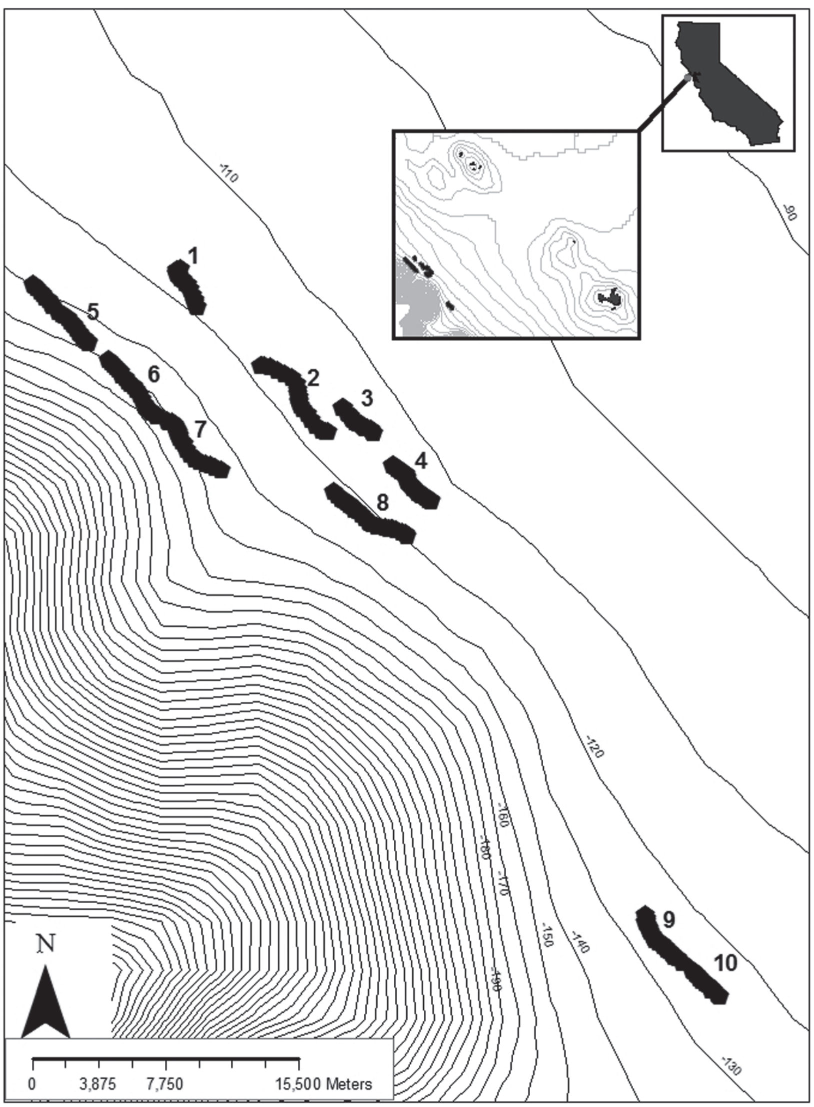
In June 2006, while conducting a larger project along the continental shelf off central California (de Marignac et al., in review) we encountered a large patch of sea whips in an area that was actively fished by vessels using otter trawls. Video records collected by a remotely operated vehicle (ROV) allowed us to quantify sea whip density and to calculate the relative abundance of upright sea whips vs. damaged or broken sea whips. We offer hypotheses to explain the patterns in sea whip distribution that we observed.

Materials and Methods

The study area was located adjacent to the Farallon Islands in 110 -140 m water depth (Figure 1). The seafloor was characterized by low-relief, fine-grained sands. Data provided by the National Marine Fisheries Service allowed us to sample in areas of highly concentrated trawling effort. Trawl track data were analyzed first as aggregated effort in 0.25 km^2 blocks to identify areas of intense trawling effort, and then as individual trawl tracks (trawl start to trawl end) to select a specific study area. Sampling sites were systematically sited adjacent to a closure (designated by the Pacific Regional Fishery Management Council in May 2006) that was actively trawled through 2005 (the most recent effort data available at the time of the study).

FIGURE 1

Map of the study area off the Farallon Islands (inset), including the 10 ROV transect lines and 10 m isobaths.



The X2 ROV (Figure 2; Deep Ocean Engineering and Research, Alameda, CA) was configured with two video cameras (forward and down-looking), a down-looking digital still camera, and two down-looking lasers for image calibration and for estimating height off the bottom. Quartz halogen HMI lights provided illumination for the video and lighting for still photographs. The ROV was operated at an altitude of approximately 0.5 m above the seafloor.

A total of 10 transects were conducted in the study area (Figure 1). Each transect consisted of 20 min of continuous video. Video imagery was analyzed as a series of non-overlapping video quadrants, each measuring

FIGURE 2

The X2 ROV configured with forward and down-looking video cameras and down-looking digital still camera and paired 20 cm lasers. (Photo: Ashley Knight)

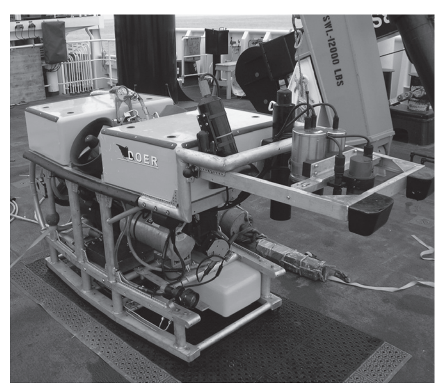


FIGURE 3

Still photograph depicting multiple erect sea whips and a prostrate (broken) sea whip fragment. (Photo: James Lindholm)

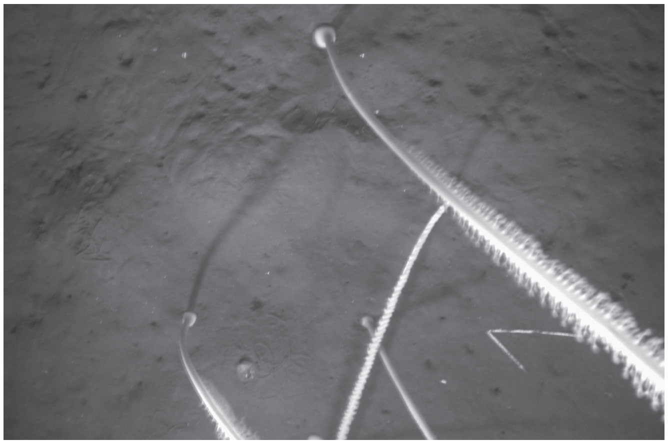
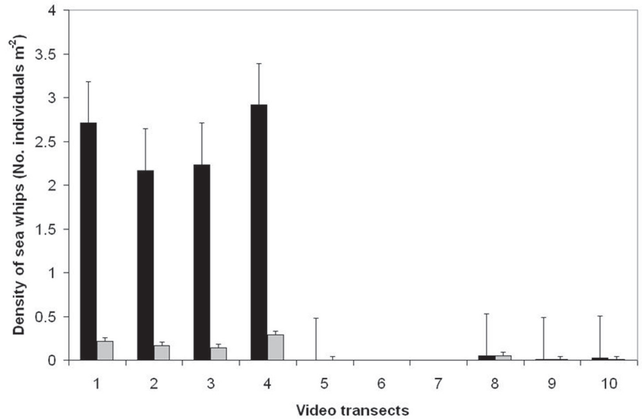


FIGURE 4

Density (number of sea whips m^{-2}) of upright (black) and prostrate (gray) sea whips across 10 ROV transects. The standard error is reported.



approximately 1.39 m^2 based on the mean altitude of the ROV over the seafloor. Down-looking video was used to compute the density of upright, prostrate (whole), and prostrate (broken) sea whips for each transect. An example of upright and prostrate (broken) sea whips is provided in Figure 3. ANOVA was used to compare the relative densities of upright and prostrate (broken and whole) sea whips among the transects in which they both occurred.

Results

Sea whips (both upright and prostrate) were observed in 8 of the 10 ROV transects. A sea whip specimen collected by the ROV was identified as *H. willemosi* Upright sea whips occurred in densities ranging from 0.001 to 2.91 sea whips m^{-2} (Mean = 1.01, SD = 1.3; Figure 4). The highest densities of upright sea whips were recorded in transects 1-4, with few-to-no individuals recorded in transects 5-10. The majority of the upright sea whips we observed occurred at a uniform height of 0.5 m based on the known altitude of the ROV above the seafloor, suggesting that they were part of a single cohort. We recorded no broken-but-erect sea whips in any of the transects.

Prostrate sea whips lying on the seafloor occurred in densities ranging from 0.001 to 0.29 sea whips m^{-2} (Mean = 0,09, SD = 0.011; Figure 4). These sea whips also occurred most frequently in transects 1-4. In contrast, of the sea whips lying prostrate on the seafloor, the majority of those observed in transects 5-10 were broken fragments. At least one prostrate and/or broken sea whip was recorded in each transect in which upright sea whips were observed.

The densities of upright and prostrate (whole and broken) sea whips differed significantly among Transects 1-4 in which they occurred most frequently (ANOVA:

$F_{1,6}$ = 156.04, P-value = 0.000).

Discussion

Any study of the marine subtidal is dependent on a research platform for the support of data collection instrumentation (e.g., still photographic and video cameras). Potential platforms for such work include remotely operated vehicles (ROVs), towed camera sleds, human-occupied submersibles, and autonomous underwater vehicles (AUVs). In this study, we used an ROV to collect video imagery on seafloor communities along the outer continental shelf of western North America. The ROV was configured to provide both down- and forward (oblique) looking video imagery of the same area of the seafloor.

The marked difference in the occurrence of upright sea whips among video transects was un-anticipated and may be attributable to two primary factors: water depth and/or impacts from otter trawling. Data collected during the larger study indicated no difference in sediment particle size, sorting coefficient, or moisture content among the 10 transects (de Marignac et al., in review). This suggests that sea whip selection for a particular sediment type was not a factor in the patchy distribution among the 10 transects. However, the water depth varied among transects from 117 m to 141 m, and the highest densities of upright sea whips occurred in the shallowest 4 transects. Though the larger study found no difference among the 10 transects with respect to the infaunal invertebrate community that was attributable to water depth (de Marignac et al., in review), it is possible that sea whips responded to depth in some way. CTD casts in the study area showed no difference in water temperature at the seafloor, suggesting sea whip persistence, once settled, would likely not be influenced by ambient temperature. While we observed sea whips at multiple depths, the interaction of water depth and current patterns may have contributed to the local distribution of the whips during settlement in the study area. Further study of sea whip settlement dynamics is required.

An alternative explanation for the differences we observed in sea whip density is the heterogeneous distribution of otter trawl fishing effort. We selected sample sites in an area that had been actively fished using otter trawls for the four years prior to our study. These data, which we were not able to publish due to the proprietary nature of the information on individual fishing vessels, were provided as straight lines between trawl tow start and stop points. In fact, our communications with the fishing community indicated that trawl tows are rarely conducted in straight lines, but rather will frequently follow isobaths. As such, it is possible that transects 1-4 had not been impacted by fishing gear for multiple years prior to our sampling effort, though the trawl track data suggested that they had been. This problem highlights a significant limitation in the way trawling effort is currently collected. More accurate, geo-referenced trawl track data will enable greater precision in management decisions that depend on an understanding of bottom contact time and location.

Two aspects of the data supported this later explanation. First, the high density of sea whips in the four transects was strongly suggestive of no impacts from otter trawls. Even were sea whips pliable enough to bounce back following a single pass from an otter trawl, as theorized by Troffe et al. (2003), it is not likely that multiple passes of an otter trawl (as were reported in the study area) would leave an average of 92% of the sea whips upright and unbroken. Indeed, Freese et al. (1999) found greater than 50% of sea whips (*Stylea spp.)* were either broken or removed following a single pass of an otter trawl. Further, under a regime of intense trawling pressure, we would have expected more evidence of broken whips lying on the seafloor, which is precisely what we did find in several of the other transects.

Though the data we collected were limited, the patterns we observed were suggestive with respect to the interaction of otter trawls and erect sea whips and warrant additional study. Ultimately, the linkage between sea whips and exploited and/or endangered fishes (Brodeur, 2001; Choo and Liew, 2003; Troffe et al., 2003) necessitates a better understanding of how mobile fishing gear impacts the structural attributes of seafloor communities upon which fishes depend for cover.

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