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Bathymetric Extent of Recent Trawl Damage to the Seabed Captured by an ROV Transect in the Alboran Sea

By Michael L. Brennan, Miquel Canals, Dwight F. Coleman, James A. Austin Jr., and David Amblas

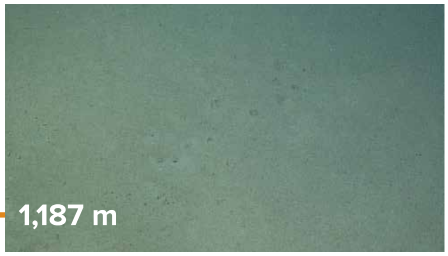

FIGURE 1. The ROV transect began at nearly 1,200 m on flat, muddy seabed, with small mounded burrows and clear bioturbation. Below 850 m, no trawl marks are evident. Macrofauna, including rattail fish, sea urchins, crabs, and blackmouth catshark, were observed in the area.

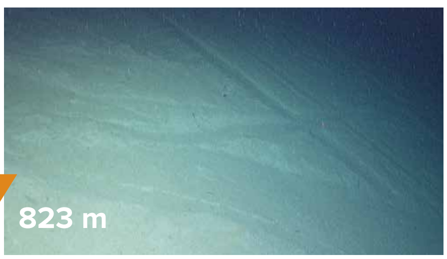

FIGURE 2. At 0530 GMT, *Nautilus* crossed paths with a trawling vessel and caused the team to slow the ROV transect. When the vehicles reached the area the where the fishermen were operating, fresh trawl marks were visible on the seabed. New trawl marks are crisscrossed with older scars, although all appear recent, with rectangular-shaped edges rather than the U-shaped scars that develop once they become partially filled in with sediment.

Bottom trawl fishing is among the most destructive anthropogenic pressures acting on benthic ecosystems, but the full extent of the damage is undocumented because of the limited number of deep-sea observations of impacted regions (e.g., Brennan et al., 2012, 2016). As part of its continuing ocean exploration mission, in 2011, E/V *Nautilus* conducted a remotely operated vehicle (ROV) survey along a transect in a submarine canyon in the Mediterranean's Alboran Sea off southern Spain at depths ranging from 1,200 m to <300 m (Coleman et al., 2012). This exploration along the South Alboran Ridge offered the opportunity to directly observe with video the bathymetric extent and intensity of recent trawling damage to the seafloor in this area. This dive revealed large furrows running in multiple directions caused by trawl doors scraping across the seabed. Little biological activity was evident in the depth ranges where these scars were observed. The destructive nature of bottom trawl fishing should be viewed with the same public affront as subaerial clear-cutting of forests and strip-mining. The only difference is that the ocean hides trawl damage from the public eye. The more we explore the deep sea, repeatedly map the seafloor with sonar, and observe the seabed and its ecosystems with video captured by ROVs, the greater we can understand the full impacts of trawling.

The deleterious and nonselective damage that trawling operations cause to the seabed has been a subject of concern and debate among ecologists and fisheries managers for decades (e.g., Caddy, 1973; Jones, 1992; DeAlteris et al., 1999; Demestre et al., 2015). Bottom trawls have a long-lasting impact beyond their removal of large quantities of fish from the ecosystem, including bycatch. Trawling destroys benthic habitats and hard ground for invertebrates, smooths over seabed morphology, and resuspends sediments (e.g., Watling and Norse, 1998; Ivanović et al., 2011; De Juan and Demestre, 2012; Lucchetti and Sala, 2012; Norse et al., 2012; Martín et al., 2014a). In the Mediterranean, the trawl fleet works along both the continental shelf and the continental slope. Trawls catch many species, although only some of them are targeted, including blue whiting (*Micromesistius poutassou*), hake (*Merluccius merluccius*), red mullet (*Mullus* spp.), octopus (*Octopus vulgaris* and

FIGURE 3. Many ridges in the sediment were observed during the ROV transect when moving upslope; steeper terrain indicates slope failures. Trawl operations can smooth over such sedimentary features and also trigger slope failures, as has been noted in the Black Sea (Brennan et al., 2013).

FIGURE 4. This picture of fresh, deep trawl furrows in the sediment shows larger clumps of sediment that have settled next to the scar. Smaller particles are resuspended into the water column and can be transported further downslope as a sediment cloud caused by the turbulence of the weighted net and gear passing by (Jones, 1992; Puig et al., 2012).

FIGURE 5. Isolated bedrock outcrops commonly found on flatter slopes create habitat for a variety of fauna that live on and around them. Here, an outcrop is inhabited by corals as well as a siphonophore and a visiting Conger eel (*Conger conger*). Both of the latter were commonly seen during this transect.

Eledone cirrhosa), Norway lobster (*Nephrops norvegicus*), and red shrimp (*Aristeus antennatus*). Hake and blue whiting dominate depths of 150–350 m, while the fishing grounds >350 m are primarily targeting decapods such as lobster and red shrimp (García-Rodríguez, 2003; Commission of the European Communities, 2004).

The ROV dive began at 1,200 m depth in an area of flat, muddy seabed with burrows and other abundant benthic features that continued to ~850 m depth (Figure 1), where the seascape changed dramatically—deep trawl furrows began to dominate the seafloor morphology. While surveying, *Nautilus* encountered an active trawler and had to wait for it to pass before continuing the transect (Figure 2). It is likely that the scars we observed on the seabed were at least in part the result of this fishing vessel's operation. The region of heavy scarring continued as the ROV progressed upslope another 100 m (Figures 3 and 4). Between 750 and 550 m depth we observed little trawling damage—rock outcrops and macrofauna, including small sharks and eels, dominated the seabed (Figures 5–8). Perhaps fishermen know to avoid such rocky areas as they can damage their gear. Trawl scars returned between 550 m and 400 m depth, but these marks appeared older and were partially filled with sediment (Figures 9 and 10). Shallower than 400 m

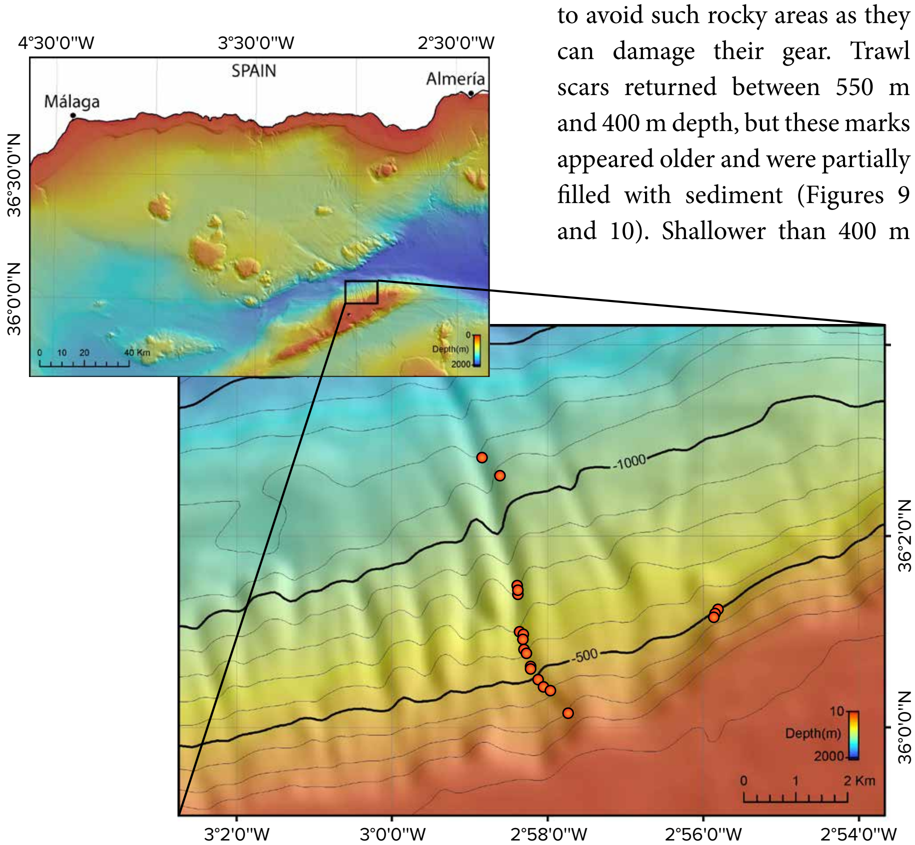

FIGURE 11. Smaller, older scars were observed as the transect neared its end. Animal tracks can be seen crossing over the scars, suggesting they were not recent and that the benthos had had some time to recover. These smaller scars were likely made by smaller fishing vessels targeting shallower species than the deeper trawlers seeking crustaceans like red shrimp.

FIGURE 10. Upslope of the canyon north of the plateau that forms Alboran Island, precipitous slopes consist of large bedrock outcrops that are too steep for sediment to settle.

FIGURE 9. More trawl scars were observed here, but they were older and faded, partially filled in with sediment to create a U-shaped scar compared to the rectangular furrows seen in the deeper, fresher scars.

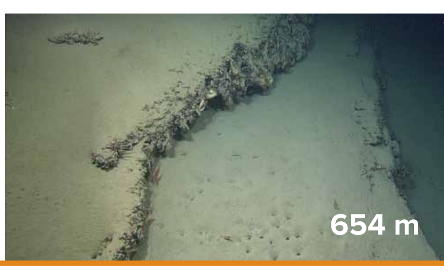

FIGURE 6. As the slope of the canyon continued to rise, flatter ridges were encountered with sponges, shrimp, and urchins living on and around them. These stepped features would present an obstacle and hazard to towed fishing gear, especially when towed upslope. As a result, these areas tended to be devoid of trawl scars.

FIGURE 7. Here is further evidence of trawl activity—debris of a broken trawl door deposited on the seafloor.

FIGURE 8. Blackmouth catshark (*Galeus melastomus*) are commonly observed in areas of untrawled seabed, along with burrows and other bioturbation features. Trawling causes vertical redistribution of the sediments, erasing bioturbation features. Repeated trawling prevents the benthic ecosystem from recovering (Jones, 1992).

along the transect, older scars continued to be observed, and signs of gradual recovery included animal tracks crossing the partially infilled scars (Figure 11). Given the smaller size and shallower depth of these furrows, they were likely the result of the activities of smaller vessels (Brennan et al., 2012) targeting hake and blue whiting (Commission of the European Communities, 2004).

Recent work off Spain shows the wide-reaching impact of sediment flows generated by trawls, which smooth over bathymetric features and accelerate the infill of submarine canyons, a seascape change that drastically affects how the benthic ecosystem functions (Puig et al., 2012; Martín et al., 2014b; Palanques et al., 2014). From a macrofauna and fisheries standpoint, the full reach of trawling damage is also beyond the depths trawled, as many species caught are ontogenetic migrators, and the nonselective catch of their juveniles at trawling depths increases the decline of the deeper-dwelling adults (Schrope, 2008). In addition, as shallower fish populations have declined, trawling has moved to greater depths, further impacting even deeper seafloor and benthic ecosystems.

This upslope ROV transect in the Alboran Sea during the *Nautilus* expedition provided important observations of the damage to the seabed from bottom trawl operations in this area, but it does not document the full extent of the damage caused by trawling. In our limited survey through a submarine canyon, we crossed two different trawling depth regimes where different vessels and gear target different species. We observed areas where trawling activity is not evident, in part due to the rugged geology, and we noted that the areas containing trawl scars exhibited strikingly different biology than those left untouched. All signs of benthic activity were gone from areas of heavily trawled sediment (Figures 2 and 4). Shallower areas where the scars were older did show some minor repopulation of benthic fauna (Figure 11). ROV documentation at these previously unexplored depths is imperative to understanding the extent and nature of trawl damage to the seabed and the effects of trawl size and frequency of trawl fishing activities by depth regime.

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