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SHORT PAPER

Observations of food falls off the Shiretoko Peninsula, Japan, using a remotely operated vehicle

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Sinking carcasses deposit highly concentrated organic matter in benthic ecosystems. Numerous studies have simulated natural food fall and have used time-lapse cameras to examine the response of scavengers to the bait [1–3]. The few studies of natural food falls include a description of an aggregation of amphipods on a shrimp body [4], a shot of a fish skeleton [5] in the deep sea, and aggregations of ophiuroids around giant jellyfish carrion [6]. Here, we report observations of natural scavenging on fallen fish carrion that was found by chance on the sea floor.

A survey was conducted in the Nemuro Strait off the Shiretoko Peninsula (Fig. 1), Hokkaido, Japan, from 21 to 23 January 2008, using a remotely operated vehicle (ROV; Expert Nova System, Kowa, Japan; Fig. 2). The ROV was equipped with three cameras and 100-mm parallel lasers, and was maneuvered from a ship by controlling two pairs of thrusters for vertical and horizontal movement. The free movable range was about 20 m from a ca. 70 kg weight that was attached to the ROV cable with an angle frame to keep the ROV near the target depth, as the vehicle was neutrally buoyant. Images from the ROV were monitored on the ship in real time and were recorded with a video recorder (AK-V100, Toshiba).

In 11 runs, we observed fish (e.g., walleye pollock *Theragra chalcogramma*, Okhotsk atka mackerel *Pleurogrammus azonus*, sculpins, flat fish, and rockfish, benthic invertebrates (e.g., echinoids, ophiuroids, and ivory shells), and plankton (e.g., *Sagitta* and euphausiids). Generally, the fish did not respond notably to the ROV, except when the vehicle approached them quickly. In contrast, the plankton aggregated near the ROV's lights, especially when it moved slowly or stopped. In this survey, we observed two food falls of walleye pollock, which are abundant in the strait [7]. The first carcass was found at Sta. 1 (43°57.98′N, 145°10.81′E, depth 228 m). Its total length was ca. 33 cm, and numerous ophiuroids were aggregated around it (Fig. 3). The second carcass, discovered at Sta. 2 (43°58.00′N, 145°10.83′E, depth 234 m), ca. 50 m away from Sta. 1, was ca. 45 cm long, and some echinoids and ophiuroids were attached to it (Fig. 3). No accumulations of amphipods, which typically appear rapidly after bait reaches the sea floor, [3] were visible on the carrion.

In this area, pollock is considered one of the key species that shift energy from lower to higher trophic levels through predation (Matsuda et al., unpublished data, 2008). Our footage showed benthic scavengers consuming the pollock carrion, suggesting that pollock does not only act as an agent for the one-way transfer of energy but is also a food source for benthic scavengers. We could not determine what killed the pollock (e.g., natural death or fisheries activities). Nevertheless, scavengers lead to faster transfer of organic matter to the food web than decomposition by micro-organisms [8]. This may enhance secondary

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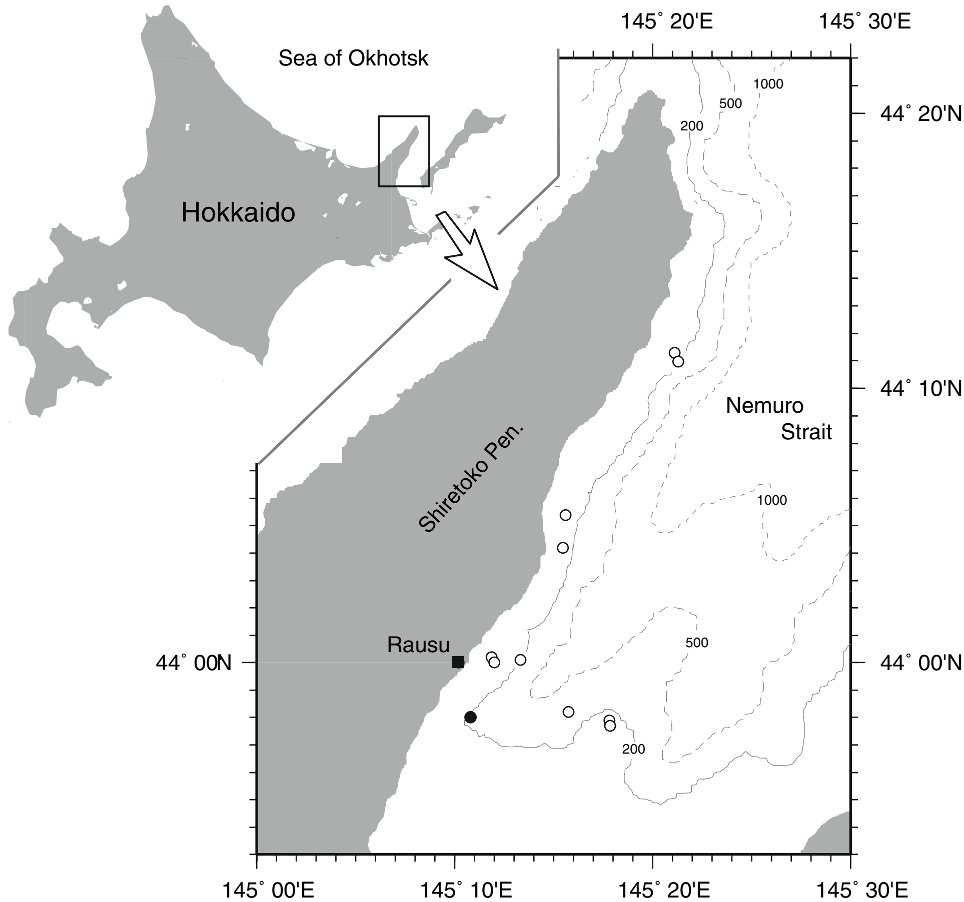

Fig. 1 Survey area near the Shiretoko Peninsula, Japan. The *circles* show the ROV stations and the *solid circle* indicates the site where carcasses were observed. *Dotted* and *broken lines* show the isobaths of the bottom topography

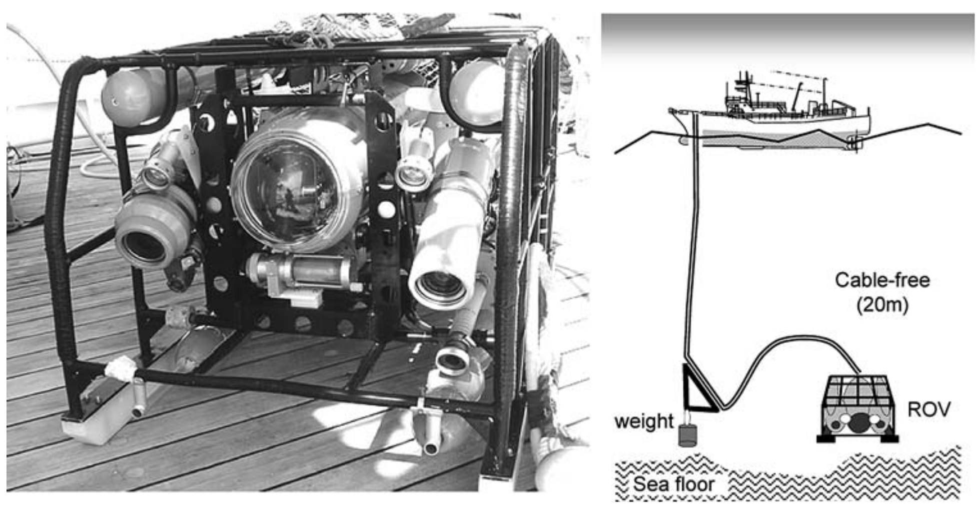

Fig. 2 The ROV system and a schematic of the observations. The ROV measured 1.2 × 0.8 × 0.7 m (L × W × H) and weighed 90 kg; its maximum diving depth was 400 m. It was equipped with two video cameras, a 0.41-megapixel (*MP*) 1/3 charged-coupled device (*CCD*) and a 0.41-MP 1/2 CCD), a digital still camera, a 5.2-MP 2/3CCD, and 100-mm parallel lasers

production resulting from feeding activity within the scavenger community and may help maintain species diversity in this area.

This study used a ROV, which is capable of conducting searches that are more thorough than those of ship-towed camera systems in a metal frame [5, 6], given that a ROV can be maneuvered from the ship while monitoring real-time images. Some details were difficult to measure as compared to time-lapse camera studies, such as when the first scavengers appeared, scavenger species composition, and temporal changes in the carrion. However, our footage provides information from a different viewpoint that elucidates the interactions and energy flow among the species in the ecosystem.

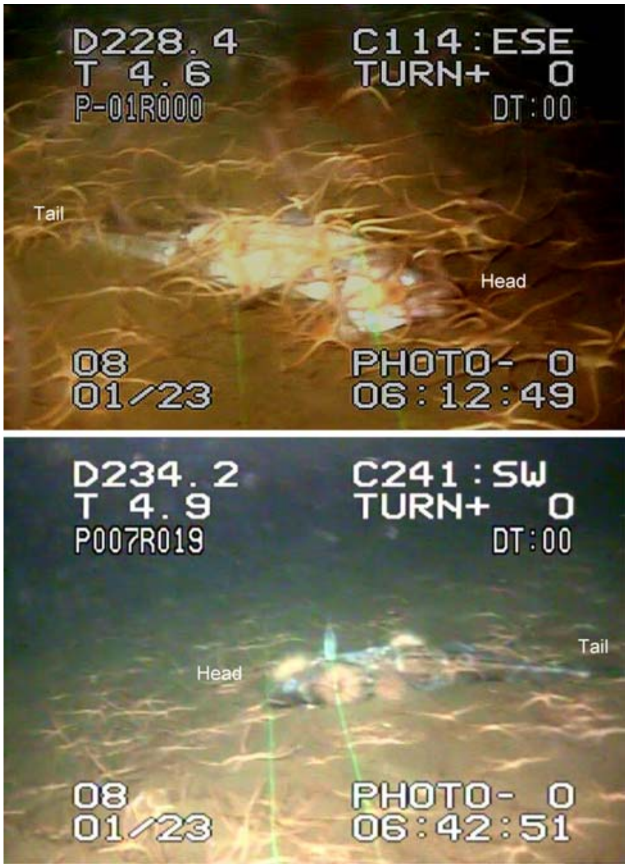

Fig. 3 Carcasses of walleye pollock *Theragra chalcogramma* on the sea floor at Sta. 1 (*top*) and Sta. 2 (*bottom*). The *straight lines* are spaced at ca. 100-mm intervals, as determined by the laser lines from the ROV

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