東京湾海底に残された桁網通過跡の観察

誌名	水産工学研究所技報
ISSN	13418750
著者名	松下,吉樹 藤田,薫 Erickson,D.L.
発行元	水産庁水産工学研究所
巻/号	23号
掲載ページ	p. 71-75
発行年月	2001年2月

水工研技報　23,71～75, 平12
Tech. Rept. Nat. Res. Inst. Fish. Eng., 23, 71-75, 2000

Observation of Seabed Trenches Left by a Beam Trawl in Tokyo Bay

Yoshiki MATSUSHITA[#], Daniel L. ERICKSON** and Kaoru FUJITA*

Abstract: Seabed disturbance by mobile fishing gears is of concern because they may destroy or substantially alter habitats or benthic communities. Information regarding seabed impacts by mobile fishing gears is limited, particularly for Japanese coastal waters. In this study, we documented a trench created by a beam trawl fishing in Tokyo Bay, Japan. Maps of the mud substrate in Tokyo Bay were created using side scan sonar before and after trawling operations. These maps were subsequently compared to assess operation-related disturbances. The conventional beam trawl used for this research measured 2.75 x 0.3m at the opening and was 9m in length. The beam (including tickler chain) weighed 130kg. Towing speeds were either 4 knots (normal towing speed) or 2.5 knots. Towing locations were continuously recorded using differential GPS. Seabed images produced by side scan sonar were not significantly different between "pre-trawling" and "post-trawling" maps for tows made at 4 knots. On the other hand, one continuous trawl trench was observed for 113m (6.5% of towed distance) for the 2.5 knots experiment. This result suggests that only extreme changes to the seabed can be detected by side scan sonar (e.g., depths > 6.5cm) and that impacts are greatest at slower towing speeds. Even though we demonstrated only small impacts to bottom topography using side scan sonar, it is likely that this gear type adversely impacts epifauna and possibly infauna. Other tools are required to assess these potential impacts.

Keywords: *Beam trawl, Seabed impact, Tokyo Bay, Side scan sonar*

東京湾海底に残された桁網通過跡の観察

松下吉樹・Daniel L. ERICKSON・藤田　薫

底曳網などの運用漁具が海底上を通過する際に，海底面やそこに分布する生物群集に損傷を与えることが危惧されるが，その知見は十分でない。本研究では，東京湾における桁網漁業を対象に，サイドスキャンソナーにより作成した桁網の通過前後の海底地形図を比較することで桁網が海底を掘り起こした跡の観察を試みた。その結果，通常の曳網速力(約４ノット)では桁網操業によると考えられる地形の変化は認められなかった。一方，曳網速力を遅くした試験（約2.5ノット）では113m（総曳網距離の6.5%に相当）に渡って桁網の通過跡と考えられる地形の変化が認められた。サイドスキャンソナーの分解能（>6.5cm）を考えると，観察できた通過跡は比較的大きな攪乱である。

Introduction

Mobile fishing gears such as bottom otter trawls, beam trawls and dredges have been used to harvest a wide variety of marine organisms living on or in the seabed. These gears move over the seabed surface and accumulate many of the organisms (targeted catch and bycatch) that are encountered. In Japan, discarded bycatch was identified as the major impact of

---

2000年11月7日受理　水産工学研究所業績A第389号

*Fishing Methods Section, Fishing Technology Division
**Wildlife Conservation Society, International Programs, Bronx, New York, NY, USA
[#]Corresponding author: yoshiki@nrife.affrc.go.jp

mobile fishing gears to the marine ecosystem. However, seabed disturbance by these fishing practices, considered a serious problem by many researchers around the world, should also be identified as a potential major impact in Japan. For example, Watling and Norse[1] demonstrated that the area disturbed annually around the world by mobile fishing gears is more than two orders of magnitude higher than that impacted by forest clearcutting. Many researchers worldwide have initiated studies and evaluations on fishing-gear impacts to the seabed,[2,3] whereas this research topic has been largely ignored in Japan. We therefore need to initiate new studies on fishing gear impacts to the seabed and develop recommendations for technical measures that will reduce or eliminate serious impacts.

In this report, the impacts of beam trawling to the seabed in Tokyo Bay were assessed using side scan sonar. Sonar-produced images of the bottom topography were recorded before and after trawling took place. Video observations were not possible because visibility was poor.

Materials and Methods

Beam trawl fishing in Tokyo Bay: Over 300 small beam trawlers (less than 10GRT, approx. 100HP) fish in Tokyo Bay.[4] A wide variety of marine organisms including ground fish, pelagic fish, crustacean, and mollusk are targeted by this fishery. Various types fishing gears are used by these trawlers depending on target species. For example, trawlers licensed by Chiba prefecture operate 3 types of fishing gears with different types of opening devices: (1) 8m iron bar, (2) 8m iron bar with sledges, and (3) a 3m x 0.3m (opening) iron beam. The iron-beam trawl is heaviest among these opening devices, whereas the seabed contact area by this device is smallest. The 3m x 0.3m beam trawl was used during this experiment (see below).

At-sea experiment: At-sea experiments were carried out on March 21, 1999 on a small beam trawler (9.9 GRT, 100 HP) belonging to North Tokyo Bay Funabashi Trawlers Association (Funabashi, Chiba). The type of beam trawl used in this experiment is illustrated in Fig. 1. This gear is commonly used by fishers in Tokyo Bay to catch flatfish species such as marbled sole (*Limanda yokohamae*) and stone flounder (*Kareius bicoloratus*). The iron beam was 2.75m in width, 0.3m in height and weighed approximately 100 kg. In addition, a tickler chain (30kg in air) was attached at both ends of the beam. The netting consisted of polyethylene meshes (90mm stretched measurement). Typical towing speeds for this fishing gear is 4-4.5 knots during commercial operations.

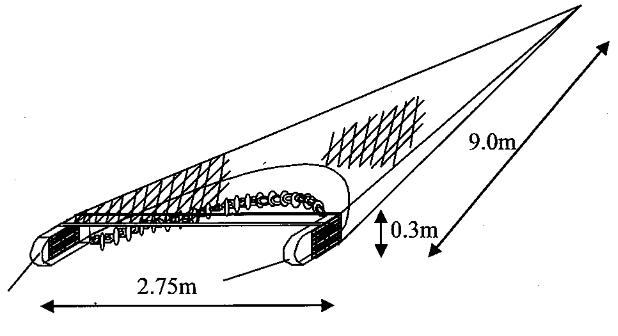

Fig. 1. A beam trawl fishing gear used in this study.

This experiment took place in Tokyo Bay on commercial fishing grounds (Fig. 2). Fishing was conducted over a flat seabed at depths of approximately 10m. The bottom type at this location was mud consisting of 40 to 60% fine clay, according to the topography map issued by Hydrographic Department of Japan.[5]

Beam trawling was conducted along predetermined grid lines (approximately 1500 x 400m). Towing speeds were either 2.5 knots (experiment 1) or 4 knots (experiment 2). Two tows were made each experiment in opposite directions (i.e., north and south during experiment 1; east and west during experiment 2). Trawling paths, continuously monitored and recorded by differential GPS, crossed at several locations.

Observation protocol: Use of side scan sonar to measure seabed disturbance is not new. [6–9] However, with few exceptions (e.g., side scan sonar images of bottom impacts at Grand Banks[9]), evidence of bottom disturbance provided by side scan sonar has been suspect (i.e., "disturbances" shown by side scan sonar may or may not have been made by trawling). This study was carefully planned to differentiate between beam-trawling impacts to the seabed and other bottom disturbances. The seabed was mapped before and after each tow

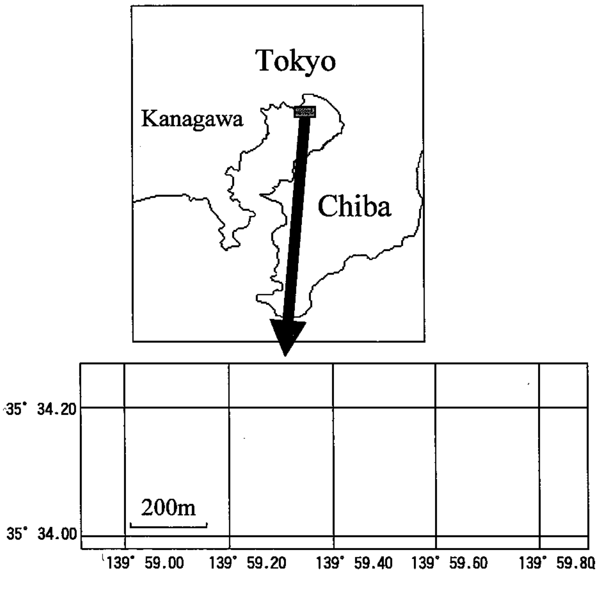

Fig. 2. Experimental area set for this study. Upper map shows general location, lower shows details.

using side scan sonar (Edge Tech Model DF-1000, USA, http://www.edgetech.com). Side scan sonar recorded seabed images within 50m from each side of the towed transducer by dual frequency supersonics (100 kHz and 500 kHz). The resolution at this setting was 6.5 cm. Trawling paths (provided by differential GPS) and side scan sonar images were overlaid to determine whether disturbances made by the beam trawl were detectable.

Results and discussions

Side scan sonar images of the seabed were recorded over most of the substrate that was trawled during these experiments ; less than 10% of the tows were outside of the observation area (Table 1). Fig. 3 illustrates trawling locations and "pre-trawling" and "post-trawling" side scan sonar images for the 2.5 knots experiment. These images suggest that the seabed was flat and offered little structure. Both "pre-trawling" and "post-trawling" maps are similar, with the exception of the dark images found in the "post-trawling" map. These images may have been produced by fish distributed in water column.[10] It is usually observed that fish aggregate the disturbance such as mud smoke generated by trawl passing to feed exposed organisms. [11,12]

Images were magnified to determine whether potential trenches made by the beam trawl were detectable using side scan sonar. There was no significant difference between "pre-trawling" and "post-trawling" maps for tows made at 4 knots. On the other hand, differences were observed between "pre-trawling" and "post-trawling" sonar images for the 2.5 knots experiment (Fig. 4). A white image that overlaps the trawling track is noticeable in the "post-trawling" image that was not present in the "pre-trawling" map. This image likely represents a trench or small disturbance to the substrate.[10] This "trench" was observed for a distance of 113m, representing 6.5% of the observed towing distance for the 2.5 knots experiment. The depth of trench was probably more than 6.5cm ; shallower disturbances could not be detected by side scan sonar at the resolution set during these experiments.

It is not surprising that bottom impacts by the beam trawl were greatest for the slowest towing speed. It is well known that that contact pressure of fishing gear to the seabed increases as towing speed decreases. Although we did not carry out physical measurements to determine the actual depth of trenches produced by the beam trawl, we infer that the impacts to the bottom were more severe while towing at 2.5 knots than while towing at 4 knots. We suggest that the beam trawl penetrated the seabed more than 6.5 cm for the slower tows, and less than 6.5cm for the faster tows (based on the resolution of side scan sonar). We must note the possibility of more severe trenching by this gear type than inferred from

Table 1. Outline of the series of experimental operations

Nominal towing speed (knots)	Actual speed (knots)	Towed distance (A, m)	Distance which the gear passed within the observation area (B, m)	(B/A)
4	3.1～5.5	2980	2784	0.93
2.5	2.0～3.5	1951	1741	0.89

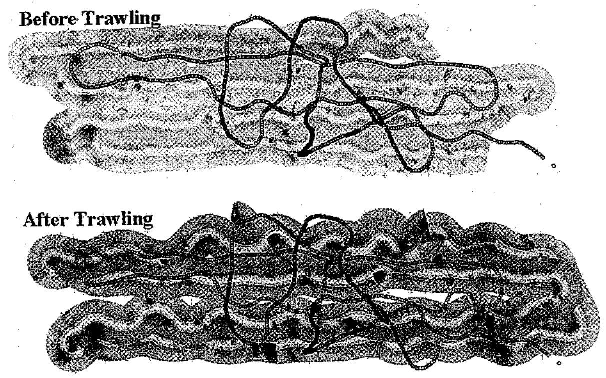

Fig.3. Examples of seabed images measured by side scan sonar (maps before and after trawling in the 2.5 knots experiment). Lines in maps designate trawl tracks recorded by differential GPS.

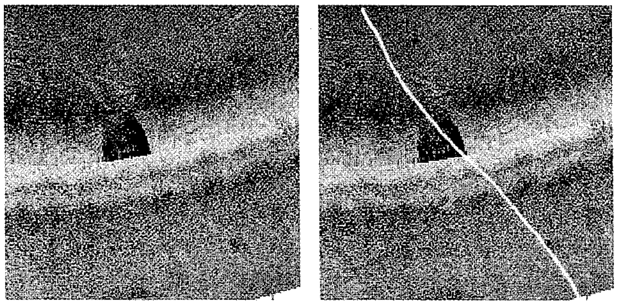

Fig. 4. A trench observed by side scan sonar. Left ; Zoomed image from original map. Right ; Image with highlighting the trench (pointed by an arrow).

these images. The bottom was soft; the trawl may have produced deep (> 6.5cm) but gently-sloping trenches which are often undetectable by side scan sonar.

Trawling impacts to epifauna in certain habitat types can be severe. These impacts have been studied/described in detail by numerous researchers. One clear impact of trawling to the epifauna is the catch and removal of fish and crustaceans. Mortality of these removals, when returned to the sea, is variable and often less than 100% (e.g. Chopin *et al.*[13)]); hence depending on the species, the effect may range from negligible to extremely adverse. Trawling impacts to sessile epifauna such as corals and sponges is most often severe (e.g. Auster *et al.*[8)], Reise.[14)]); recolonization may take years, or may never take place after being disturbed by towed gears. For example, Witman[15)] observed that none patch was colonized by the sponges that was the major component at surveyed area (Ammen Rock Pinnacle, 30m depth in Gulf of Maine, USA) over 2 years since former patches were cleared. Finally, other epifauna likely disturbed by trawling include abiotic structures such as boulders, pebble-cobble, and gravels.[16)] These structures provide habitat for numerous organisms, which may be destroyed by the passing of a trawl.

The substrate trawled during this experiment was primarily composed of fine clay. There were no areas of large rocks or larger sessile organisms (e.g., corals and sponges). Hence, potential impacts of beam trawling to these types of organisms in this environment is low. There are areas within Tokyo Bay that contain pebble and cobble.[5)] Even though fishers use gear other than beam trawls in these areas to avoid gear damage (Local Fisher, personal communication), it is likely that sessile-epifaunal encounters are likely (or were likely) since the bottom is suitable for their attachment. Because trawling effort is so large in Tokyo Bay (i.e., more than 300 beam trawlers), studies should be designed and executed to determine the impacts of these gears to the local epifauna and substrate.

Impacts to the infauna by beam trawling could be severe in Tokyo Bay, at least in slower towing speed. Trawlers operating in Tokyo Bay repeatedly tow their gears around at same fishing ground. This towing method aims to expose mantis shrimp (*Oratosquilla oratoria*) from substratum by digging the seabed (Local Fisher, personal communication). Consequently, beam trawl exposes other infauna living less than same depth of mantis shrimp as well. We captured annelid worm as bycatch in the series of experiments. Catch amount was potentially higher in the 2.5 knots experiment. It is likely that a high percentage of these annelids and other species that encountered the beam escaped through the trawl meshes, and were left exposed to predators on the seabed (as were the discarded annelids). Hence, the impact to worms and other animals living below the substrate was probably much higher than indicated by the catch on the deck. This impact is clearly related to towing speed (as we found), as well as gear type, operational procedure, type of substrate, etc. A quantitative method must be developed and applied to these beam trawl fisheries to assess the impacts of beam trawling to these infaunal organisms.

Acknowledgement

We are grateful to Naonobu Aikawa, leader of North Tokyo Bay Funabashi Trawlers Association for help and guidance. Hiroki Ueda of SEA, Ltd. and John P. Fish of American Underwater Search and Survey, Ltd. provided valuable suggestions on the use of side scan sonar and for subsequent data analysis and interpretation.

References

1) Watling, L. and E. A. Norse: Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. *Conservation Biology*, **12**, 1180-1197, 1998.

2) Conservation law foundation: Effects of fishing gear on the sea floor of New England (ed. by E. M. Dorsey and J. Pederson), Conservation law foundation (Massachusetts), 160pp., 1998.

3) American Fish. Soc.: Fish habitat: Essential fish habitat and rehabilitation (ed. by L. R. Beneka), *American Fish. Soc. Symp.* **22**, American Fish. Soc. (Maryland), 459pp., 1999.

4) Statistics and Information Department, The Ministry of Agriculture, Forestry and Fisheries of Japan: The 9th fisheries census, **3** (2), Association of Agriculture and Forestry Statistics (Tokyo), 301pp., 1995.

5) Hydrographic Department, Marine Safety Agency of Japan: Submarine structural chart, 6363-9S, 1974.

6) DeAlteris, J., L. Skrobe, and C. Lipsky: The significance of seabed disturbance by mobile fishing gear relative to natural processes: A case study in Narragansett Bay, Rhode Island. in "Fish habitat: Essential fish habitat and rehabilitation (ed. by L. R. Beneka)", *American Fish. Soc. Symp.* **22**, American Fish. Soc. (Maryland), 224-237, 1999

7) Carr, H. A., and H. Milliken: Conservation engineering: Options to minimize fishing's impacts to the sea floor. in "Effects of fishing gear on the sea floor of New England (ed. by E. M. Dorsey and J. Pederson)", Conservation law foundation (Massachusetts), 160pp., 1998.

8) Auster, P. J., R. J. Malatesta, R. W. Langton, L. Watling, P. C. Valentine, C. L. S. Donaldson, E. W. Langton, A. N. Shepard, and I. G. Babb: The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. *Rev. Fish. Sci.*, **4**, 185-202, 1996.

9) Schwinghamer, P., D. C. Gordon, Jr., T. W. Rowell, J. Prena, D. L. McKeown, G. Sonnichsen, and J. Y. Guignes: Effects of experimental otter trawling on surficial sediment properties of a sandy-bottom ecosystem on the Grand Banks of Newfoundland. *Conservation Biology*, **12**, 1215-1222, 1998.

10) Fish, J. P., and H. A. Carr: Sound underwater images: A guide to the generation and interpretation of side scan sonar data. Lower Cape Publishing (Massachusetts), 190pp., 1990.

11) Caddy, J. F: Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. *J. Fish. Res. Board Can.*, **30**, 173-180, 1973.

12) Norse, E. A. and L. Watling: Impact of mobile fishing gear: The biodiversity perspective. in "Fish habitat: Essential fish habitat and rehabilitation (ed. by L. R. Beneka)", *American Fish. Soc. Symp.* **22**, American Fish. Soc. (Maryland), 31-40, 1999.

13) Chopin, F. S. and T. Arimoto: The condition of fish escaping from fishing gears - a review, *Fish. Res.*, **21**, 315-327, 1995.

14) Reise, K: Long-term changes in the macrobenthic invertebrate fauna of the Wadden Sea: are polychaetes about to take over? *Netherlands J. of Sea Res.*, **16**, 29-36, 1982.

15) Witman, J. D: Natural disturbance and colonization on subtidal hard substrates in the Gulf of Maine. in "Effects of fishing gear on the sea floor of New England (ed. by E. M. Dorsey and J. Pederson)", Conservation law foundation (Massachusetts), 30-37, 1998.

16) Barnes, R. S. K. and R. N. Hughes: An introduction to marine ecology. Blackwell Science (Oxford), 286pp., 1999.