日水研報告，(40)：227-232，1990.
Bull. Japan Sea Natl. Fish. Res. Inst., (40)：227-232, 1990.

SHORTER CONTRIBUTION

Free-Drifting Sediment Trap Array for Tracking a Water Parcel*

Kazuo ISEKI[1], Hiroshi NAGATA[1] and Kozo KITANI[1]

Abstract

A free-drifting sediment trap array (FD-STAR), carrying an Aanderaa current meter, was deployed in Toyama Bay in order to compare the drifting speed with the relative speed recorded on the current meter. During a short term experiment (7-h deployment), the array steadily drifted southward at a speed of 29 to 39cm s^{-1}, but the relative current was less than 3cm s^{-1}. In addition, no measurable wave motion was recorded during the experiment. In view of these speeds and wave motion, it is concluded that horizontal watar movements were not significantly affecting trap collection efficiency of the array.

Key words sediment trap, current meter, free-drifting, mooring, collection efficiency

Introduction

In the past decade, the use of sediment trap in studies of vertical flux of particulates has become increasingly common, and mooring (HONJO, 1978; DEUSER and ROSS, 1980; ISEKI, 1981a) and free drifting (ZEITZSCHEL *et al.*, 1978; ISEKI, 1981b; STARESINIC et al., 1982; KARL and KNAUER, 1984) are major installation methods of the trap. Interpretation of the sediment trap record, however, is not easy due to several sources of potential error. The most basic critical source of error is uncertainty of the trap collection efficiency which depends on the interaction of the trap with its surrounding hydro dynamic environment. The presence of a stationary object in the sea will generate local turbulence which may bias estimation of both the quantity and quality of settling material in moored traps. Also, the effect of the turbulence is dependent on the trap geometry, tilting, current speed, and particle sinking velocity, etc. (GARDNER, 1980a, 1980b, 1985; HARGRAVE and BURNS, 1979). On the other hand, free-drifting sediment trap, in theory, should follow the ambient water mass and therefore not induce such turbulence. Evidently, STARESINIC *et al.* (1978) observed no turbulent wake over the free-drifting trap in 30cm s^{-1} current, and some workers showed that the free-drifng trap collects more material than its moored counterpart does (ZEITSCHEL *et al.*, 1978; STARESINIC *et al.*, 1982). Thus, it is anticipated that drifting traps are the ideal device to collect true vertical flux, but, in practice, they were not always exact followers of truly Lagrangian fluid parcels. This is

Accepted : November 15, 1989. Contribution A *No.* 465 from Japan Sea National Fisheries Research Institute

1) Japan Sea National Fisheries Research Institute, Suido-cho, Niigata 951, Japan
(〒951 新潟市水道町1丁目5939-22
日本海区水産研究所)

*This work was financially supported by a Special Coordination Fund for Promoting Science and Technology of the Science and Technology Agency.

because surface-attached drogues have a slippage problem. A large surface buoy system with long tethers for deep co-llection or collection at multiple depths on the same drifting array invite drogue slippage. This may produce the same problems of particle collection behavior (poor collection efficiency due to turbu-lence) associated with moored traps.

We have designed a free-drifting sediment trap array (FDSTAR) to study vertical flux of particulates through tracking the same water parcel. On June 16, 1989 in Toyama Bay, we had an op-portunity to compare the drifting speed of FDSTAR with the relative current speed recorded on a current meter set on FDSTAR.

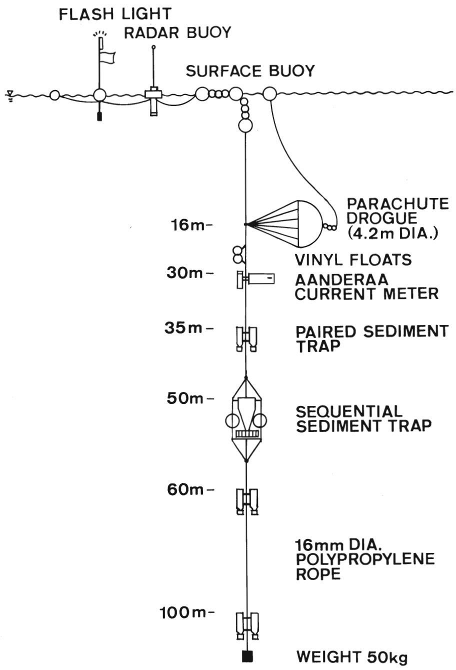

Fig. 1. A schematic representation of the free-drifting sediment trap array (FDSTAR).

Instrumentation

The FDSTAR (Fig. 1 and 2) used in this study consisted of surface buoys, one parachute drogue (4.2m in diameter), a sequential sediment trap (0.5m in diameter and 12 collection bottles), and three cylin-drical sediment traps (CST). The drift-ing array carried an Aanderaa current meter at 30m to record relative current speed. Current speed, direction, temper-ature conductivity (salinity), and depth (pressure) werer recorded at 2–min inter-vals. During a 7–h deployment from 14: 17 to 21:19 on June 16, 1989, 7 Loran-C fixes of the FDSTAR were made when the ship was within a 100m distance of the surface buoy. Ths relative positions of the drifting buoy in relation to the re-search vessel were often determined by a radar system. To obtain absolute current speed in the surrounding water, one current meter was hung at 5m from a large buoy which was anchored to the bottom with two mooring chains (St. C–1). An acoustic doppler current meter (JRC Model JLM–612) installed on board was also used for comparison. CTD observations and water samplings were also conducted at 3 stations along the drift-ing trajectory. Details of the sediment trap and suspended matter data will be published elsewhere.

Results and Discussion

To avoid the possibility of shoreward drift, the traps were launched east of the moored buoy station (Fig. 3). The array position was regularly checked to make sure it had not drifted ashore or not entangled itself with surface tethered objects such as fishermen's surface buoys, fishing nets, and ropes. The array drifted

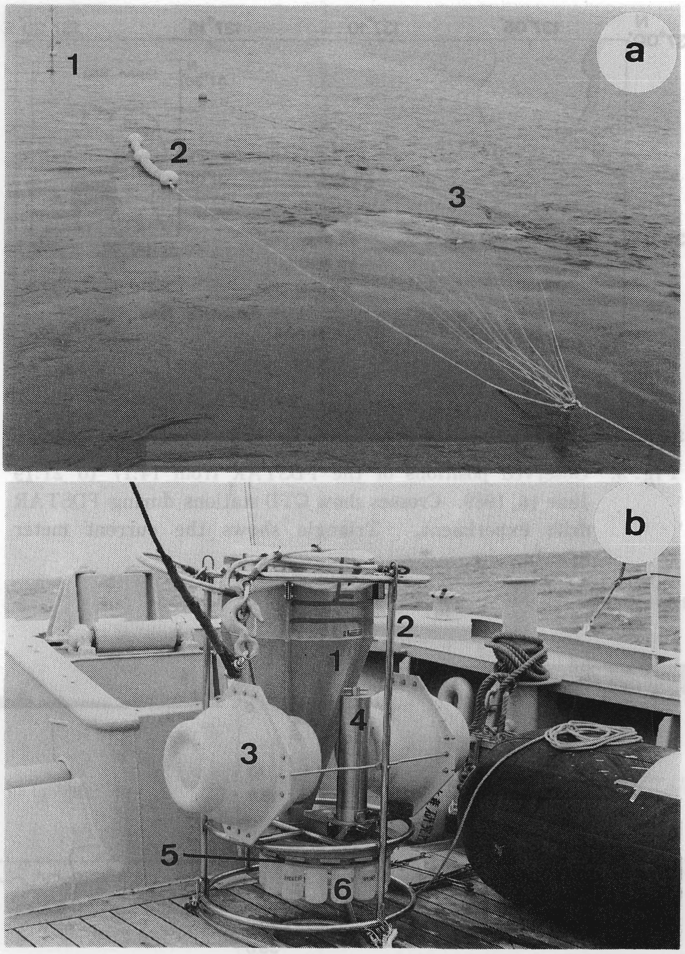

Fig. 2. (a) Surface buoy systems and parachute drogue just released from the ship. 1, radar buoy; 2, surface buoy; 3, parachute drogue
(b) Sequential sediment trap ready to deploy. 1, PVC funnel; 2, frame; 3, flotation spheres (hard-hat buoy); 4, pressure case for electronics and batteries; 5, turn table; 6, sample receiving bottle

steadily southward (SSE) at a speed of 29 to 39cm s^{-1} and changed its direction to southeast at the end of the experiment (Fig. 3). These drifting patterns coincided well with the earlier observations (NAKURA and WAKABAYASHI, 1984) which showed the presence of a prevailing counterclockwise circulation (with a speed of 20 to 30cm s^{-1}) inthe Bay. The currents at St. C-1 also continuously showed a southward flow during the experiment (Fig. 4), but an acoustic doppler current meter installed on board indicated that the flow direction shifted from southward to eastward in the vicinity of St. 7 at the end of experiment.

On the other hand, the relative currents recorded by the current meter on FDSTAR showed quite different flow characteristics (Fig 5). First, the relative

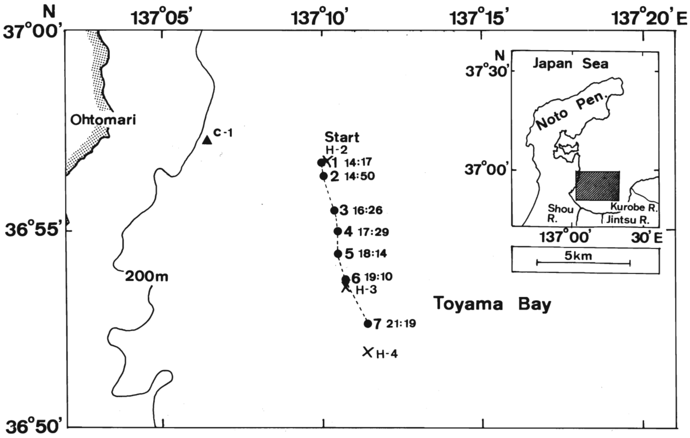

Fig. 3. Observed positions of the FDSTAR from 14:17 to 21:19 June 16, 1989. Crosses show CTD stations during FDSTAR drift experiment. Triangle shows the current meter mooring site.

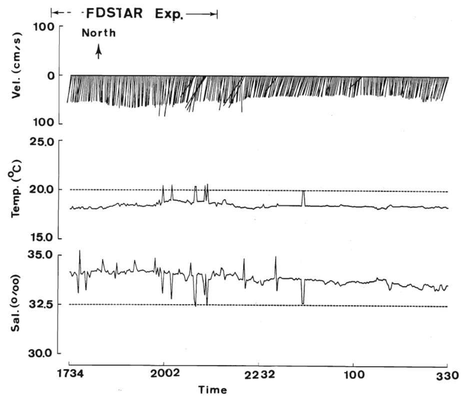

Fig. 4. Absolute currents recorded at 5 m depth of St. C-1. Note that temperature and salinity record are not very reliable due to the use of the sensors which were set for deep sea ranges.

current speed was only 3 to 4cm s^{-1} which was one order magnitude less than the drifting speed. Second, the flow direction of the relative currents was opposite (northward) compared with the southward drifts of the sediment trap array, and its direction changed to southeastward at the end of the experiment.

During the experiment winds over the study area were consistently from the northnortheast and their force varied

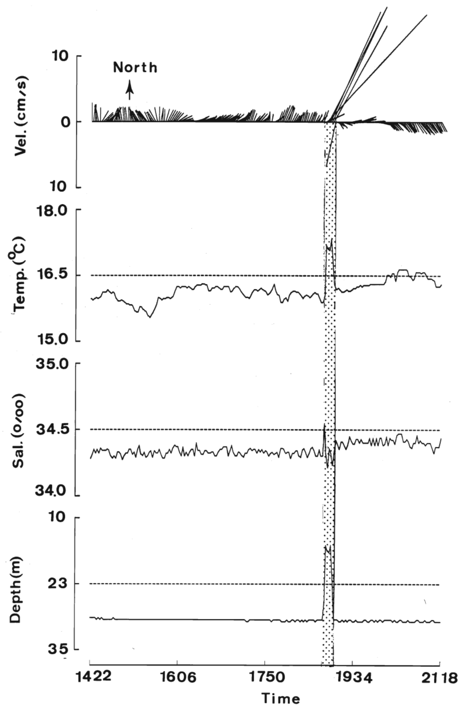

Fig. 5. Relative currents, temperature, salinity and depth recorded at 30 m on FDSTAR. Note that unusual high currents, abnormal peaks of temperature, salinity and depths observed between 18:58 and 19:12 (dotted area) were artifacts due to temporal towing the array to avoid collision with fishermen's buoy systems.

from 1 (~3.0m s^{-1}) to 3 (~5.5m s^{-1}). Thus, there is a possibility that the wind force may accelerate southward drifting of the array in this present study. It appears that weak northward component of the relative current is a reflection of this acceleration.

BROENKOW (1982) conducted a similar experiment in an eddy about 200km off of the California coast and observed that the mean relative current speeds of his drifting trap array (having 2000m long line) were 6.7 and 3.4cm s^{-1} at 150 and 1500m, respectively. These velocities were two times higher than our observations. The drift rates of his array, varying from 4.2 to 11.4cm s^{-1} with a mean of 7.5cm s^{-1}, were much smaller than our observations. This indicates that his array was less effective than our drifting system in tracking the same water parcel, probably due to a long tether for multiple-depth collections.

The above observations suggest that our FDSTAR responded well to water column accelerations (current) and not directly to wind stress. In view of the relative current speed, the wave motion, and the trap geometry (SST cone and CST cylinders, both with baffles), it is concluded that FDSTAR is a good follower for tracking a same water parcel and that there is no significant bias on the collection efficiency of sinking material.

Acknowledgemnts···Financial support was provided by the Special Coordination Fund for promoting Science and Technology of the Science and Technolgy Agency. The effort of the captain, officers, and crew of the R/V Mizuho-maru in field work are greatly appreciated. Our thanks are extended to H. KATAGIRI and K. AMAIKE for the preparation of the enclosed figures.

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水塊追跡用のセディメント・トラップ漂流ブイシステム

井関和夫・長田　宏・木谷浩三

セディメント・トラップ漂流ブイシステムの漂流速度とブイシステムに取り付けた流速計で観測される相対速度を比較するために富山湾でブイの追跡実験を実施した。7時間の追跡実験中に，ブイは南方向に29–39cm s^{-1} の速度で漂流した。この間，相対速度は3 cm s^{-1} 以下であり，波浪の影響は認められなかった。以上の観測事実から考えて，水平方向の流れは漂流ブイのトラップ補集効率に影響を与えていないと判断された。