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The Tucker opening-closing micronekton net and its performance in a study of the deep scattering layer

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Abstract

An opening-closing, single-sample net system designed to capture micronektonic organisms is described. The net is opened and closed at the mouth by mechanical time-release devices, and can be hauled from small ships on hydrographic wire. Data are presented from a series of 4 hauls made with this system during a study of sonic scattering layers. The population maxima of euphausiids, sergestid prawns and physonect siphonophores corresponded to the level of the main scattering layer. Fishes were concentrated below the layer, and amphipods above it.

Introduction

A generation of workers has developed an amazing number and variety of plankton-net opening and closing devices to study the vertical distribution of marine organisms (consult Bé, 1962; Currie, 1962; Yentsch et al., 1962; Kinzer, 1966; Harrisson, 1967, for history and bibliographies). Few have been widely used. Successfully opening and closing the larger, horizontally towed midwater trawls and nets is even more difficult than the smaller plankton nets and samplers, but such devices are necessary for obtaining critical depth data on the more powerful, faster swimming micronectonic animals. To this end the Issacs-Kidd midwater trawl has been modified (Issacs and Brown, 1966), and various devices have been adapted to its cod-end (Foxton, 1963; Pearcy and Hubbard, 1964; Aron et al., 1964; Harrisson, 1967). This paper describes an opening-closing modification of the Tucker net (Tucker, 1951), and presents data on the Deep Scattering Layer (DSL) obtained with its use.

Development of the present net system has a long history. Tucker theorized that a vibrating tow cable and bridle frightened the animals, mainly responsible for sound scattering, from the net's path. He therefore designed the original net with an unobstructed, 6 feet (1.8 m) square mouth for use in his early DSL studies. Barham (1956) made slight modifications in cut and mesh size of the webbing, and added a large, nonstraining cod-end bucket. He later experimented with an opening-closing cod-end sampler of his own design (Barham, 1957) to use with the net.

In 1954, N. Nicoloff, of the Navy Electronics Laboratory (NEL) Engineering Design Division, built a pair of time-release mechanisms to open and close the Tucker net. Before the gear could be tested and described, Tucker left the laboratory. When we resumed biological sampling of scattering layers in 1963, following Tucker's death, the equipment was renovated and taken to sea. It functioned perfectly, and we and members of Stanford University's "Te Vega Expeditions" have since used it successfully with only minor modifications.

The Tucker net with the opening-closing modification has the following advantages: (1) Folds for easy handling and storage; (2) Usable from small ships not equipped with large A-frames or booms; (3) Haulable on standard hydrographic wire; (4) Maintenance-free mechanical operation; (5) Retrieves specimens in excellent shape for anatomical and physiological studies. In contrast to other closing systems for large nets, however, it has the disadvantage of collecting only 1 sample per haul.

The numerous inquiries received concerning this net have prompted the following description of the system and its performance.

Operation and description

The opening-closing cycle of the net is shown in Fig. 1. The net is lowered to the desired sampling depth with the net bars held together at the top, each attached to its time-release mechanism as in Fig. 1A. At a predetermined time the lower bar is released by its mechanism, opening the net (Fig. 1B). After the required sampling time, the upper bar is released. The net is now closed (Fig. 1C), and ready for recovery.

The net system can conveniently be considered to consist of: (1) Mouth frame hardware; (2) Net and cod-end bucket; (3) Time-Release (T-R) mechanisms; and (4) Depth-recording instruments.

Mouth frame hardware: The parts of the net mouth are shown in Fig. 1. A triangular steel frame, fitted with eyes, provides points of attachment for the towing cables, the side cables, and the T-R mechanisms. The stainless steel side cables run through guides on the net bar ends, then through rings lashed to the net side lines, and terminate at the spacer bar. The channel-iron spacer bar holds the side cables apart, stops the net bars as they are released, and provides a shackling point for two 20 kg bronze depressors. These depressors take the net down and keep the net mouth vertical during the haul. Standard iron pipe is used for the net bars, and eyes are welded at each end to guide the side cables. The lower net bar is lead-filled to aid its action when released and provide additional weight for keeping the net mouth vertical. Wire-rope bridles link the net bars to the T-R mechanisms during the initial closed and open periods of the cycle (Fig. 1A, B).

Net and cod-end bucket: Dimensions, materials used, and cod-end design have been modified from TUCKER's original net. Major dimensions of the net presently in use are shown in Fig. 1B and D. Nylon line forms the net mouth and runs along the 4 corners of the coarse-mesh, forward portion of the net for strengthening. The net is secured to the mouth frame hardware by lashing. The coarse-mesh portion terminates in a circular canvas sleeve, 0.5 m in diameter, which mates with the fine-mesh posterior end. This portion is made from No. 333 Nitex gauze (approximately 30 meshes/cm), and terminates in a short nylon collar which receives the stainless steel cod-end bucket. Because of its large size and lack of straining area, this bucket retains captured organisms in excellent condition.

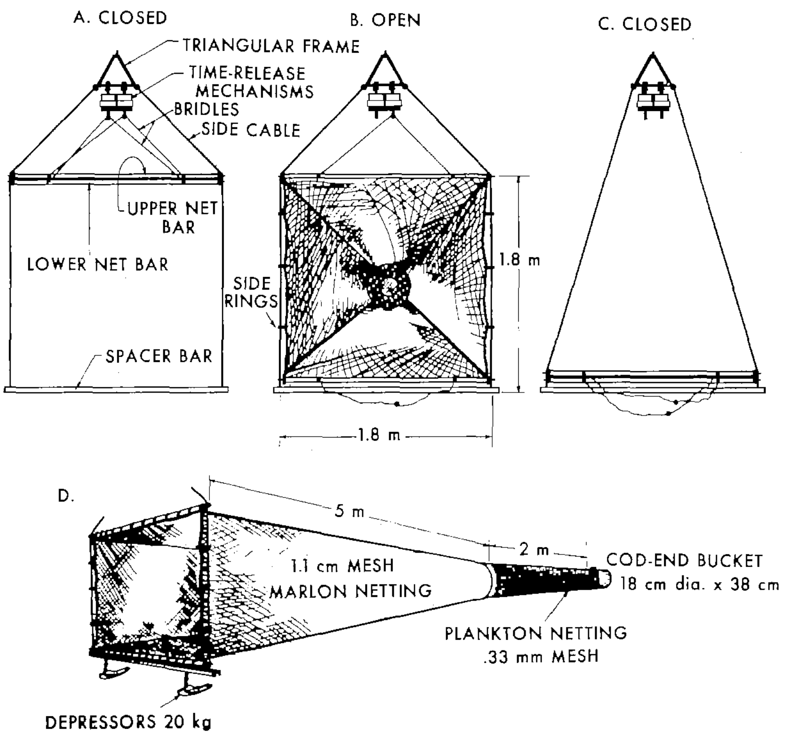

Fig. 1. A schematic drawing showing the operating principle of the Tucker net and its major dimensions. A: The net is closed and ready to be lowered to sampling depth. B: The bridle from the lower net bar has been released and the net is fishing. C: The upper net bar has been released and the net is closed for recovery. D: Side view of the net while open

The net is designed to capture the larger plankton organisms and smaller nekton. Some contamination by smaller organisms will occur through the coarse mesh of the net, even when the net is closed.

Time-Release mechanisms: Basically, the T-R mechanism is a clock-activated break-link. The clock and necessary internal parts are contained in a stainless steel pressure case. The break-link is mounted externally on the bottom of the case, and access to clock settings is gained through threaded lids sealed by an O-ring. Fig. 2 pictures a set of T-R mechanisms with their lids removed exposing their clock-driven cams and time plates. Hour and quarter-hour increments are marked on the plates. The devices are set by moving the arrow pointer inscribed on the cam to the time desired before release. In operation, two T-R mechanisms are used; one to open the net, the other to close it. A steel plate pairs the T-R mechanisms, and they are mated to the underside of the triangular frame by pad-eyes on the lids (Figs. 2 and 3). Enough time is allowed when setting the opening mechanism to get the gear to the desired sampling depth before activation. This time, plus the desired time of sampling, is then set on the closing mechanism. Tests of the T-R mechanisms made in air with a weight representing the strain of the net show the release time is accurate to within $\pm$ 1 min.

Fig. 3 shows diagrammatically the operating principle of the T-R mechanisms. In Fig. 3A the mechanism is in the engaged position, and in 3B, the released position. Intermediate steps between these positions proceed as follows. The basic drive mechanism is clock A which rotates eccentric cam B. At the high point on the cam, lever C is forced outward pushing catch D far enough to release arm E. This allows spring-loaded piston F to travel forward. Differential hydrostatic pressure at opening G works on the face of the piston to assist in this operation. Arm H travels forward with the piston, pulling catch I into the release position. Latch J is now free to fall. The wire-rope bridles from the net bars are run over these latches prior to the haul, and it is this action that effects the opening-closing operation. Once released, the mechanisms must be re-armed before making another haul. This is accomplished by applying pressure to arming pin K which reverses the above procedure.

These devices may have other oceanographic applications for releasing heavy objects under water. A recent modification dispenses with the clock and utilizes a solenoid activated through a cable (detailed descriptions are available in N. NICOLOFF, U.S. Patent Office 3,337,255, 22 August 1967).

Depth-recording instruments: In our recent work, fishing depth of the net has been monitored by 2 instruments. A Benthos Model 1020 Depth Telemetering Pinger, attached to the towing cable just ahead of the net, is used to position the net at the desired depth during the haul. This is an acoustic device, and its output can be read directly on any depth recorder operating at the same frequency.

To record the path of the net during the haul, and to check on data from the pinger, a Benthos Model 1170 Depth-Time Recorder is fastened to the underside of the spacer bar. As the heavy net bars fall on the spacer bar during the opening-closing operation, the resultant jar is sufficient to move the recording stylus in the device. This provides a depth-time record of these operations.

Reliability: We have used 2 sets of T-R mechanisms. The only failures of the original set made in 1954 were due to our errors in rigging the net bar bridles. Accidental reversal of these bridles resulted in the first released bridle hanging up on the other, keeping the net from opening completely. A new set of mechanisms would occasionally pre-release, but a stronger latch spring has cured this problem. R. L. Bolin and M. Gilmartin of Stanford University's "Te Vega Program" have informed us that their Tucker Closing Net System has functioned perfectly.

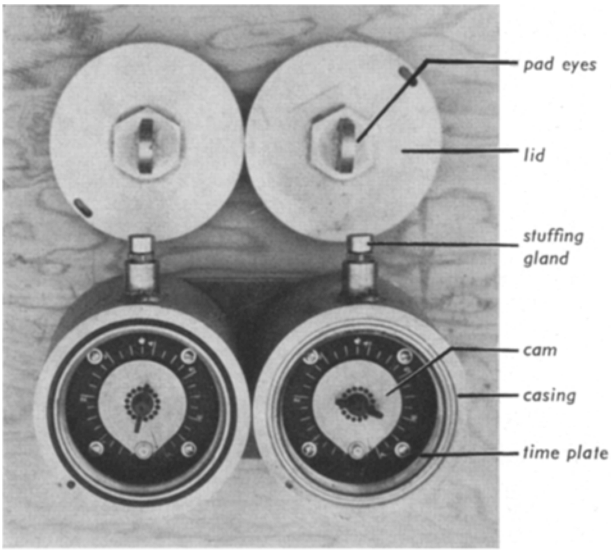

Fig. 2. A pair of Time-Release mechanisms, viewed from the top, with their lids removed to show the eccentric cam and time plates. Increments on the plates are in hours, with quarter-hour marks. The stuffing glands on the sides of the devices were provided for electric cables in case a conversion to solenoid activation was desired

Net performance in a deep scattering layer study

Data from a series of 4 net hauls made on 30 July 1963 off southern California (32°35'N, 117°30'W) from the USS Marysville (EPCER 857) are shown in Fig. 4. Two distinct layers were evident on the Precision Depth Recorder (PDR) Mark V, using an EDO echo sounder to drive a UQN-1D transducer at a frequency of 12 kc/sec. The upper layer, between 220 and 280 m, was very faint. Between 300 and 380 m, a strong diffuse scattering layer, typical of this area, was recorded. Occasional discrete, hyperbolic traces were recorded at the depth of the upper layer.

In Fig. 4 the net paths, computed from Depth-Time Recorder data, are delineated by the heavy lines superimposed over facsimiles of the echograms. The dashed portions represent the periods when the net

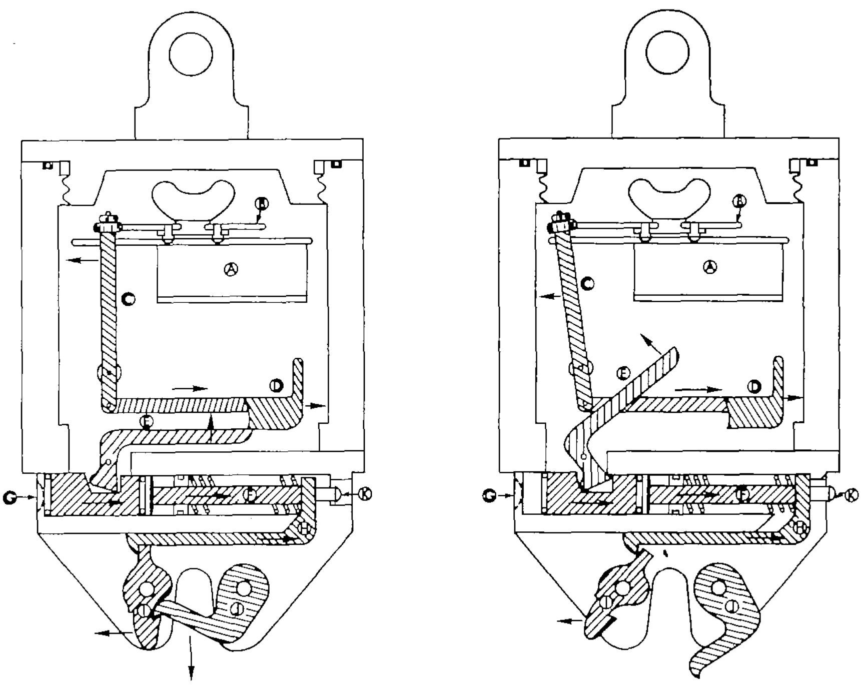

Fig. 3. A cut-away side view of a Time-release mechanism to show the sequential operation. The device is in the engaged position in A and released in B. Arrows denote the direction of position change of the moving parts during activation

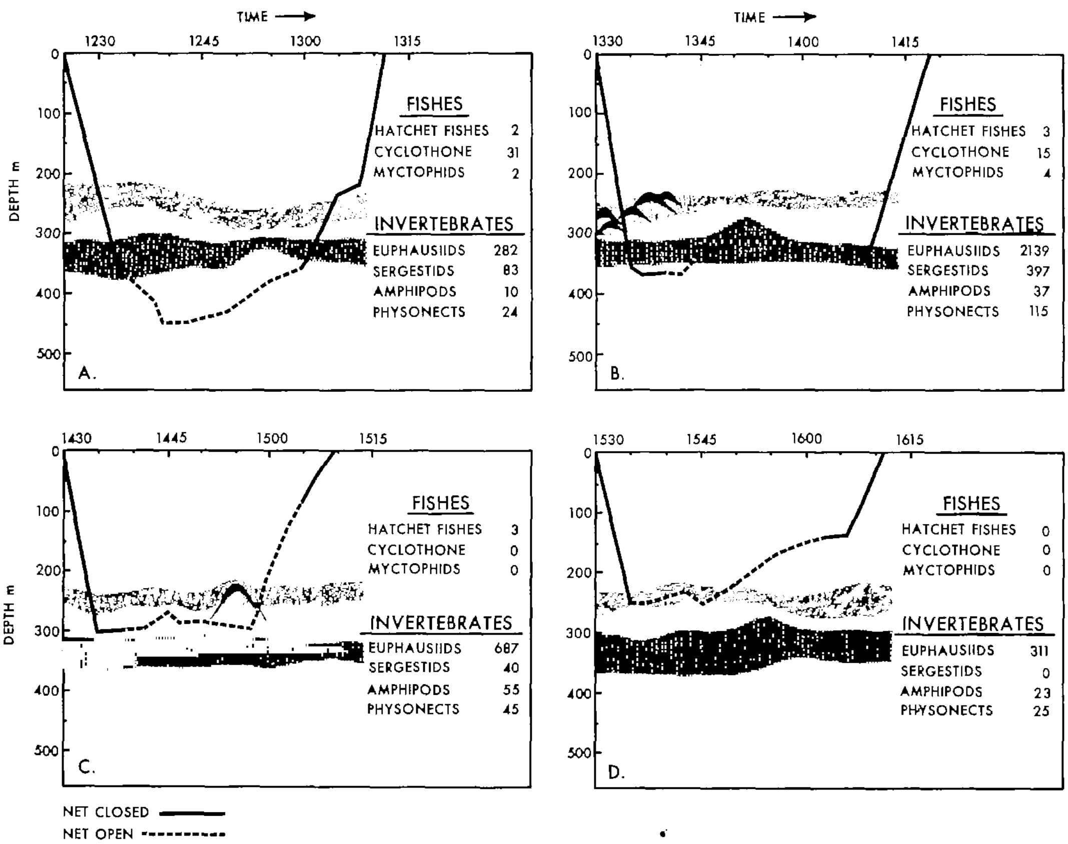

Fig. 4. The path of the net, during a series of 4 hauls made on 30 July, 1963 in the San Diego Trough, is superimposed on facsimiles of echograms recorded simultaneously. Dashed portions of the paths denote the periods when the net was open. Counts of selected organisms are tabulated for each haul

was open and sampling. The Marysville's slowest speed is 5 kts. (9.25 km/h), thus the gear was lowered with the ship hove-to, and the net positioned by its trace on the PDR. As the ship got under way, wire was slowly paid out, and the net depth estimated by the length of the warp and its angle from the vertical (these hauls were made prior to the acquisition of the depth-telemetering device). The ship's engines were alternately started and stopped to maintain an average towing speed of approximately 2 kts. (3.7 km/h). Using this figure and assuming 100% filtration, each 26-min haul then sampled about 5000 m^3 of water.

The main purpose of the hauls was to obtain siphonophore pneumatophores for gas analysis and metabolic measurements (Pickwell et al., 1964), and the last 2 hauls were purposely made to sample a relatively thick zone. The times, sampling strata, and catch of selected organisms are indicated in Fig. 4. Vertical stratification is evident for all the organisms. Amphipods are concentrated at shallower levels above the main (lower) scattering layer, and the mass of the catchable fish population is below this layer. Euphausiids and physonect siphonophores (mainly *Nanomia bijuga* (Delle Chiaje) show a broad vertical zonation, but their population maxima are clearly centered at the level of the main DSL. The sergestid prawns, all adult *Sergestes similis* (Hansen), are also concentrated in the main layer, but the top of the population seems to be sharply limited. These data are in close agreement with visual observations made from bathyscaphe Trieste in the same general area (Barham, 1963).

Because of their gas-filled pneumatophores, which should effectively scatter sound, the physonects are suspected as one of the main causes of this particular DSL. The spacing of the hauls provides little information on the cause of the upper layer.

Summary

1. An opening-closing, single-sample net system designed to capture micronektonic organisms is described.

2. The net is opened and closed by mechanical time-release devices, and can be hauled from small ships on hydrographic wire.

3. Data are presented from a series of 4 hauls made with this system during a study of sonic scattering layers. The population maxima of euphausiids, sergestid prawns and physonect siphonophores corresponded to the level of the main scattering layer. Fishes were concentrated below the layer, and amphipods above it.

Acknowledgements. We are grateful to N. NICOLOFF for design of the net hardware and T-R mechanisms. J. BALESTERI of Hopkins Marine Station, Stanford University, and M. BALESTRIERI, a San Diego, California, net-maker, have hung the nets, and continuously improved their design. J. WILTON and M. TAYLOR of Grossmont College assisted at sea and in data analysis. The latter has worked with the Tucker net since its original design, and has made many valuable contributions throughout the years. The figures were done by B. BURNS and G. PRIBLE.

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