PFRP

Pelagic Fisheries Research Program

Volume 3, Number 4 October 1998

Do You Know Where Your Longline Is?

Answers to this question have important implications for fishing operations, fisheries research and, ultimately, fishery regulation. Controlling depth is one of the tools that fishers use to selectively fish for different species. Lack of control results in capture of unwanted fish and reduces the profitability of fishing operations. Inferences about the fishing depth are used in stock assessment procedures to assist in interpretation of longline catch and effort data. This newsletter explores three different aspects of the problem in three different longline fisheries.

PFRP

How to Set a Longline to a Desired Depth

The local longline fishery in French Polynesia is booming–8 fishing vessels (totaling 354 mt landed) in 1991 to 60 vessels (4,336 mt landed) in 1997. In 1993, the French Polynesia government promoted a research program to support the industry. One of the program's goals is to develop a method that would allow fishermen to set their longlines at the depth where targeted species are known to swim.

Determining the Decisive Factors

To investigate this issue, Pascal Bach of the French research organization ORSTOM and Christophe Misselis and R. Abbes of the Institute Francais de Recherche pour l'Exploitation de la Mer (IFREMER) conducted 188 experimental longline sets. The sets were made in July and August 1993 and between May 1995 and August 1997 in the northern part of the exclusive economic zone surrounding French Polynesia (Figure 1).

For each set, the researchers estimated the average linear distance between floats (D) by recording the geographical coordinates and time of release of floats at the longline extremities. They estimated the longline drift (LLD) by recording the geographical coordinates for the first float when the longline was hauled out. The shape, symmetry and maximum depth (Dmax) of the mainline were determined by data from time-depth recorders (TDRs) placed at various locations on the mainline (Figure 2). The mainline length (L) was determined by using a tachymeter to record the speed of the mainline shooter. The ratio between D and L was then calculated to determine the sagging rate, or shortening rate (SR), of the mainline.

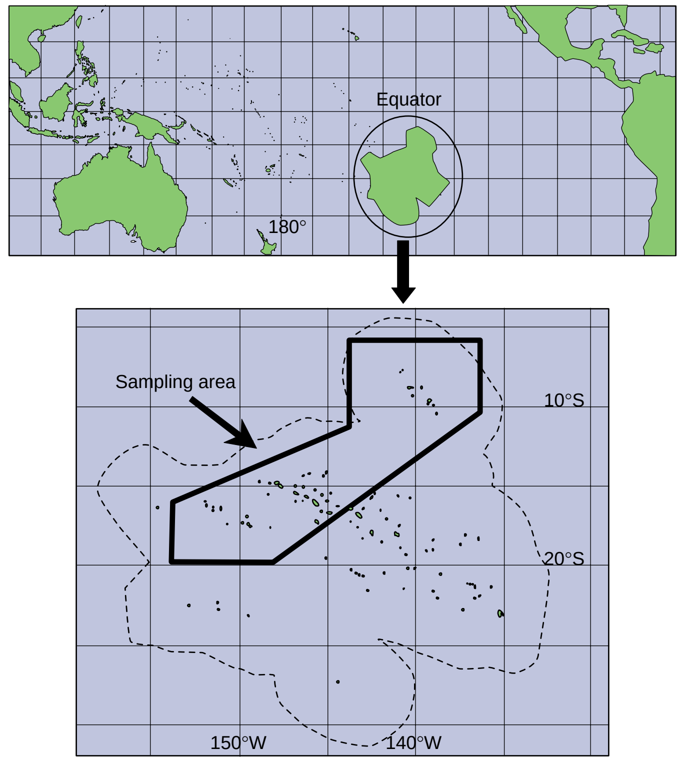


Figure 1. Area of fishing experiments in the exclusive economic zone surrounding French Polynesia.

Results from these experiments show that D and SR are the key factors for fishermen to consider when aiming for particular Dmax. The researchers note that the separate relations between Dmax and SR and between Dmax and D are not significant (explained variances are 27% and 0%, respectively), but the relationship between Dmax and the two variables combined is highly significant, accounting for 82% of the variability of Dmax.

(continued on page 2)

CONTENTS

How to set a longline (continued from page 1)

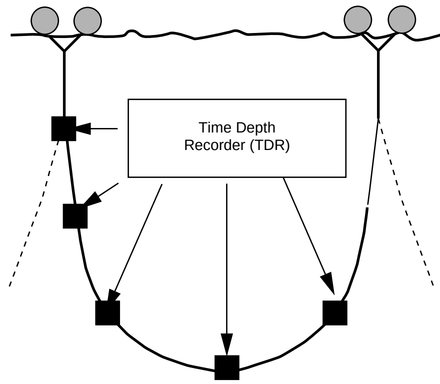


Figure 2. Different TDR positions on a basket to test shape, symmetry and maximum fishing depth of the mainline.

Other important factors are the wind and currents. As measurements for the currents were not possible during the experiments, LLD was used as a current indicator. The researchers arranged the LLD data into 6 classes from 0 to 5 (Table 1). When the LLD factor was added to the earlier model, the researchers were able to obtain an even more significant accounting of Dmax.

Table 1. Correspondence between the drift class and the interval of drift values.

Drift class	Drift interval (knots x 10^{-3})
0	0-1
1	1-2
2	2-3
3	3-4
4	4-5
5	5-6

Testing the Results

Using the revised model, the researchers produced a chart (Figure 3) that can be used to calculate the SR needed to get a longline to a desired depth given the distance between floats (D) and the drift condition. Fishermen can obtain the desired SR by determining the appropriate mainline length per basket and the shooter speed.

To test their results, the researchers conducted three fishing sets in which they targeted bigeye tuna in waters surrounding the Society Islands. Previous sonic tracking operations showed that bigeye swim principally at 400 m to 550 m depth during the daytime in the area. Therefore, the researchers aimed for 550 m depth.

To determine the conditions needed to get the mainline to the desired depth, the following steps were followed:

- Given D=1,000 m and drift class=1, Figure 3 was consulted to determine the appropriate SR (i.e., 0.59).
- Next, D was divided by SR to determine the required mainline length per basket (D/SR=L; i.e., 1,000/0.59=1,695 m).
- L was then divided by the time needed to set a basket (estimated at 6.5 minutes given a boat speed of 5 knots) to determine the required speed of the shooter (L/setting time per basket=shooter speed; i.e., 1,695 m/6.5 min=260 m/min).

Results from the field tests were positive. First, Dmax (determined by TDRs placed on 12 baskets at their mid-points, the assumed Dmax) ranged from 440 to 660 m. Second, bigeye tuna was the most abundant species to be caught—10 individuals totaling 409 kg. The catch yield was 57 kg/100 hooks. Catch yield for albacore was equal to those of Polynesian longliners fishing in the same area (23 kg/100 hooks), but the yields for bigeye were 20 times greater than those of the other longliners.

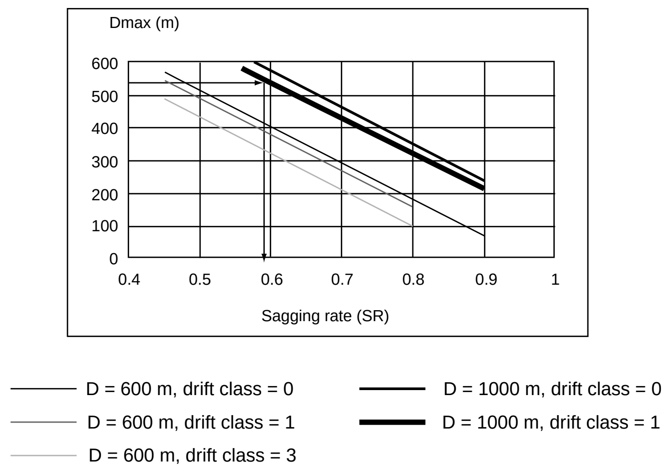


Figure 3. Estimated sagging rates calculated for various conditions (i.e., target Dmax, distance between floats and drift class).

Conclusion

The strategy developed by Bach, Misselis and Abbes for setting a longline to reach a desired depth appears to be effective and promises to be useful. The method can help fishermen get longlines to appropriate depths for targeted species and thus increase catch per unit effort and decrease bycatch. It can also be used by scientists who are analyzing commercial longline catches to estimate Dmax for individual sets and thus provide key information on the accessibility of tuna resources. However, the researchers note, the model could be improved through inclusion of more accurate data on the velocity and direction of currents.

PFRP

Reducing Longline Bycatch

Fishery managers worldwide are increasingly concerned about bycatch. Catching unwanted species is not only a waste of valuable resources, it may also—as in the case of the Atlantic longline fisheries—cause some species to be overfished and significantly impede other species (such as swordfish, bluefin tuna and some shark species) from rebuilding their stocks.

After a 3-year study monitoring the U.S. yellowfin tuna fishery in the Gulf of Mexico, Steve Berkeley of Oregon State University and Randy Edwards of Mote Marine Lab, Sarasota, Florida, conclude that the inability of longliners to fish selectively is a result of the highly unstable and unpredictable nature of the gear.

Even within a set, gear configured and deployed exactly the same end up at depths that vary as much as 100 m or more. Figure 1, for example, illustrates six sections of one set monitored by Berkeley and Edwards. Section T3-3-4 reaches a depth of almost 200 m, while section T6-3-4 never sinks deeper than about 60 m, they note.

Of equal interest, they point out, is the complex behavior of some sections during the course of a soak (time the gear is in the water), which can last as long as 24 hours. For example, in Figure 1, after deployment the mainline of Section T2-3-4 sinks rapidly to 60 m after which it begins to rise slowly for a couple of hours before sinking to 100 m. Over the next 12 hours, the line gradually rises again to about 60 m and then plunges back down to 100 m just before it is hauled up. Careful screening of the data reveals that converging and diverging currents constantly working on different sections of the longline apparently cause the depth excursions by dragging the gear down or pulling the floats apart.

In all, Berkeley and Edwards monitored 79 longline sets over the course of 10 longline trips and discovered that a high percentage of hooks were not fishing in appropriate locations for the yellowfin tuna that were being targeted.

(continued on page 4)

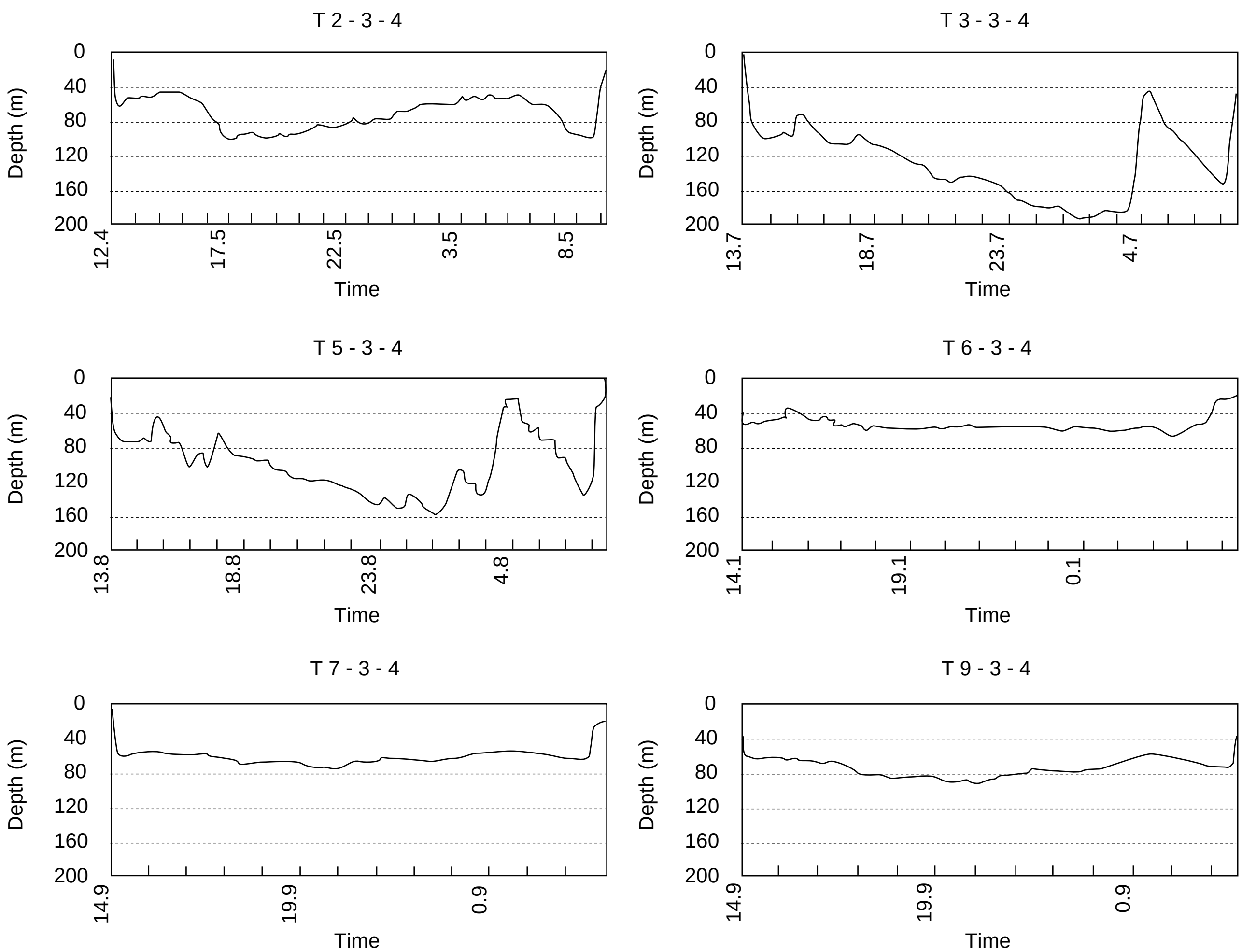


Figure 1. Depth traces from 6 TDRs attached to different sections of the mainline from a single set of longline gear (Trip 4, Set 3). Length of buoy drops was 18 m.

Reducing longline (continued from page 3)

Table 1. Number and percent of hooks on 79 monitored longline sets that were outside the normal temperature range of yellowfin tuna.

Temperature	No. Hooks	Percent of Total
<SST-8°C	13,004	22.8%
<20°C	7,141	12.5%
Total	20,145	35.3%

Table 2. Summary of 10 longline trips (79 sets) and mean catch per set for yellowfin tuna, swordfish, billfish and sharks. CPUE=number of fish per 1,000 hooks.

No.	Mean	Mean No.	Mean Catch Per Set				Mean YFT
Trips	Length	Hooks	YFT	SWF	BILL	SHK	CPUE
10	31.1 nm	765	6.2	2.5	1.0	1.2	7.45

Although the absolute lower temperature limit for yellowfin is not known, if water more than 8°C colder than sea surface temperature represents the lower limit, then nearly a quarter of the hooks being monitored were set outside the range for yellowfin. If 20°C represents a reasonable estimate, as many as 35% of the hooks may have been outside the normal temperature range for yellowfin (Table 1).

During the experiment, information was gathered by placing hook timers on the gangions and time-depth recorders (TDRs) on the mainline of working longline gear. From the hook timers (digital watch modules triggered to start when separated from a small magnet), Berkeley and Edwards were able to determine the time that each fish was hooked. From the TDRs, they were able to determine the depth and temperature of the mainline throughout the set. By knowing the length of the gangion and float lines and the thermal profile of the water column (determined from expendable bathythermographs, or XBTs), the researchers are able to estimate the depth and temperature at which each fish was hooked. Gear performance, survival after hookup and differences in feeding time, depth and temperature between target species and bycatch species should also be revealed by these data.

A summary of their study is given in Table 2. The target species on all but two sets was yellowfin tuna. The relative scarcity of billfish in the catch (only about 1 per set) makes it difficult to detect statistically significant differences in behavior between tuna and billfish, if they exist.

On the two sets that targeted swordfish, the gear was more stable, and 51 swordfish were caught. The percentage of swordfish still alive on haulback was significantly less on swordfish sets (6%) than on tuna-directed sets (28%). This difference may be due to hook type (circle hooks are used on tuna sets and straight shank hooks are used on swordfish sets) or to the length of time fish were on the line. Hook timer data indicate that some marlin and tuna are still alive 10-12 hours after hookup. On average, more than 60% of the billfish and nearly 50% of the tuna are still alive after 6 hours. Swordfish, in contrast, do not appear to live much longer than 4 hours after hookup. By 6 hours, survival is only 15%.

Determining how to stabilize and control longline gear is essential to developing gear and deployment strategies that will reduce bycatch, Berkeley and Edwards contend. Unless and until fishermen are able to more precisely control the depth and temperature at which their hooks are fishing, the researchers claim, the only apparent options to reduce bycatch are either hardware changes (e.g., using hook types that increase survival rate) or some form of effort reduction (e.g., short soak times, fleet reduction or time/area closures).

PFRP

PFRP Technical Reports

For a copy of any of the following technical reports, please contact
PFRP Administrative Assistant Dodie Lau
Tel.: (808) 956-7895 Fax: (808) 956-4104
E-mail: dlau@soest.hawaii.edu

or contact
Joint Institute for Marine and Atmospheric Research
University of Hawai‘i at Mānoa
1000 Pope Road, MSB 313
Honolulu, HI 96822
Tel.: (808) 956-8083 Fax: (808) 956-4104

Feasibility of Dual Mode Lidar for Pelagic Fish Surveys, by Christian Schoen and John Sibert, SOEST 96-02, JIMAR 96-301.

Cost-Earnings Study of the Hawaii-Based Domestic Longline Fleet, by Marcia Hamilton, Rita Curtis and Michael Travis, SOEST 96-03, JIMAR 96-300.

Social Aspects of Pacific Pelagic Fisheries, Phase I: The Hawai‘i Troll and Handline Fishery, by Marc Miller, SOEST 96-04, JIMAR 96-302.

The Contribution of Tuna Fishing and Transshipment to the Economies of American Samoa, the Commonwealth of the Northern Mariana Islands, and Guam, by Michael Hamnett and William Sam Pintz, SOEST 96-05, JIMAR 96-303.

Quality and Product Differentiation as Price Determinants in the Marketing of Fresh Pacific Tuna and Marlin, by Paul Bartram, Peter Garrod, and John Kaneko, SOEST 96-06, JIMAR 96-304.

Sociology of Hawaii Charter Boat Fishing, by Julie Walker, SOEST 97-02, JIMAR 97-309.

Design of Tag-Recapture Experiments for Estimating Yellowfin Tuna Stock Dynamics, Mortality, and Fishery Interactions, by Peter Bills and John Sibert, SOEST 97-05, JIMAR 97-313.

Cost-Earnings Study of Hawaii's Small Boat Fishery, 1995–1996, by Marcia Hamilton and Stephen Huffman, SOEST 97-06, JIMAR 97-314.

An Assessment of Bigeye (Thunnus obesus) *Population Structure in the Pacific Ocean, Based on Mitochondrial DNA and DNA Microsatellite Analysis*, by Peter M. Grewe and John Hampton, SOEST 98-05, JIMAR 98-320.

Predicting the Shape of Longlines

The shape of a longline underwater has often been assumed to be catenary, i.e., a symmetrical curve hanging freely from two points with the midpoint of the line reaching the deepest. Recent experiments by Japanese scientists, however, show that currents—especially those that create shear—can significantly alter longline shape. The study—conducted by Keisuke Mizuno, Makoto Okazaki, Hideki Nakano and Hiroshi Okamura of the National Research Institute of Far Seas Fisheries—also shows that longlines can have periodic swinging movements and that the degree of sagging of the mainline, or shortening rate, must be estimated accurately and continuously in order to obtain a correct estimate of the longline shape.

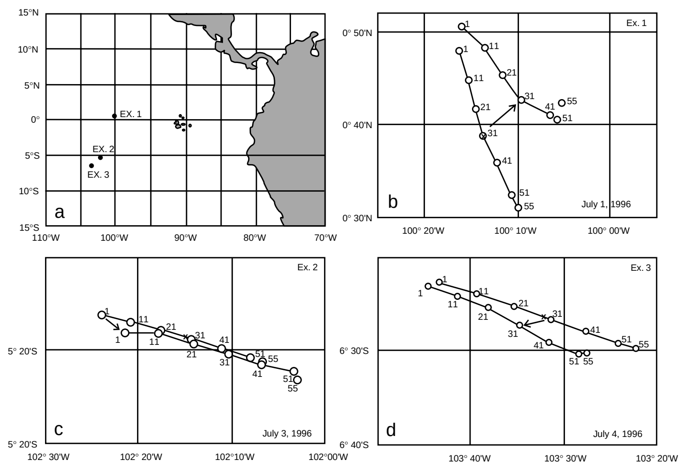


Figure 1.

continued on page 6

Pelagic Fisheries Research Program Newsletter

Volume 3, Number 4 **October 1998**

Editor John Sibert
Writers Sylvia Spalding and John Sibert
Layout May Izumi
Printing Printer Name

For more information

Pelagic Fisheries Research Program
Joint Institute for Marine and Atmospheric Research
University of Hawai‘i at Mānoa
1000 Pope Road, MSB 313
Honolulu, HI 96822

TEL (808) 956-4109 FAX (808) 956-4104

E-MAIL jsibert@soest.hawaii.edu
WWW http://www.soest.hawaii.edu/PFRP

Upcoming Events

November 4–6

Annual CalCOFI Conference
Pacific Grove, California;
e-mail ghemingway@ucsd.edu
or molivarria@ucsd.edu

November 16–19

Ocean Community Conference 1998
(Celebrating International Year of the Ocean)
Baltimore, Maryland;
1 (800) 810-4333
or 1 (732) 562-6826,
fax 1 (732) 981-1203,
e-mail mts-occ98@ieee.org

November 16–19

ICES International Symposium on Confronting Uncertainty in the Evaluation and Implementation of Fisheries-Management Systems
Cape Town, South Africa;
27 (21) 650-2681,
fax 27 (21) 685-3937,
e-mail ljohnsto@botzoo.uct.ac.za or
dll@maths.uct.ac.za

March 16–19, 1999

ICES/SCOR Joint Symposium on
The Ecosystem Effects on Fishing
Montpellier, France; e-mail hg@dfu.min.dk

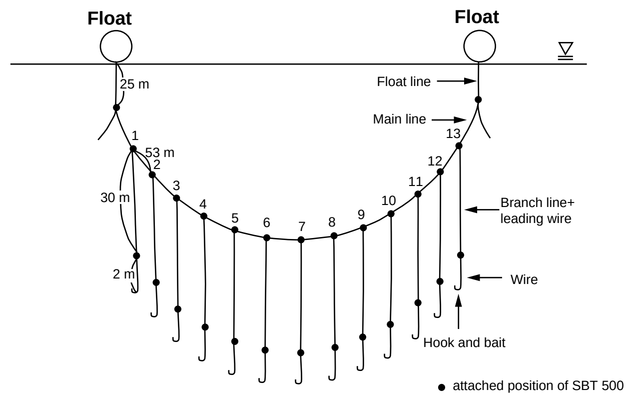


Figure 2.

The scientists' findings are based on three experiments in the tropical eastern Pacific during July 1996 (Figure 1a). In each experiment, a longline with 54 baskets (i.e., portions of mainline between a pair of neighboring floats) was set. The fifth basket of each set was monitored by 15 micro-bathythermograph (BT) probes, attached to the top of the 13 branch lines and the bottoms of the two float lines (Figure 2).The probes recorded depth and temperatures every 10 seconds. Launching and retrieving positions of floats for every 10 baskets were measured by global positioning satellite (GPS) (Figures 1b–d).

During the longline operations, the ocean current was measured vertically by acoustic Doppler current profiler (ADCP) for each 8-m depth bin from 16 m to about 400 m. Pinging interval was about 1 second, and the data were averaged over an interval of 5 minutes. Also, expendable bathythermographs (XBTs) were dropped at the midpoint of each setting of the longline.

The Effects of Current Shear

Results from the experiment show that the presence of differential vertical current shear across the length of a mainline will cause dragging and lifting forces to modify the shape and motion of the line. This was clearly demonstrated in Experiment 1, which was conducted in a current with a distinctively defined two-layer flow structure, with a strong vertical shear between (Figure 3). The

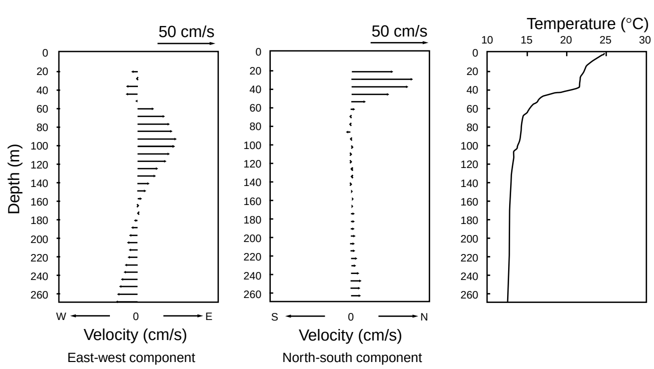


Figure 3.

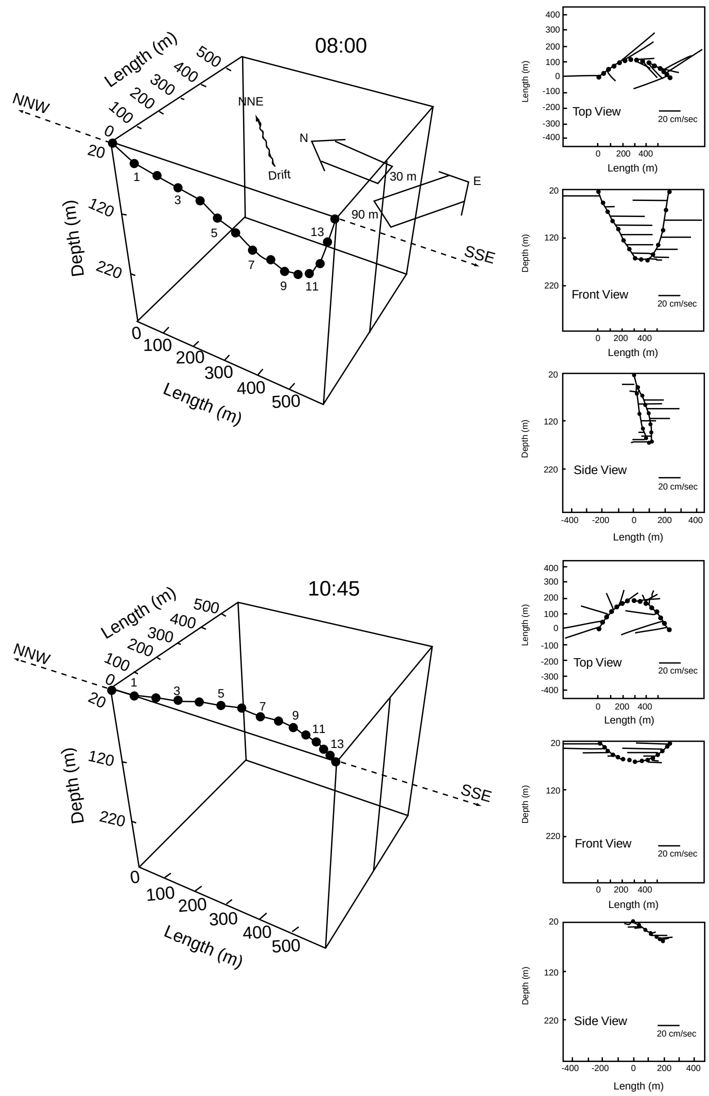


Figure 4.

upper-layer water, from the surface to 50 m, flowed northward, with its lower boundary consistent with the depth of thermocline. Below the upper layer, an eastward flow was dominant between 60 and 160 m, with the maximum velocity at 90 m. Temperature profiles showed a 13°–14°C layer at 70–100 m, which characterizes the equatorial undercurrent (EUC).

The strong vertical shear affected the longline in two ways. First, dragging caused the line to be asymmetrical. Time/depth records from the micro-BTs show that, when the mainline had sunk to its maximum depth at about 0800 hrs, the deepest point was reached by the 9th branch line rather than the 7th branch line (the central branch line). The second effect of the shear was a lifting of the longline toward the surface after maximum depth had been reached. By 1045 hrs the central part of the line (branch lines 5–9) was stable at 60–70 m.

The shape of the mainline points of greatest and settled depths are shown in Figure 4. The shape at 0800 hrs is skewed to the right (front view) by the eastward-flowing EUC dragging the deeper parts of the longline obliquely to the south-southeast. In addition, the mid-depth segment of the longline is dragged eastward (side view). The shape at 1045 hrs is elevated drastically, which is clearly shown by the side view. The front view shows that the center of the mainline (i.e., the top of branch line 7) reaches a depth of no more than 70 m.

Periodic Vertical Movement of the Mainline

The study also shows that, although the bottoms of float lines remain at constant depths, other parts of the line move up and down in a somewhat regular pattern, with the movements of the deeper parts being greater. In Experiment 2, for example, time/depth data from the micro-BTs show that the mainline settled at approximately 200 m depth about 20 minutes after being launched. Then, after settling, the mainline rises and then lowers approximately every 1 to 2 hours (Figure 5). This swinging motion appeared in all three experiments, but the size and duration of the movement varied with each. The sea state during the experiments was generally quiet, without large, long-period swells and large surface waves. Mizumo, Okazaki, Nakano and Okamura note that the nature of the motion will be investigated by numerical simulation models in the future.

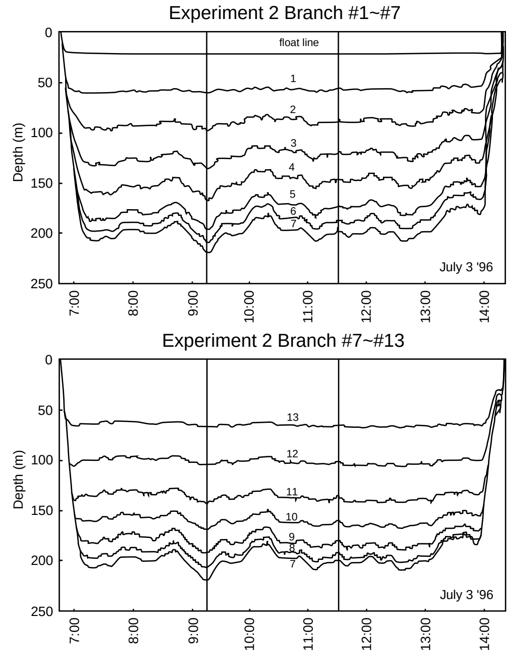


Figure 5.

Problems with Shortening Rate Estimates

Finally, the study shows that there can be problems associated with estimated shortening rates—which must be accurate when calculating the shape of the mainline. Some of these problems were highlighted in Experiment 3.

First is the accuracy of the GPS system used to estimate the position of floats (actually positions of the ship at launching and retrieving of the floats). In Experiment 3, for example, the shortening rate at launching exceeded 1.0, which indicates that the accuracy of the GPS systems was limited (Table 1).

Table 1. Shortening rates

Experiment	Launching	Retrieving	*
1	0.79	0.82	(0.85)
2	0.86	0.82	(0.83)
3	1.01	0.86	(0.95)

*Values in parenthesis are estimated by the ratio of averaged releasing speed of mainline and ship speed.

Second is the possibility of the shortening rate changing during the duration of the set. In Experiment 3, the shortening rate changed by 15% (from 1.01 at launching to 0.86 at retrieval, based on GPS of floats) (Table 1). This was caused by the mainline being deployed tightly (i.e., with a large shortening rate) at the beginning followed by considerable loosening (i.e., achieving a lesser shortening rate) over time. Mizumo, Okazaki, Nakano and Okamura suggest that simultaneous positioning by GPS buoys might give more accurate relative locations of them than repeated positioning using a single GPS system. They also recommend that GPS buoys be used whenever possible in future experiments.

A third source of error of the shortening rate is change of the mainline length itself caused by tension on the line when deployed. Mizuno, Okazaki, Nakano and Okamura measured the expansion rate in situ, using a line in the shape of a vertical catenary and with a shortening rate of 0.94 (as assumed in Experiment 3 estimated by the ratio of average releasing speed of mainline and ship speed) and found the expansion rate to be insignificant, i.e., less than 1%.

Conclusion

Mizuno, Okazaki, Nakano and Okamura have developed a model that is capable of estimating line shape from observed depth data as model input but that is not capable of predicting line shape from current data as model input. Results of their experiments confirm that the shape of the line depends on current shear relative to the mainline and encourages the researchers to develop a dynamic model that can output line shape from input of current data.

Because a longline operation lasts from 12–20 hrs, the optimal estimation of the shape must be based on the concurrent current structure, which is available only from vessels equipped with ADCPs. Another possible source of data is a recently deployed array of buoys in the equatorial Pacific, which may supply nearly real-time information in a limited area. However, a more valuable first approach would be to calculate shear from climatological data, the researchers note.

PFRP

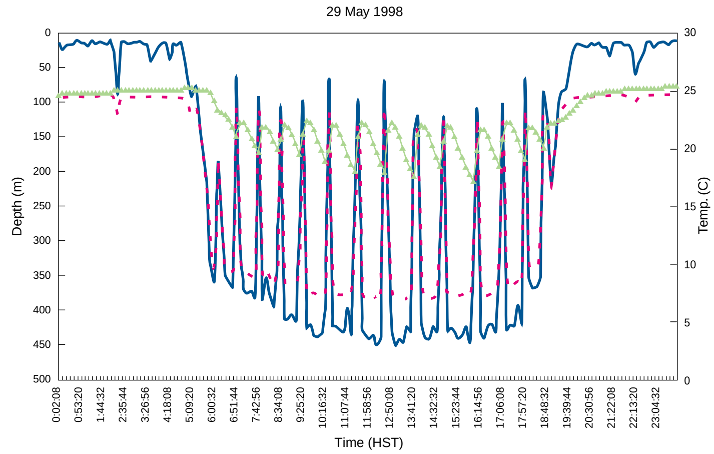
Recovered Tag Loaded with Data

On July 2, 1998, Kona fisherman Michael Berman landed a bigeye tuna containing a NFMS archival tag. Fish cutter Shane Balucan discovered the tag and returned it to NMFS for a $500 reward. The tag contained three months of data on the fish's swimming depth (blue line) and internal (yellow triangles) and external (red dots) body temperatures, recorded every 8.5 minutes since the fish's tag and release by NMFS scientists on April 9 off the Kona Coast (see PFRP newsletter vol. 3, issue 3).

The daily pattern of the fish was very repetitive. It remained at 10–90 m from the surface at night and dove to 350–500 m each day. When its body temperature dropped to 17° C it swam to the surface to get warm (about once per hr) before diving again. Because the tuna remained principally in darkness, scientists could not use light measurements recorded by the tag to determine the fish's daily position by longitude and latitude. However, dawn and sunset were estimated from the fish's behavior. On May 28, it began a descent from 80 m to 350 m at about 0518 hrs and then began an ascent from 200 m to 10 m at 1857 hrs. These times are extremely close to dawn and dusk along the Kona Coast, indicating the fish remained in Hawai‘i waters.

To return a NMFS archival tag for a $500 reward, send the tag, along with notes on the length and weight of the tagged fish and the time, date and location of its capture to Christofer Boggs, NMFS Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822. For assistance, call any local fishery office, the toll free number on the tag (1-800-588-8066) or the NMFS Lab at (808) 983-5300.

PFRP



PFRP Pelagic Fisheries Research Program

Pelagic Fisheries Research Program
Joint Institute for Marine and Atmospheric Research
University of Hawai‘i at Mānoa
1000 Pope Road, MSB 313
Honolulu, HI 96822