Relation between Hook Depth and Fishing Efficiency in Surface Longline Gear

Juan Carlos Rey
Spanish Institute of Oceanography, Coastal Center of Fuengirola
P.O. Box 285, Fuengirola, Málaga, Spain

Ramon Muñoz-Chápuli
Department of Animal Biology, Faculty of Science
University of Málaga, 29071 Málaga, Spain

Surface longline gear can operate at a range of depths, and hooks placed at different depths can have different fishing efficiencies, depending on the target species and its behavior. With better knowledge of the relationship between hook depth and hook catch rates, catch rates could be improved by placing the majority of hooks at the depth range preferred by the target species. However, little data exist on this subject in the literature, probably due to the difficulty of obtaining information about the differential catch rates of each hook and in estimating absolute depths. Yoshihara (1951) reports that the vertical distributions of *Thunnus orientalis* and *Germo germo* caught by longline are bell-shaped, suggesting different water temperature preferences by each species. Suzuki et al. (1977) state that the same fishing methods and longline gear are frequently used regardless of the areas and species. These authors also remark that there have been no systematic studies on the vertical distribution of tunas and billfishes. A well-known exception was in the 1970s when the Korean and Japanese commercial longliners changed from regularly using the gear near surface to fish for bigeye tuna to using it at greater depths to target yellowfin tuna *Thunnus albacares* (Saito 1975, Suzuki et al. 1977, Yang and Gong 1987). There is also some information about the behavior and depth range of swordfish *Xiphias gladius* (Carey and Robison 1981) and blue shark *Prionace glauca* (Sciarrota and Nelson 1977) in the literature.

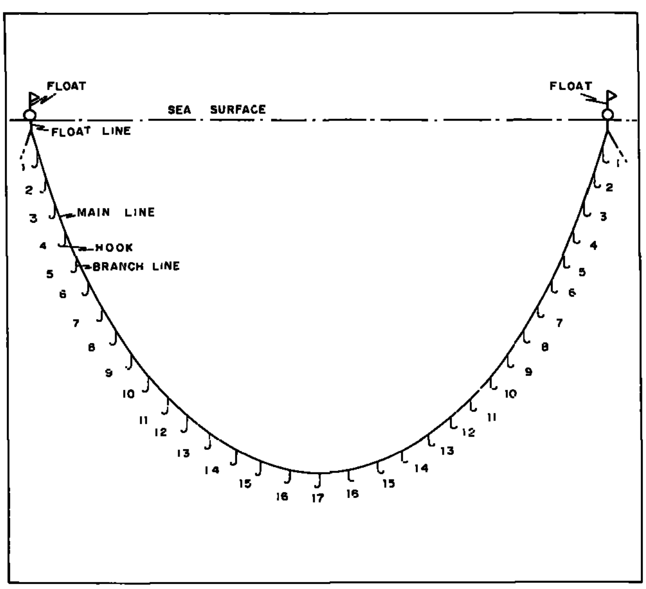

Figure 1
Scheme of the longline used in this study. Numbers show hook position.

Our aim was to obtain a simple, statistical relationship between the fishing efficiency of each hook in a basket (a stretch of longline between two floats) and its relative depth. We used data from a tropical eastern Atlantic Ocean fishing trip, where commercial longline gear was regularly used by southern Spanish fishermen to catch swordfish as a primary target species and mako shark *Isurus oxyrinchus* as the most valuable bycatch species. The study was carried out on the gross catch, in which the target species, swordfish and mako shark, comprised only 5–21% of the total catch.

Methods

The longline gear employed in this study consisted of "baskets" between floats (Fig. 1). Float lines measured about 7 m, while the main line within each basket measured about 1200 m. Branch lines (33 per basket) were 15 m long. This standard gear design is modified by

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Spanish fishermen operating in the Atlantic Ocean and Mediterranean Sea according to their experience and customs.

A total of 706 baskets were deployed during 16 nocturnal fishing operations in April 1985, located between 10°27′–11°42′N lat. and 17°17′–17°45′W long. Each fish was identified, sexed, and measured. The hook number within each basket was also recorded. A summary of the species caught and their abundances will be reported in a separate paper (Rey and Muñoz-Chápuli, in press).

Maximum depth reached by the deepest hook (position 17) was estimated to be between 370 and 460 m, using the theoretical procedure described by Yoshihara (1951, 1954).

Hook catch rates (HR) per 100 hooks were calculated using:

$$HR = (\text{number of fish caught/number of hooks set in the } j\text{th position}) \times 100.$$

A total of 1412 hooks were set in positions 1–16, while 706 hooks were set in position 17.

Results and discussion

Table 1 shows the hook catch rates (HR) obtained for total catch, swordfish, and mako shark which was the most valuable species in the bycatch. Composition of bycatch is also presented in this table. A maximum HR of more than 5 fish/100 hooks for the total catch was observed between hook positions 3 and 5 (Fig. 2A). Values were generally lower beyond position 10, where the HR values were 2.8–4.6 fish/100 hooks.

The highest HR for swordfish was recorded at hook positions 3–13 (Fig. 2B). Mako sharks were captured mainly between hook positions 5 and 8 (Fig. 2C). They were never captured at hook position 15 or 17.

Table 1 includes the proportion of bycatch (total catch less swordfish and mako shark). As can be observed in Figure 2D, hook positions 14–17 show the highest HRs for the bycatch proportion. This indicates that these lower hooks are less effective for catching both swordfish and mako shark, which are caught in higher numbers on hooks 3–13.

Few data exist in the literature to compare with our results. Suzuki et al. (1977) compared catches of regular (to 150 m depth) and deep (250–300 m depth) tuna longlines in the western and central equatorial Pacific Ocean. They recorded a higher HR for swordfish using shallower gear. Carey and Robison (1981) observed, through radio-tracking, that in the Atlantic Ocean swordfish follow isoluminic trajectories. They were located in depths of 400–600 m during the day and 0–170 m at night. However, in the Pacific Ocean the depth range recorded for swordfish was 50–100 m during the day and 0–70 m at night. This could explain the slightly deeper maximum depth of fishing efficiency we recorded in the tropical eastern Atlantic Ocean, compared with that of Suzuki et al. However, Yang and Gong (1987) found a higher swordfish catch per unit of effort around 150 m in the central Atlantic (0°–10°N).

Table 1

Hook catch rates of total fish, swordfish *Xiphias gladius*, and mako shark *Isurus oxyrinchus* during 16 nocturnal fishing operations in the tropical eastern Atlantic Ocean. Right column shows proportion of "other species" in the total catch. Correlation coefficients (r) from the linear relationship between hook position and HR/proportion other species are also shown. HR = no. hooks with catch/no. hooks set in jth position × 100 (see text).

Hook position	Total fish	Hook catch rates (fish taken/100 hooks) Swordfish	Mako shark	Other species*	Proportion of other species (%)
1	4.46	0.35	0.28	3.83	86
2	4.18	0.35	0.21	3.62	87
3	5.67	0.92	0.21	4.54	80
4	5.10	0.57	0.21	4.32	85
5	5.24	0.64	0.35	4.25	81
6	4.39	0.42	0.07	3.90	89
7	4.96	0.71	0.28	3.97	80
8	3.68	0.42	0.35	2.91	79
9	4.81	0.57	0.14	4.10	85
10	4.81	0.57	0.21	4.03	84
11	3.47	0.50	0.21	2.76	80
12	4.53	0.64	0.21	3.68	81
13	4.18	0.64	0.07	3.47	83
14	3.68	0.07	0.21	3.40	92
15	4.60	0.50	0.00	4.10	89
16	3.89	0.42	0.07	3.40	87
17	2.83	0.14	0.00	2.69	95
r	−0.59**	−0.35	−0.63**		0.43

* 55.9% *Carcharhinus signatus*, 17.0% *C. falciformis*, 9.3% *Alopias superciliosus*, 7.8% *Prionace glauca*, 5.5% *Mobula* sp., 1% *Sphyrna lewini*. Less than 1%: *Sphyrna couardi*, *S. mokarran*, *S. zygaena*, *Centrophorus granulosus*, *Galeocerdo cuvieri*, *Isurus paucus*, *Carcharhinus plumbeus*, *Thunnus obesus*, *Lepidocybium solanderi*, *Alepisaurus ferox*.
** $P<0.01$.

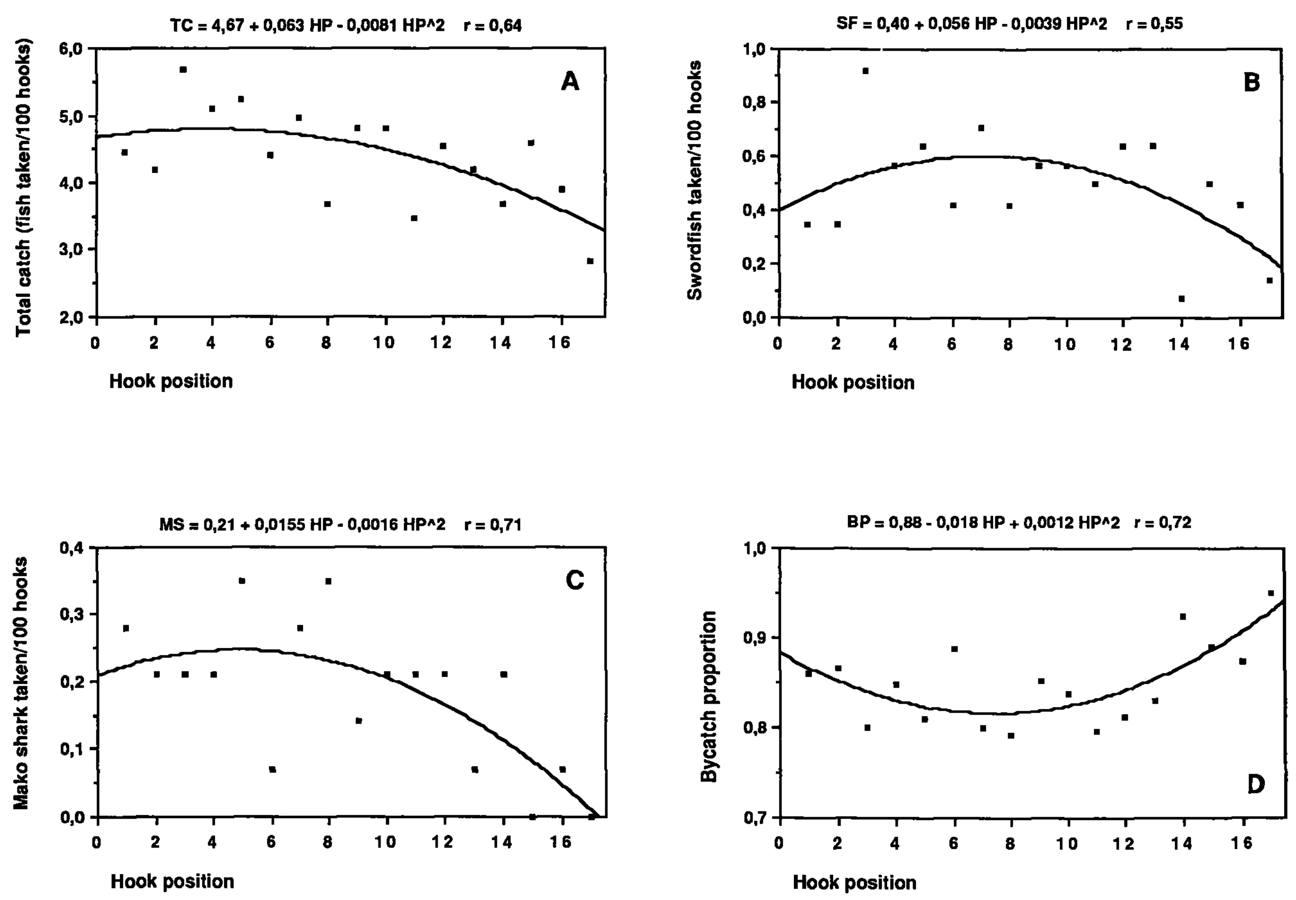

Figure 2
Relationships of hook catch rates to hook position for the total catch (A), swordfish (B), and mako shark (C). (D) Relationship between bycatch proportion (total catch less swordfish and mako shark) and hook position.

The ratios described in the results suggest that a better catch could be obtained with a different basket shape. Thus, by eliminating the deepest hooks, a smaller basket would be produced with most of the hooks placed in the depth range that demonstrated better fishing efficiency.

It should be noted that these data are valid only for particular spatial-temporal conditions, and they depend on environmental and biological variables such as temperature, light level, current, behavior, and food availability. Notwithstanding, our results show that further comparative and experimental studies on longline gear design could significantly improve the yield of fishing operations.

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