Historical changes and variations in pelagic longline fishing operations

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Summary

Observer data and published reports are examined to determine how soak time and the timing of operations have varied historically and between pelagic longline fleets. Combined with the estimates of the effects of soak time and timing presented by Ward et al. (in prep.), the information provides insights into how variations in operations have biased estimates of longline catch rates and catch levels.

There has been a reduction in the average soak time of hooks deployed by large-scale, "distant-water" longliners. Since the 1950s, the number of hooks deployed in daily operations has steadily increased. However, the increased hook numbers have not resulted in increased soak times because the changes were accompanied by faster retrieval and deployment speeds. Consequently, soak time declined, from about 11.5 hours when large-scale longlining commenced in the 1950s to about 10.0 hours in the 1990s.

For many species, changes in the timing of operations have also affected and biased abundance estimates. Since the 1950s there has been a shift from having all longline baits available at dawn to having equal proportions available at dawn and dusk. Ward et al. (in prep.) show how changes in soak time and timing have resulted in systematic bias in estimates of mortality levels and abundance indices for many species.

Introduction

Commercial fishers often modify fishing practices and gear to improve their economic returns, through improved catch rates, size composition or species composition. Such changes will affect estimates of mortality and abundance that are derived from fishery catch and effort data. Hutchings and Ferguson (2000, p. 10), for example, found that the soak time of gillnets in the north Atlantic cod fishery doubled during the 1980s, resulting in large increases in unreported catches. Ward et al. (in prep.) found that soak time had negative effects on the catch rates of several species and positive effects in the catch rates of many species caught in pelagic longline fisheries.

We examine how soak time and the timing of longline operations may have varied historically and between fleets. Combined with the estimates of the effects of soak time, the information provides insights into how variations in operations have biased estimates of catch rates and catch levels.

Types of operations

Pelagic longlines consist of a series of baited hooks, each attached to a branchline. The branchlines, which are also called "snoods" or "gangions", are attached at regular intervals along a mainline. The mainline is suspended from buoys floating at the sea

surface. The entire longline, which may span 100 km of the seas' surface and consist of several thousand baited hooks, is deployed and retrieved in a 24-hour operation (Ward 1996). The sparse and patchy spatial distribution of fish, diurnal cycles in their feeding activity and distances from port usually necessitate a 24-hour longlining operation, regardless of catch rates or vessel size.

To catch tunas, longliners usually commence deploying their longlines three hours before dawn (Figure 1). Deployment takes about five hours. It is completed about three hours after dawn. There is then a waiting period of about four hours before retrieval, which commences in mid afternoon. Retrieval takes about 13 hours. A new operation will then commence after a brief period (about two hours), which we term the "search time".

Line tangles, line breaks and mechanical failures sometimes result in operations that last longer than 24-hours (Yamaguchi 1989, p. 31). Subsequent operations would involve reduced wait and search periods to allow a return to a 24-hour cycle that maximizes the exposure of baits to dawn and dusk. Occasionally longliners deploy fewer hooks or forego a day's fishing after a prolonged retrieval.

Longlines are usually "counter-retrieved"; the last hook that had been deployed is retrieved first (Hirayama 1969). Counter-retrieval reduces fuel costs unless the vessel master is intending to head the next day in the same direction as the longline was deployed (Yamaguchi 1989, p. 16). The observer data sets analyzed in Ward et al. (in prep.) indicate that most operations are counter-retrieved. Observers on fresh-chilled longliners of the Western Pacific Bigeye fishery report that about 80% of operations are counter-retrieved. Higher frequencies of counter-retrieval are reported in the South Pacific fisheries (~90%of operations) and almost all Central Pacific Bigeye and North Pacific Swordfish operations are counter-retrieved.

The total time that a hook is in the water is termed the "soak time". In counter-retrieved operations of the South Pacific fisheries it ranges from about 3 hours for hooks at the beginning of retrieval up to about 21 hours for the last hooks retrieved. In contrast, the hooks of longlines that are "return retrieved" have a narrower range of soak times (8–16 hours). However, the average soak time of all hooks in return retrieval (9.4 hours) is similar to that of counter-retrieved hooks (10.0 hours).

The preceding description is for Japan's large "distant-water" longliners that fish for bluefin tunas in temperate waters and for bigeye and yellowfin in warmer waters. The main features are applicable to other distant-water longliners, such as Korea's longliners fishing for bigeye in equatorial waters and for Taiwan's longliners fishing for albacore in sub-tropical waters.

Fresh-chilled longliners, which undertake trips ranging from a few days up to several weeks, also maintain 24-hour operations. But, they deploy fewer hooks than distant-water longliners. Line tangles, line breaks, mechanical failures and rough weather sometimes prolong the duration of longline retrieval. High catch rates may also extend operations because fresh-chilled longliners have fewer crewmembers. Many aspects of the fresh-chilled fishing operations, such as hooks per operations and soak time, vary between fleets, between vessels and even for the same vessel during a fishing trip. By contrast, distant-water longline operations tend to vary much less (author's pers. obs.).

Distant-water longliners rarely need to slow the longline retrieval speed to bring a hooked fish on board, even when the fish is large and alive. However, when distant-water longlining commenced in the 1950s the catch rates of many species were an order of magnitude higher than they were in the 1990s, e.g. data presented by Nakamura (1949, p. 24) suggest that catch rates frequently exceeded 100 fish per 1000 hooks. We therefore suggest that high catch rates may have sometimes prolonged the duration of retrieval in the earlier years.

Soak time

Figure 1 highlights operational differences between distant-water and fresh-chilled longline operations. During the 1990s, Japan's longliners had much faster deployment and retrieval speeds than fresh-chilled longliners. However, the fresh-chilled longliners had long wait times between retrieval and deployment. Consequently, the average soak time of their hooks was much longer than those of Japan's longliners. Analyses presented in Ward et al. (in prep.) show that the differences in soak time would have a major effect on the catch rates of most species.

The number of crewmembers and the degree of mechanization are key determinants of the number of hooks deployed in each operation. Since distant-water longlining commenced in the 1950s, longliners have refined and expanded their fishing operations. The number of hooks deployed in each operation by Japan's longliners increased from as few as 1200 hooks in the 1950s to well over 3000 by the late 1990s (Figure 1) (Campbell 1997). Fresh-chilled longliners deploy far fewer hooks, typically ranging from 500 to 1500 hooks per operation. In many areas (e.g. Hawaii and Australia) the number of hooks per operation has increased as fleets have developed (Ward and Elscott 2000).

We might expect the increased hook numbers to result in longer soak times. However, Campbell (1997) highlights how doubling the number of hooks per longline operation does not double the number of hook–hours (the sum of the time that each hook is in the water). Furthermore, the increases in hook numbers were accompanied by increased retrieval and deployment speeds and reduced wait and search times. Consequently, the average soak time of each hook actually decreased, from about 11.5 hours in the 1950s to 10.0 hours in the 1990s (Figure 1). Ward et al. (in prep.) estimated an expected catch rate for swordfish of 0.94($\pm$ 0.06) per 1000 hooks for a soak time of 11.5 hours compared to 0.82($\pm$ 0.06) per 1000 hooks for 10.0 hours.

Operation times

Longline catch rates are linked to whether baited hooks are available during peak feeding times. Generally, longliners that target swordfish deploy their longlines at dusk and commence retrieval at dawn. The opposite cycle is used to target tuna, such as yellowfin and bluefin; longlines are deployed at dawn and retrieved in the late afternoon and evening (Ward and Elscott 2000).

The operations of longliners from different fleets targeting the same species show variations in operation times. Longliners in the Western Pacific and Central Pacific Bigeye fisheries deploy after dawn and retrieve after dusk. Consequently almost all their baits are exposed to dusk, but rarely are they exposed to dawn. By contrast, approximately equal proportions of the baits are exposed to dawn and dusk in the South Pacific Yellowfin fishery (Figure 1).

In addition to differences in timing between fleets, there is evidence of historical variations in timing. During 1960–80, Japan's longliners apparently commenced deployment at midnight and began retrieval soon after dawn. Consequently about 50% of hooks were available at dawn, but many were retrieved before dusk. By the 1990s they had adjusted operation times so that more hooks were available at dusk and fewer were available at dawn (Figure 1). Analyses presented in Ward et al. (in prep.) show that the differences in operation times between fleets and over the years would affect catch rates of target and non-target species. For example, the expected catch rate for swordfish is 0.89 per 1000 hooks in the early operations compared to 0.83 per 1000 hooks in the later operations where more hooks are available at dusk.

References

Au, D. 1985. Species composition in the Japanese long-line fishery off southern and eastern United States. Collective volume of scientific papers, International Commission for the Conservation of Atlantic Tunas, Madrid.

Campbell, R. 1997. Measures of effort in commercial longline fisheries – A theoretical discussion. Working paper presented at the Seventh Meeting of the Western Pacific Yellowfin Tuna Research Group (WPYRG7), June 18–20, 1997, Nadi, Fiji, South Pacific Commission, Noumea.

Hirayama, N. 1969. Studies on the fishing mechanism of tuna longline: III The difference of catch by retrieving methods. Nihon Suisan Gakkai shi (Bulletin of the Japanese Society of Scientific Fisheries) 35:629–635.

Hutchings, J. A. and Ferguson, M. 2000. Temporal changes in harvesting dynamics of Canadian inshore fisheries for northern cod, *Gadus morhua*. Canadian Journal of Fisheries and Aquatic Sciences 57(4): 805–814.

Nakamura, H. 1949. Tuna longline fishery and fishing grounds. Report of the Nankai Regional Fisheries Research Laboratory 1, 144 pages. (Translation by Van Campen, W.G. 1952. [U.S.] Fish and Wildlife Service, Special Scientific Report: Fisheries 82, 168 pages).

Maéda, H. 1967. Distribution pattern of fish in relation to fishing method, with special reference to that of tuna along longline. Symposium on Scombroid Fishes. publisher?

Shapiro, S. 1950. The Japanese longline fishery for tunas. U.S. Fish and Wildlife Service. Commercial Fisheries Review 12(4):1–26.

Shimada, B. M. 1951. Japanese tuna-mothership operations in the western equatorial Pacific Ocean. U.S. Fish and Wildlife Service. Commercial Fisheries Review 13(6):1–26.

Sivasubramaniam, K. 1961. Relation between soaking time and catch of tunas in longline fisheries. Bulletin of the Japanese Society of Scientific Fisheries 27(9):835–845.

Ward, P. J. 1996. Japanese longlining in eastern Australian waters, 1962–90. Bureau of Resource Sciences, Canberra, 249 pages.

Ward, P. and Elscot, S. 2000. Broadbill swordfish: Status of world fisheries. Bureau of Rural Sciences, Canberra, 242 pages.

Ward, P. Myers, R.A. and Blanchard, W. (in prep.). The effect of soak time and timing on pelagic longline catches. Submitted to Fishery Bulletin, 27 August 2002.

Yamaguchi, Y. 1989. Tuna long-line fishing II: Fishing gear and methods. Marine Behaviour and Physiology 15:13–35.

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Figure 1 (following page). Schematic representation of the duration of the various types of longline operations discussed in the present paper. Also shown is the average number of hooks deployed per operation and the average soak time for all hooks in each type of operation. The daily cycle is chosen to consist of 11 hours of night, 1 hour of dawn, 11 hours of day and 1 hour of dusk. Each tic mark represents 100 hooks so that the density of tics reflects deployment and retrieval speeds. All operations are counter-retrieval, except for the return retrieval shown for Japan's longliners in the South Pacific Yellowfin fishery. The historical series is based on data for the South Pacific Yellowfin fishery for the 1980s and 1990s. For other decades the series uses published sources for Japan's longliners fishing yellowfin and bigeye in various areas of the Pacific Ocean.

Abbreviations in fishery names:

NP North Pacific **WP** Western Pacific

CP Central Pacific **SP** South Pacific

Sources:

(a) Australian Fisheries Management Authority observer data (South Pacific Yellowfin fishery, 1992-97)

(b) Australian Fisheries Management Authority observer data (South Pacific Bluefin fishery, 1992-97)

(c) Yamaguchi (1989, p. 15)

(d) Au (1985, p. 377)

(e) Sivasubramaniam (1961, p. 836) and Maéda (1967, pp. 1034-35)

(f) Shapiro (1950, p. 9, 17,22) and Shimada (1951, p. 13)

(g) US National Marine Fisheries Service observer data (1994-99)

(h) Secretariat of the Pacific Community observer data (1990-99)

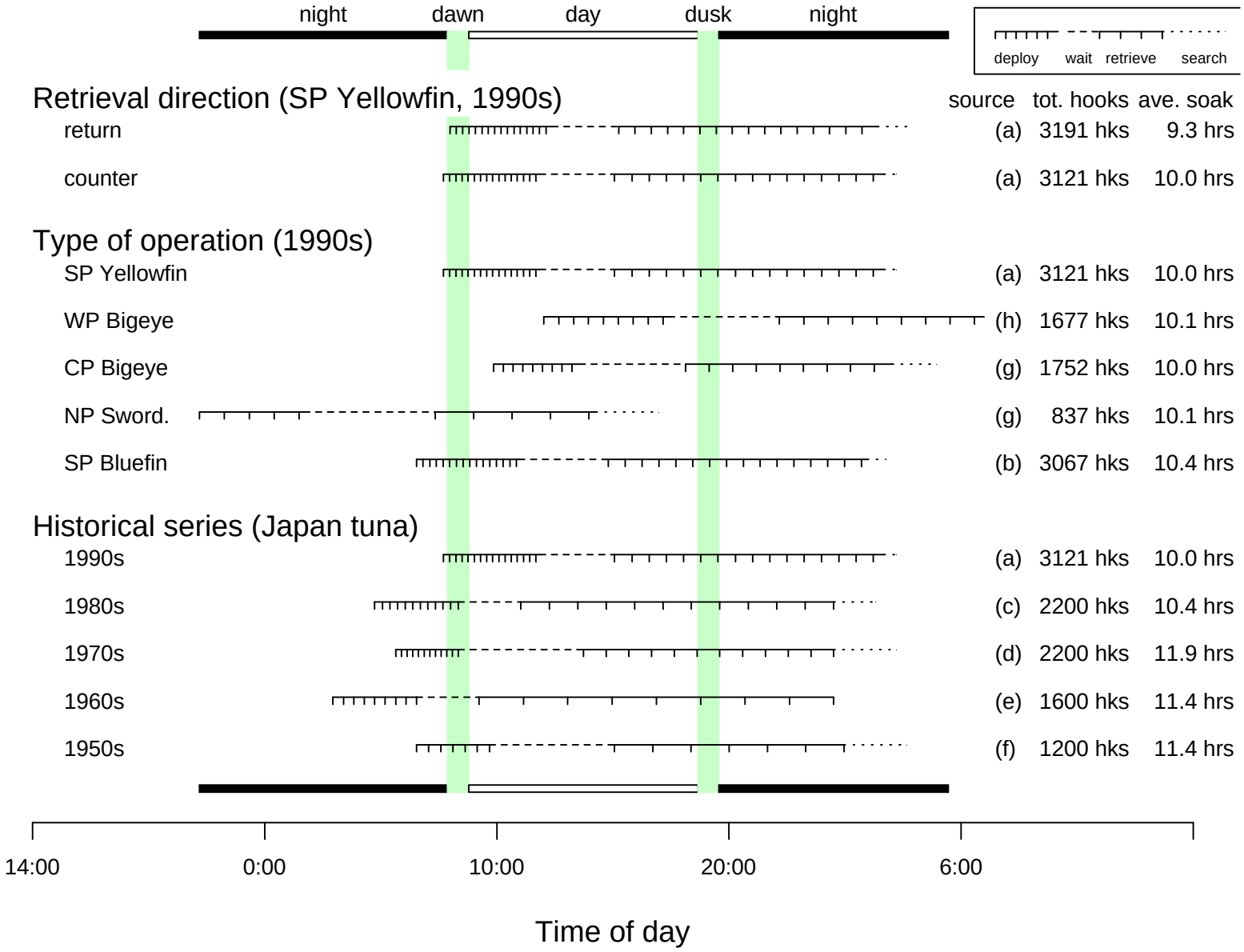
night
dawn
day
dusk
night
deploy
wait
retrieve
search
Retrieval direction (SP Yellowfin, 1990s)
source tot. hooks ave. soak
return (a) 3191 hks 9.3 hrs
counter (a) 3121 hks 10.0 hrs
Type of operation (1990s)
SP Yellowfin (a) 3121 hks 10.0 hrs
WP Bigeye (h) 1677 hks 10.1 hrs
CP Bigeye (g) 1752 hks 10.0 hrs
NP Sword. (g) 837 hks 10.1 hrs
SP Bluefin (b) 3067 hks 10.4 hrs
Historical series (Japan tuna)
1990s (a) 3121 hks 10.0 hrs
1980s (c) 2200 hks 10.4 hrs
1970s (d) 2200 hks 11.9 hrs
1960s (e) 1600 hks 11.4 hrs
1950s (f) 1200 hks 11.4 hrs
14:00
0:00
10:00
20:00
6:00
Time of day

Figure 1.