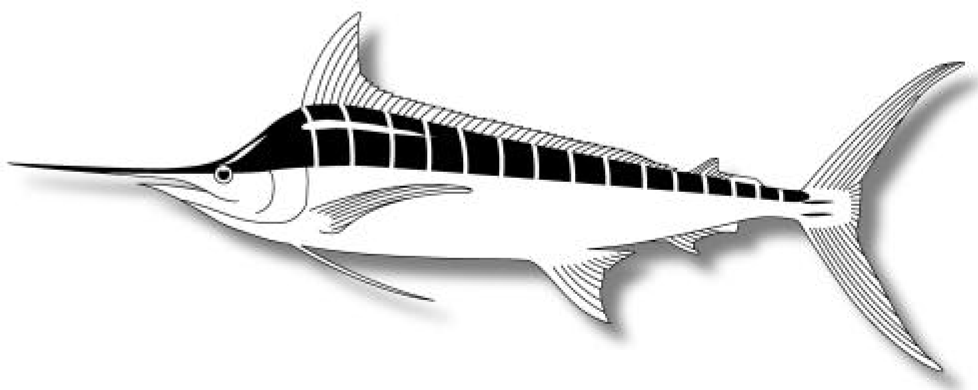
SCTB15 Working Paper

BBRG-5

Dive-depth distribution of loggerhead (*Carretta carretta*) and olive ridley (*Lepidochelys olivacea*) turtles in the central North Pacific: Might deep longline sets catch fewer turtles?



Jeffrey J. Polovina[1], Evan Howell[2], Denise M. Parker[2], and George H. Balazs[2]

[1]National Marine Fisheries Service (NMFS), Honolulu Laboratory, Hawaii

[2]Joint Institute for Marine and Atmospheric Research, University of Hawaii

Dive-depth distribution of loggerhead (*Carretta carretta)* and olive ridley (*Lepidochelys olivacea*) turtles in the central North Pacific: Might deep longline sets catch fewer turtles?[1]

Jeffrey J. Polovina
Honolulu Laboratory
Southwest Fisheries Science Center
National Marine Fisheries, NOAA
2570 Dole Street
Honolulu Hawaii 96822-2396

Evan Howell
Denise M. Parker
Joint Institute for Marine and Atmospheric Research
University of Hawaii
1000 Pope Road
Honolulu, Hawaii 96822

George H. Balazs
Honolulu Laboratory
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
2570 Dole Street
Honolulu, Hawaii 96822-2396

Introduction

The Hawaii-based longline fishery operates over a large area in the central North Pacific, from the equator to latitude 45°N, between longitudes 130°W and180°W. In 2000, 125 vessels were active in the fishery, producing total landings estimated at 24 million pounds and ex-vessel revenues of $50 million. The target species include bigeye tuna *(Thunnus obesus)*, yellowfin tuna (*T. albacares*), and albacore tuna (*T. alalunga*), and broadbill swordfish (*Xiphias gladius*). Caught incidentally with these target species are leatherback (*Dermochelys coriacea*), loggerhead (*Carretta carretta)*, olive ridley (*Lepidochelys olivacea*), and green (*Chelonia mydas*) sea turtles. Over the period 1994-99, it was estimated that an annual average of 418 loggerheads, 112 leatherbacks, 146 olive ridleys, and 40 green sea turtles were caught in the Hawaii-based longline fishery (McCracken, 2000).[2]

---

[1] A working document submitted to the 15th Meeting of the Standing Committee on Tuna and Billfish, Honolulu, Hawaii, 22-27 July 2002.

[2] McCracken, M. L. 2000. Estimation of sea turtle take and mortality in the Hawaiian longline fisheries. Southwest Fish. Sci. Cent., Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Sci. Cent. Admin. Rep. H-00-06, 29 p.

Historically, the Hawaii longline fishery has set longlines considerably shallower than 100 m to target swordfish (*Xiphias gladius*) or substantially deeper than 100 m to target bigeye tuna. Analyses of incidental hooking of loggerhead turtles in the Hawaii longline fishery observer data, which cover about 5% of the total annual effort, found that loggerhead turtles were caught only when gear was set shallow enough to target swordfish, primarily in the northern portion of the fishing ground. No loggerheads were caught when longline gear was set deep to target bigeye tuna, primarily in the southern portion of the fishing ground. These analyses suggest that a ban of shallow sets in the fishery since April 1, 2001, may reduce future incidental catches of loggerhead turtles. However, analyses based only on observer data suffer from the limited observer coverage and the dependence between depth of setting and area fished. For example, swordfish are targeted at night in the north, while tuna are targeted during the day in the south. To better understand the depth usage of the turtles, we used diving depth distributions collected from satellite-linked dive recorders attached to two loggerhead and two olive ridley turtles caught and released in the Hawaii-based longline fishery. While other studies on the dive depths of olive ridley and loggerhead turtles have been conducted in the Pacific, these have been conducted with turtles in coastal areas rather than in the oceanic central Pacific (Beavers and Cassano, 1996; Sakamoto et al., 1993).

Materials and methods

Two loggerhead and two olive ridley turtles that had been caught with commercial longline fishing gear were instrumented with Wildlife Computer Argos satellite-linked depth recorders (SDR-T10). One loggerhead and one olive ridley were hooked in the mouth and were released after the hook and line had been removed. The other loggerhead and olive ridley had deeply ingested hooks, and on both of these we cut the fishing line close to the mouth but did not remove the hook. Trained observers on the fishing vessel attached transmitters to the carapace of each turtle, using fiberglass cloth strips and polyester resin patterned after the method presented in Balazs et al. (1996). The observers noted that all four turtles swam vigorously away after release.

Data on daily location of the turtles were estimated from the signals received by the Argos receiver on a NOAA satellite. The position data were edited, and only the single most accurate daily position was plotted. The accuracy of each position was estimated by Argos as a function of the number and configuration of satellites and the number of transmissions received. Data on the dive behavior transmitted by the Argos receiver were not individual dive profiles but rather frequency distributions of time at depth, dive duration, and maximum dive depth, aggregated over four 6-hour periods and binned in specific depth or time intervals. The lower range of the depth bins (in meters) for the time-at-depth distributions were 1, 3, 5, 10, 15, 25, 35, 50, 60, 75, 100, 125, 150, 150+. Each time the turtle descended below 2 m, it was recorded as a dive. The lower range of the depth bins (in meters) for the dive-depth distributions 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 100, 150, 150+. The 6-hour periods over which the time-at-depth and dive-depth data were pooled were programed in Hawaii standard time as 2100-0300, 0300-0900, 0900-1500, and 1500-2100. One period was night, another mid-day; one included dawn, the other dusk. Mean time-at-depth and dive-depth distributions for each turtle in each of the four time period were computed as the average of all frequency distributions for each 6-hour period.

Mean time-at-depth and dive-depth distribution for the combined four time periods for each species were computed as the average of the four mean time-at-depth and dive depth distributions for each turtle, then averaged by species.

Finally, after every 20 transmissions a special status message that contained technical data about the operation of the transmitter and the maximum dive depth of that day was transmitted. Both the loggerheads and the olive ridleys made some dives below 150 m; however, the histogram data did not indicate how much deeper than 150 m these animals dove. The maximum dives sent in the status messages were used to obtain some data on the deep dives.

Results

The positions of the four turtles showed that the turtles were occupying the characteristic habitats for each species: the loggerheads were in the northern portion of the subtropical gyre, while the olive ridleys lay further south, well in the center of the subtropical gyre (Fig. 1). Loggerhead #24747, which was released with the hook removed, measured 83 cm (straight carapace length (SCL)) and transmitted 5.4 months. Loggerhead #22534, released with the hook deeply ingested, measured 61 cm SCL and transmitted 5.2 months. Olive ridley #22533 measured 57 cm SCL, was released with the hook deeply ingested, and transmitted 3.4 months. Olive ridley #22532, which measured 58 cm SCL and which was released after a hook was removed, transmitted 0.8 months.

The time-at-depth frequency distributions for day and night periods for each of the turtles showed consistent diurnal and species differences in their dive-depth distributions (Fig. 2). The turtles spent more time at the surface during the day than at night and also dove deeper during the day (Fig. 2). We do not show the dive-depth distribution for the dawn and dusk periods, but these frequency distributions fell between the distribution for day and night periods.

Since it can often take as long as 20 hours to completely set and retrieve a longline, we examined time-at-depth and dive-depth distributions pooled over the four 6-hour time periods by species. The time-at-depth frequency distribution showed that the loggerheads spent about 40% of their time in the top meter and virtually all their time shallower than100 m (Fig. 3). We also examined the frequency distribution of the maximum depth of each dive and the deepest dive in a 24-hour period. The cumulative distribution of maximum depth of each dive indicated that most dives were very shallow: 70% of the dives were no deeper than 5 m (Fig. 3). The cumulative distribution of the maximum dive depth achieved over a 24-hour period indicated that in approximately 5% of the days a dive exceeded 100 m (Fig. 3). Status messages reported that the deepest daily dive recorded was 178 m.

By comparison, the time-at-depth and maximum depth frequency distributions of the two olive ridleys showed considerably deeper depth distribution (Fig. 3). The olive ridleys spent only about 20% of their time in the top meter and about 10% of their time deeper than 100 m (Fig. 3). Their daily maximum depth exceeded 150 m at least once in 20% of the days (Fig. 3). Status messages reported daily dives of 200 m occurred, with one dive recorded at 254 m.

Discussion

The loggerheads' dive-depth distributions indicated that these animals tended to remain shallower than 100 m. If shallow longline sets were replaced with deep longline, the incidental takes of loggerhead turtles should be reduced substantially. Further, even though olive ridleys dove deeper than loggerheads, only about 10% of their time was spent deeper than 100 m. Therefore, their incidental catches should also be substantially reduced with the elimination of shallow longline sets. Of course, when deep sets are being set or retrieved or when current shear prevents the gear from sinking to its expected depth, hooks will occupy relatively shallow depths and could result in incidental catches of turtles.

Results to date in the fishery confirm the reduction in incidental catches of turtles that can be achieved from the elimination of shallow sets. Beginning in April 2001, shallow sets were prohibited in the Hawaii-based longline fishery. Data from the onboard observer in the longline fleet, which now covers 20% of the fishing effort, showed that no loggerheads and only two olive ridleys were caught from April through December 2001.

The relatively shallow dive-depth distribution for loggerheads in the central North Pacific is consistent with our understanding of their ecology. It has been shown that loggerheads in the central North Pacific forage and migrate along convergent fronts where they encounter a shallow aggregation of forage (Polovina et al., 2000). While oceanic loggerheads have a shallower dive behavior than the olive ridleys, the loggerheads in oceanic habitat appear to dive deeper than those in coastal habitat. For example, the dive distribution of two internesting loggerheads off Japan indicated that virtually all their dives were shallower than 30 m (Sakamoto et al., 1993). The deeper-dive distribution of olive ridleys is also consistent with their oceanic habitat, which differs from the loggerhead habitat. Olive ridleys are found south of the loggerhead habitat in the central portion of the subtropical gyre. The oceanography of this region is characterized by a warm surface layer with a deep thermocline depth and an absence of strong horizontal temperature gradients and physical or biological fronts. It is likely that the deeper diving seen in the olive ridleys results from foraging at depths associated with the deep scattering layer.

Acknowledgments

We wish to acknowledge the NMFS observers who attached the transmitters to the turtles; also Shawn K. K. Murakawa and Shandell Eames who assisted in observer training and logistics.

Literature cited

Balazs, G. H., R. K. Miya, and S. C. Beavers.
1996. Procedures to attach a satellite transmitter to the carapace of an adult green turtle (*Chelonia mydas*). *In* Proc. 15th Annual Symposium on Sea Turtle Biology and Conservation (J. A. Keinath, D. E. Bernard, J. A. Mubick, J. A., and B. A. Bell, comps.), p. 21-26. U.S. Dep. of Commer., NOAA Tech. Memo. NMFS/SWFSC-37.

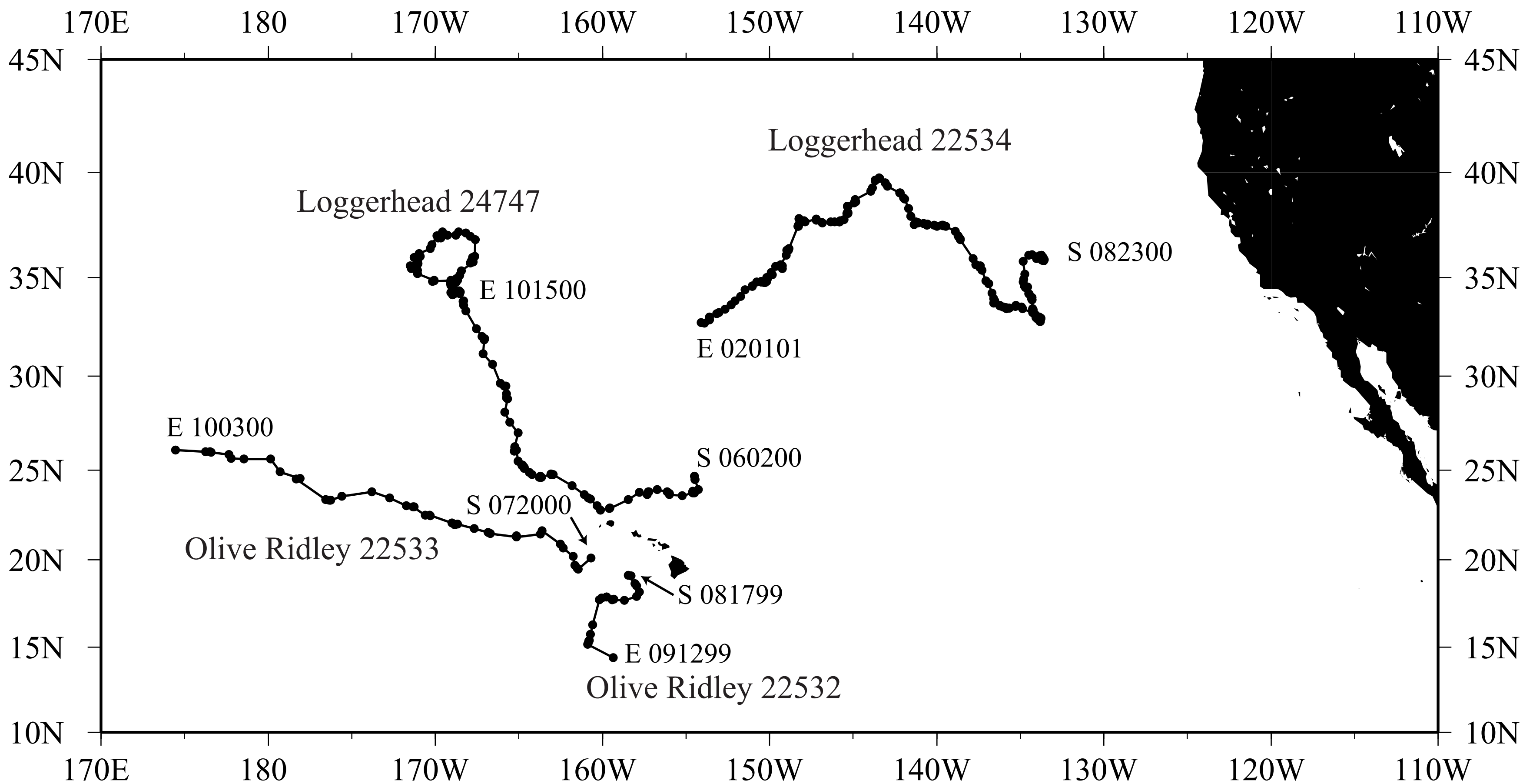
Beavers, S. C., and E. R. Cassano.
1996. Movement and dive behavior of a male sea turtle (*Lepidochelys olivacea*) in the eastern tropical Pacific. J. Herpetol. 30(1):97-104.
Parker, D. M., G. H. Balazs, S. K. K. Murakawa, and J. J. Polovina.
In press. Post-hooking survival of sea turtles taken by pelagic longline fishing in the North Pacific. *In* Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation, February 23-28, 2001, Philadelphia, Pennsylvania. U.S. Dep. Commer., NOAA Tech. Memo.
Polovina, J. J., D. R. Kobayashi, D. M. Parker, M. P. Seki, and G. H. Balazs.
2000. Turtles on the edge: movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning fishing grounds in the central North Pacific, 1997-1998. Fish. Oceanogr. 9:71-82.
Sakamoto, W., K. Sato, H. Tanaka, and Y. Naito.
1993. Diving patterns and swimming environment of two loggerhead turtles during internesting. Nippon Suisan Gakkaishi 59(7):1129-1137.

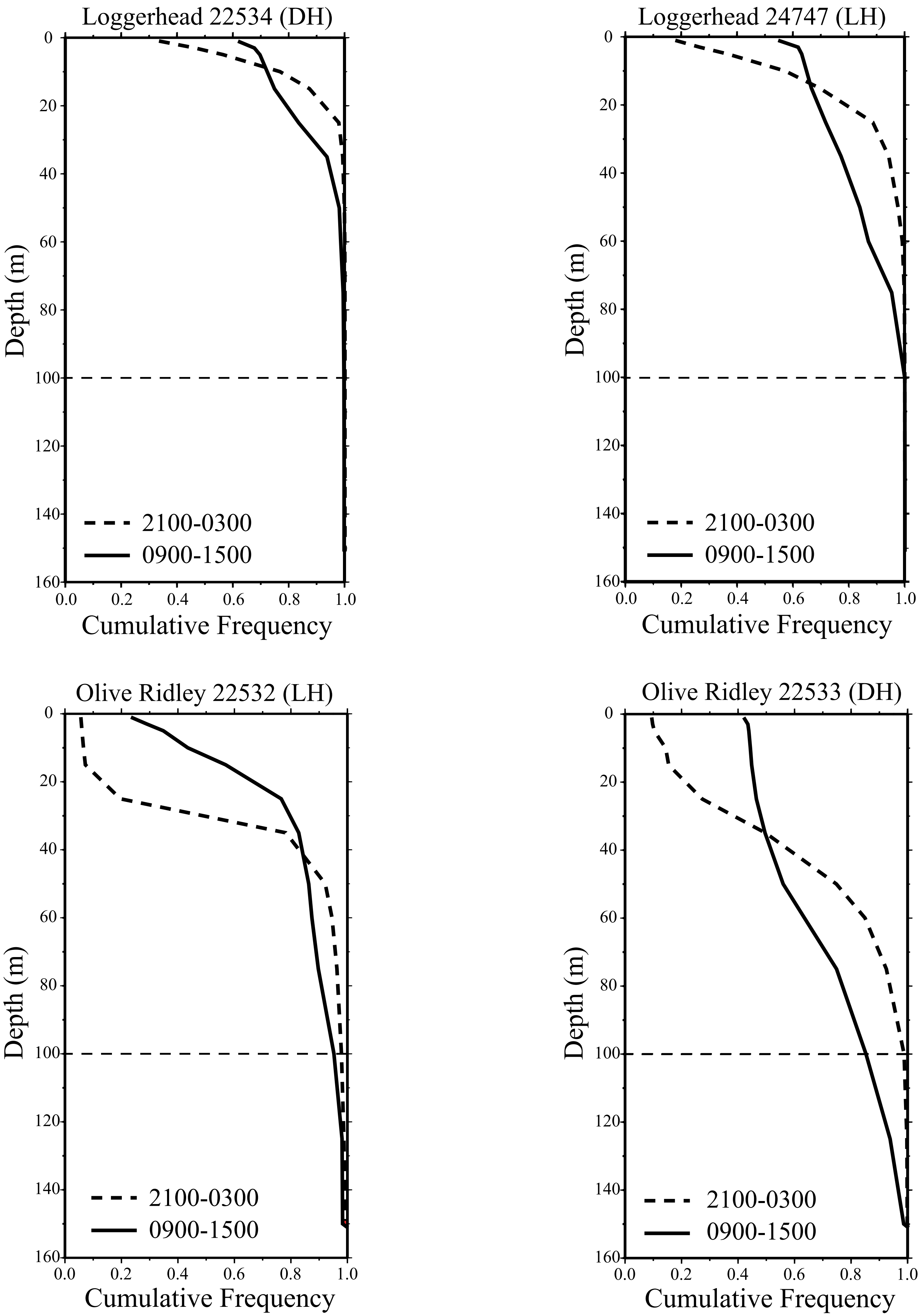
Figure captions

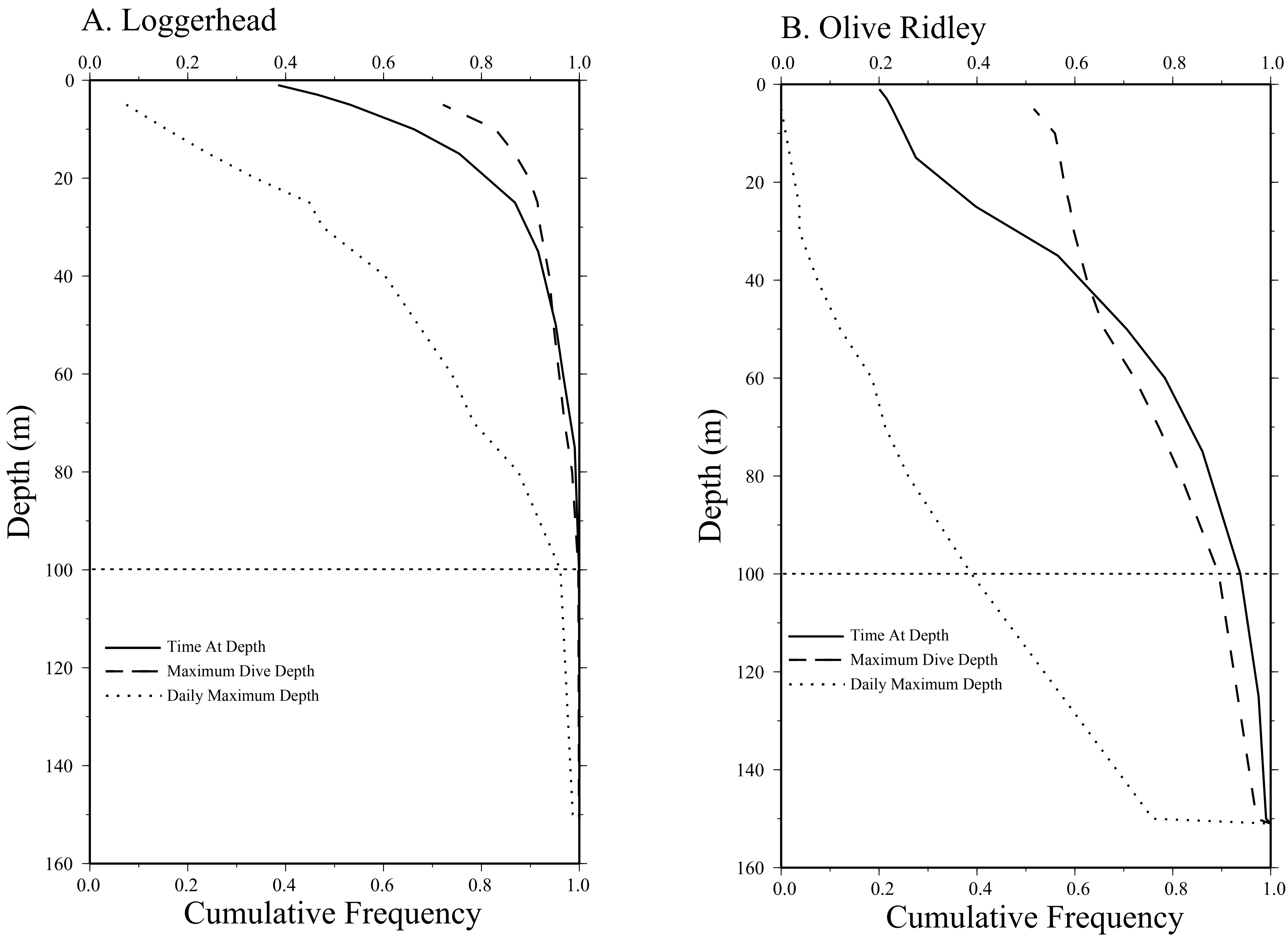
Figure 1. The start(S) and end(E) dates and track lines for the four turtles with satellite-linked dive recorders.

Figure 2. Time-at-depth cumulative frequency distributions for day (0900-1500) and night (2100-0300) periods for each of the four turtles. The 100 m reference depth is noted with a dashed line. DH indicates that the turtle was released with the hook deeply ingested, LH indicates that the turtle was lightly hooked and released with the hook removed.

Figure 3. The time-at-depth, maximum dive depth, and daily maximum dive-depth cumulative frequency distributions for all periods combined. A. Both loggerheads combined. B. Both olive ridleys combined.


Loggerhead 22534
S 082300
E 020101
Loggerhead 24747
E 101500
E 100300
S 060200
S 072000
Olive Ridley 22533
S 081799
E 091299
Olive Ridley 22532
170E
180
170W
160W
150W
140W
130W
120W
110W
45N
40N
35N
30N
25N
20N
15N
10N


Loggerhead 22534 (DH)
Loggerhead 24747 (LH)
Olive Ridley 22532 (LH)
Olive Ridley 22533 (DH)
Depth (m)
Cumulative Frequency
0
20
40
60
80
100
120
140
160
0.0
0.2
0.4
0.6
0.8
1.0
2100-0300
0900-1500



A. Loggerhead
B. Olive Ridley
Depth (m)
Cumulative Frequency
Time At Depth
Maximum Dive Depth
Daily Maximum Depth
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
120
140
160