Necropsy findings in sea turtles taken as bycatch in the North Pacific longline fishery

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Concern about interactions between fisheries and marine turtles has increased in recent years, particularly since East Pacific leatherback turtles (*Dermochelys coriacea*) may become extinct (Spotila et al., 2000). However, relatively little published information exists on interactions between sea turtles and North Pacific longline fisheries. The most available literature on the topic focuses on modeling data from fisheries observers for estimating the probability of animals dying and fishery-induced mortality (McCracken[1]; Kleiber[2]). A more recent study was undertaken with satellite telemetry and remote sensing to evaluate the probability of interaction between longline fisheries and loggerhead sea turtles (*Caretta caretta*) and the effects of hooking (Polovina et al., 2000; Parker, in press).

Necropsies on turtles caught by longline fisheries may provide additional objective data on the causes of mortality and the health of pelagic turtles. Although ample literature exists on evaluating the health of benthic coastal-residing immature sea turtles in Hawaiian waters (Aguirre et al., 1994; Work and Balazs, 1999), nothing is known about the health status of pelagic sea turtles because of the difficulty in locating animals (Bolten and Balazs, 1983) and the unavailability of specimens for diagnosis. Most turtles caught in longline fisheries are released alive (McCracken[1]; Kleiber[2]). The few dead turtles that are recovered can be returned to shore legally only by observers (who are present in only ~5% of the Hawaii-based North Pacific fishing fleet) (Balazs et al., 1995). Nevertheless, examining freshly dead turtles caught in longline fisheries provides a unique opportunity to gain insight into the health status and diet of pelagic sea turtles. Our objective was to systematically evaluate all available carcasses of fresh-frozen sea turtles that had been caught in the Hawaii-based longline fishery for an evaluation of their health and to document their diet.

Methods

Free-ranging marine turtles accidentally taken as bycatch by the North Pacific longline fishery were landed on the fishing vessel and evaluated for signs of life by fishery observers employed by the National Marine Fisheries Service. Sea turtles that were judged to be dead by specific criteria (Balazs et al., 1995) were stored frozen and returned to Honolulu, Hawaii, where we recorded weight (kg) and body morphometrics (cm).

Gross necropsies entailed a complete external and internal exam of all organ systems. We also recorded any identifiable stomach contents. Body condition of turtles was subjectively classified as good, fair or poor if coelomic and mesenteric fat reserves appeared ample, moderate, or sparse, respectively. Postmortem condition was classified as good, fair, or poor depending on the gross appearance of organs during the necropsy. We classified turtles as lightly hooked if the longline fish hook was lodged in the mouth or externally, or as deeply hooked if the hook was present in the gastrointestinal tract caudal to the glottis. Hooks were classified as tuna (3.6 or 3.8 mm) or swordfish and mustad (offset 8/0 or 9/0).

Tissue samples (heart, lung, kidney, liver, spleen, brain, stomach, small intestines, skin, trachea, salt gland, gonad, thyroid, pancreas, and brain) were fixed in 10% buffered formalin, sectioned at 5 µm and stained with hematoxylin and eosin for microscopic examination. Representative tissues were stored frozen (–70°C) in sterile plastic bags. Where gross necropsy findings suggested infectious or inflammatory disease, swabs or tissues were processed for microbiology. For bacteriology, swabs were plated on McConkey and blood agar and incubated at 27°C and 37°C for 48 h. For virus isolation, frozen tissues were homogenized, the supernate filtered through a 0.22-µm filter, and plated on green sea turtle embryo fibroblasts (Moore et al., 1997).

[1] McCracken, M. L. 2000. Estimation of sea turtle take and mortality in the Hawaiian longline fisheries. Administrative Report H-00-06, 29 p. Southwest Fisheries Science Center, Nat. Mar. Fish. Service, NOAA, 2570 Dole St., Honolulu, HI 96822.

[2] Kleiber, P. 1998. Estimating annual takes and kills of sea turtles by the Hawaiian longline fishery, 1991–97, from observer program and logbook data. Administrative Report H-98-08, 21 p. Southwest Fisheries Science Center, Nat. Mar. Fish. Serv., NOAA, 2570 Dole St., Honolulu, HI 96822.

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Table 1

Vital necropsy statistics for turtles caught by the Hawaii-based pelagic longline fishery in the North Pacific. Age are immature (I), subadult (S), and adult (A). Body and post-mortem condition were classified as good (G) or fair (F). SCL, BC, PMC, and Set stand for smallest carapace length, body condition, postmortem condition, and hook set, respectively.

ID	Species	Wt (kg)	SCL	Age	Sex	BC	PMC	Hook	Set
1	*C. mydas*	25.4	55.6	I	M	G	F	tuna 3.6-mm	light
2	*C. mydas*	50	67.9	S	F	G	G	tuna 3.6-mm	light
3	*D. coriacea*	44.5	70.4	I	F	G	G	tuna 3.6mm	light
4	*D. coriacea*	74.1	85.3	I	F	G	G	tuna 3.6-mm	light
5	*L. olivacea*	13.2	43.7	I	F	G	F	tuna 3.6-mm	light
6	*L. olivacea*	15.3	46.6	I	F	F	G	offset 8/0	deep
7	*L. olivacea*	21	54	I	F	G	G	tuna 3.6-mm	light
8	*L. olivacea*	24.5	57.5	S	F	G	G	tuna 3.6-mm	light
9	*L. olivacea*	33.4	62.1	A	F	G	G	tuna 3.6-mm	light
10	*L. olivacea*	34.1	60.4	A	F	G	G	tuna 3.6-mm	deep
11	*L. olivacea*	37.7	62.9	A	F	G	G	tuna 3.6-mm	light

Results

We performed necropsies on seven olive ridley (*Lepidochelys olivacea*), two green (*Chelonia mydas*), and two leatherback sea turtles (Table 1). Turtles were caught between 5.4–18.0°N and 148.5–161.3°W in the North Pacific from February 1996 through June 2000.

One leatherback sea turtle (identification [ID] 3) had severe acute inflammation of the liver associated with clumps of fibrin (Fig. 1, A and B), mild acute inflammation of heart muscle, and mild diffuse pulmonary edema. No bacteria or viruses were isolated from the liver. The other leatherback sea turtle (ID 4) had severe diffuse fibrosis of the pancreas (Fig. 1C) and a large subcapsular hematoma of the liver. The lesions in both turtles were severe enough to cause significant impairment of organ function and probable morbidity. Incidental microscopic lesions in four of the seven olive ridley sea turtles included mild acute heart muscle inflammation (ID 6), mild focal necrosis in one lung (ID 7), parasite-induced necrosis in the stomach wall (ID 8), and foreign material (probable ingesta) in the bronchioles (ID 10). Microscopic lesions in the olive ridley sea turtles were not severe enough to cause morbidity, and no microscopic lesions were seen in the remaining turtles including the green sea turtles.

Cause of mortality for all sea turtles was drowning after hooking; however, in only one case (olive ridley ID 11) was there gross evidence of water in the lungs. Female (10/11) and lightly hooked (9/11) animals predominated. Most hooks were tuna 3.6-mm hooks (Table 1). In one deeply hooked olive ridley turtle (ID 10), the hook perforated the esophageal wall in two places at approximately half of the length of the wall. In the other olive ridley sea turtle, ID 6 (classified as deeply hooked by the observer), the hook perforated just caudal to the tongue. Both leatherback sea turtles had been entangled by the leader; one had the leader tightly wound around the right front flipper, the other had the leader around the neck, where it had caused lacerations .

Bait (sama; *Cololabias saira*) was seen in the esophagus of four olive ridley sea turtles; one turtle contained three fish, indicating ingestion from more than one hook. Other items in olive ridley stomachs included cowfish, pyrosomas, pelagic snails, bird feathers, and small fragments of plastic. Stomachs from both leatherback turtles and from one green turtle contained pyrosomas exclusively.

Discussion

Only two sea turtles were classified as deeply hooked; most turtles had no visible lesion indicative of hooking either to the observer present on board when the turtles were hauled into the boat, or to the observer and us at the time of necropsy. Turtles that scored as lightly hooked but that died later would suggest that deep or light hooking may not be satisfactory criteria for the probability of short-term survival in the species we studied. Similarly, Polovina et al. (2000) and Parker et al. (in press) observed that there was no significant difference in distance or speed of travel between deeply and lightly hooked loggerhead turtles that were caught by the North Pacific longline fishery and then marked with satellite tags, and followed for several months. Hence, deep versus light hooking may not be a useful indicator of long-term survival for these species.

The preponderance of females in our study was noticeable. Markedly skewed sex ratios in wild sea turtles are more commonly encountered among hatchlings (Gonzales et al., 2000), presumably due to incubation well below or above the pivotal temperature (Mrosovsky and Yntema, 1980). Studies of immature green sea turtles stranded with fibropapillomatosis in Hawaii revealed a sex ratio of close to 1:1 (Koga and Balazs, 1996). Ross (1984) in Oman reported sex ratios of adult green sea turtles to be closer to

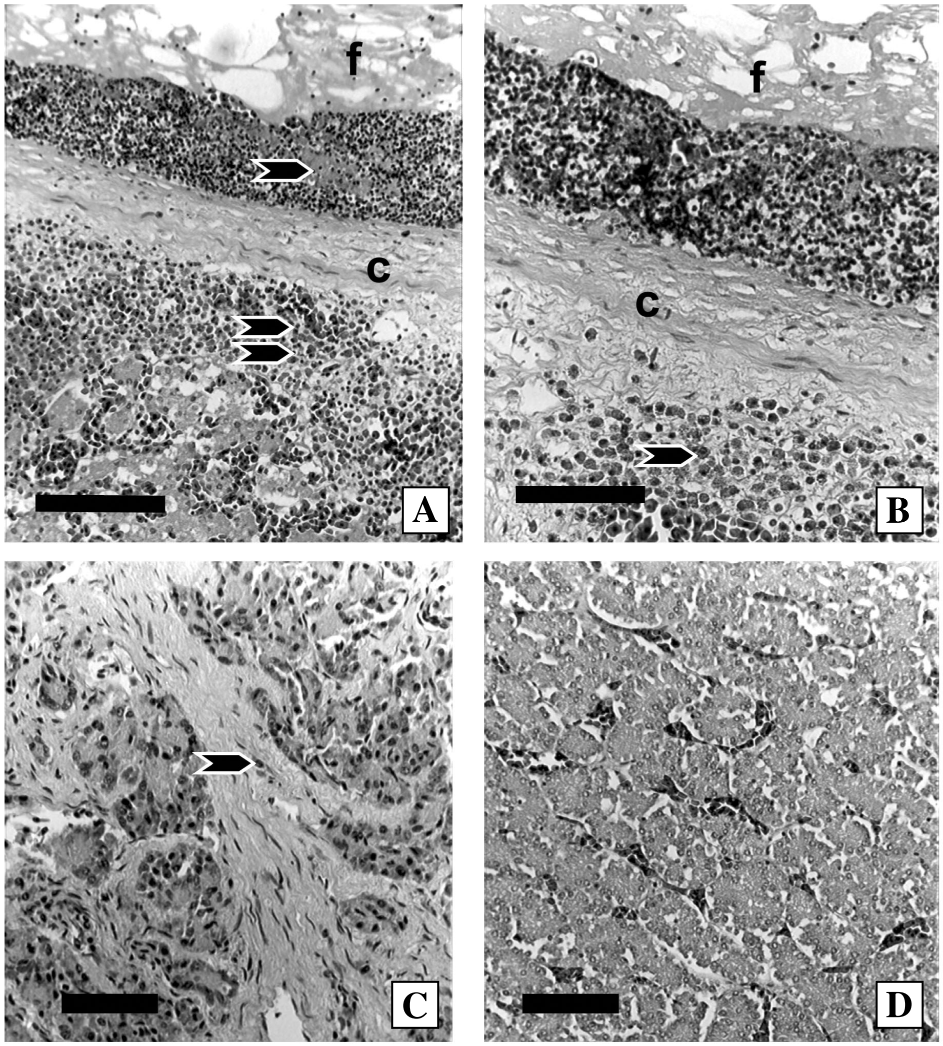

Figure 1

(**A**) Liver: Note fibrin (f), necrotic debris (large arrow), capsule (c), and inflammatory cells (double arrow), bar=100 µm; (**B**) Liver: note granulocytes (arrow), capsule (c), necrotic debris and fibrin (f), bar=50 µm; (**C**) Pancreas: Note large fibrous trabeculae coursing through pancreatic cells (arrow), bar=100 µm; (**D**) Normal pancreas from leatherback for comparison, bar=100 µm.

1:1 although slightly skewed towards females. Given the small sample size for each species, interpretation of the significance of the skewed sex ratio in our sample is problematic. Ross (1984) noted that bias in sampling, segregation of sexes in different areas, and small sample size could be responsible for deviations from the expected sex ratio of 1:1 in sea turtles.

Whether severe lesions of the digestive system occur commonly in leatherback sea turtles remains to be determined. Various factors can cause acute inflammation in the liver, including viruses, bacteria, protozoa, and poisons (Kelly, 1993); however, we saw no evidence of infectious agents in our histological examinations. Pancreatic fibrosis is a chronic lesion indicating earlier insult to the organ, secondary to infectious, toxic, or metabolic processes (Jubb, 1993). Necropsies of stranded leatherback sea turtles have revealed bacterial (Obendorf et al., 1987) and parasitic (Threlfall, 1979) infections, degenerative joint disease (Ogden et al., 1981), and struvite fecoliths (Davenport et al., 1993). The impact of these conditions to leatherback populations is unknown. Given the endangered status of East Pacific leatherback sea turtles, efforts to systematically evaluate health of these animals seem justified, including performing systematic necropsies on fresh carcasses recovered at sea or from nesting beaches, as well as performing health assessments of live animals on nesting beaches.

Lesions in the other species of sea turtles (olive ridley and green) were either mild, nonspecific, or absent altogether. The absence of lesions in pelagic green turtles was in contrast to what is seen in immature and adult specimens caught in nearshore habitats. In those cases, most green turtles have systemic infections with vascular flukes or fibropapillomas (Aguirre et al., 1998). This would support the hypothesis that at least for immature turtles, these diseases, while absent pelagically, are acquired once the animals enter their near shore foraging pastures. It is possible that very mild subtle lesions could have been overlooked because many tissues had freeze-thaw artifacts. Should this be a major concern, future studies may focus on doing necropsies on freshly dead turtles caught on fishing boats; however, the logistics of doing this will be more complicated. For example, vessels of the Hawaii-based longline fishery are at sea for weeks at a time fishing many hundreds of km from port.

Stomach contents of olive ridley sea turtles in this study (pelagic snails, pyrosomas, foreign bodies) were similar to those seen by others (Parker et al., 2002; National Marine Fisheries Service and US Fish and Wildlife Service[3]). The presence of multiple baits in some olive ridley sea turtles suggests that animals may graze from longline hooks. Pyrosomas are found in stomachs of leatherback and green turtles (National Marine Fisheries Service and US Fish and Wildlife Service[4,5]), and leatherbacks are also attracted to hooks baited with sama (Grant[6]) and squid (Skillman and Balazs, 1992). Given that fisheries may play a significant role in the decline of leatherback sea turtles (National Marine Fisheries Service and US Fish and Wildlife Service[4]), determining whether bait attraction or entanglement pose the greater threat may be of management value. Similarly, evaluating the basis of bait attraction for olive ridley sea turtles caught in longline fisheries may provide clues that will help discourage interactions between this species and fisheries.

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