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Feeding Behavior of Loggerhead and Leatherback Turtles: a study to understand longline bycatch.

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Loggerhead (Caretta caretta) and leatherback (Dermochelys coriacea) turtles are two species of sea turtle caught frequently as bycatch in longline fisheries, which use many hooks baited with fish or squid (1). The leatherback feeds primarily on gelatinous zooplankton while the loggerhead is a carnivore. Hence, the attraction and capture of loggerheads is not surprising but the attraction and capture of leatherbacks is somewhat unexpected (2). We investigated the responses of these two species to bait odors in controlled laboratory experiments to better understand releasers of feeding behavior. We measured and compared the responses to olfactory cues. Previous studies quantified and compared feeding responses including increased diving, snapping, gaping, accelerated or diminished swimming speed, and altered swimming behavior (3). The two species share some behavioral components but others were species-specific. Our comparative study highlights the differences in the two species, unexpected similarities, and suggests aspects of their behavior that may predispose them to accidental capture in fisheries.

Feeding Behavior of Loggerhead (*Caretta caretta*) and Leatherback (*Dermochelys coriacea*) Sea Turtles: a Model to Understand Bycatch

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INTRODUCTION

- Loggerhead and leatherback sea turtles are often caught as bycatch[(1)] in longline and other baited-hook fisheries. Loggerheads are often hooked in the mouth or esophagus but leatherbacks are often "foul-hooked" on the shell or shoulders or are entangled in fishing line[(1)].
- Loggerheads are primarily carnivores; leatherbacks are specialized carnivores that feed on gelatinous zooplankton[(2)]. Neither species is considered to be a carrion-feeder, however time of capture suggests that loggerheads may prefer fresh bait[(1,4)].
- This study investigates the responses of the two species to bait odors commonly used in longline fishing. Our aim was to understand if species-specific behavior may be used to reduce bycatch of sea turtles.

METHODS

Fig 1. Leatherback (left) and loggerhead (right) turtles in test tanks. Each was tethered so it could swim in any direction and dive but not contact the tank sides or bottom. 30L of filtered seawater was used for each trial. Control (seawater) or odors (20 cc) were delivered using the water circulation system without filter material.

- Neonate leatherback and loggerhead sea turtles were studied to understand the behavior of larger life stages.
- Three commonly-used longline bait odors were baits used in odor trials: Squid (*Illex illecebrosus*), Sardine (*Sardinia aurita*), and Mackerel (*Scomber scombrus*).
- Two odor solutions/bait types were prepared by soaking 120g thawed bait in 1 L filtered seawater for 1 h (fresh) or 7 h (carrion). The fresh odor solution was prepared at 360g*min/L; the carrion odor solution had a value of 50,400g*min/L.
- Turtles were allowed 30 min to acclimate to test tanks (Fig 1), then behavior associated with feeding (snapping and diving) were quantified for 15 min control and 15 min experimental periods. Behavior was video recorded and observed directly. Stroke rates were measured for one min at T=0, 5, 10, and 14 min.

METHODS

- Turtles were tested twice: once when naïve to food and once when experienced eaters. No turtle was exposed to fish or mollusk odors prior to testing.
- A subset of experienced animals were tested with Lion's Mane Jellyfish (*Cyanea capillata*) as a separate control to establish responses to natural prey.
- Each behavior by species was summarized as a mean/individual (stroke rate) or frequencies (snapping, diving). Stroke rates were compared using Fisher's Exact Test; frequencies of snapping or diving by Chi-Square tests[(5)]. P values <0.05 were considered significantly different.
- Species specific feeding behavior was identified by watching videos of trials and feeding.

RESULTS

Fig 2. Leatherback (left) and loggerhead (right) turtles after exposure to test odors. The leatherback is diving and initiating a snap. The loggerhead dove and slowed swimming. The turtles always snapped at a visual stimulus (e.g. bubbles or textured areas of the tank).

Do the species differ in feeding behavior metrics?

IN SOME CASES

Table 1-Comparisons of turtle behavior between control and experimental periods within each experience category (naïve and experienced).

	Naïve Leatherback vs. Loggerhead	Experienced Leatherback vs. Loggerhead
Stroke Rate	X^2=1.54, p=0.21	X^2=0.06, p=0.81
Snapping	X^2=0.85, p=0.35	X^2=12.39, p=0.43
Diving Frequency	X^2=4.2, p=0.04	X^2=0.09, p=0.06

Yates chi-square results tested for differences in feeding behavior between naïve and experienced animals. Naïve Leatherbacks dove more often than naïve loggerheads when presented with bait odors. Experienced leatherbacks tended to dive more frequently but varied more.

Do the species differ in their responses to different bait types?

NO

Fisher's Exact Tests comparing both naïve and experienced animals' responses to fresh and carrion bait odors reveled no significant differences in their responses to odors.

RESULTS

Do the species differ in their responses to natural prey?

IN SOME ASPECTS

Table 2- Turtle behavior when exposed to Lion's Mane Jellyfish odors

	Leatherback	Loggerhead
Stroke Rate	p>0.05	p>0.05
Snapping	p=0.31	p=0.50
Diving Frequency	p=0.31	p=0.19

Fisher's Exact Test examined behavioral differences between control and experimental periods. Stroke Rates changed in species-specific ways. Leatherback stroke rates increased during the experimental period when jellyfish odor was present (over the control rate). Loggerhead stroke rates slowed after introduction to the jellyfish odors.

Natural prey odors produced species-specific changes in the stroke rates of experienced turtles.

Do the species differ in feeding behavior?

YES

Fig 3. Leatherback feeding behavior.

Fig 4. Loggerhead Feeding behavior.

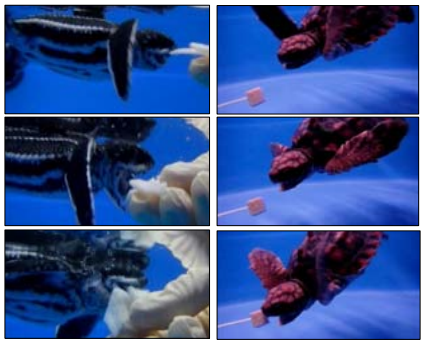

Fig 3. and Fig 4. The above images show feeding behavior of leatherback and loggerhead sea turtle feeding behavior. The images were captured from videos filmed at 29 fps.

Both species initially slow when approaching food.

- Leatherbacks display a distinctive body "wiggle" when they notice and orient towards food. The wiggle is due to an extension of the flipper and vertical sweep downward as they then lunge at the food. Leatherbacks open the mouth right before reaching the food.
- Loggerheads swim or dive towards the food item with an open mouth. The flippers are used in an anterodorsal to ventrolateral movement. The gapping mouth approach is similar to behavior described for large juveniles[(6)].

CONCLUSIONS

- There was no significant difference in feeding behavior between leatherbacks and loggerheads when exposed to different baits and soak times.
- We noticed that both species approach their prey in different manners. The differences in feeding behavior may explain why species are hooked in different manners.
- Our results differed from previous studies of leatherback feeding behavior from those reported in other studies[(3)]. We hypothesize several explanations.
  - Sample sizes were relatively low.
  - Odor solutions may be insufficient in concentration to elicit responses.
  - The animals may require both chemical and visual stimuli to respond.
  - The turtle responses to cues may differ with ontogenetic stage.
- Our next steps are to (i) explore video recordings of turtle behavior to identify other aspects of behavior that may change with odors and (ii) test odors in a series of concentrations to address the hypothesis that bait odors elicit feeding behavior by sea turtles.

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