Evidence for Temperature Elevation in the Aerobic Swimming Musculature of the Common Thresher Shark, *Alopias vulpinus*

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This paper reports on the in vivo temperature measurements for slow-twitch, red aerobic muscle (RM) and fast twitch, white muscle (WM) of 24 Common Thresher Sharks, *Alopias vulpinus*, captured off the coast of Southern California. Mean (± SE) RM temperature elevation was 2.33 ± 0.30 °C warmer than the ambient sea surface temperature (SST, 19.13 ± 0.22 °C) and 2.25 ± 0.35 °C warmer than the coldest WM temperature measured (19.23 ± 0.30 °C). The maximum RM temperature elevation was 5.4°C above SST and up to 7.6°C above the WM. Nine Common Thresher Sharks exhibited RM temperatures that exceeded 3.0°C above SST. No significant relationship was found between fish total length and RM temperature elevation. Although there was individual variability in RM temperature elevation, this study documents that the Common Thresher Shark is capable of significantly elevating its RM temperature above that of the ambient conditions.

**THE** Common Thresher Shark, *Alopias vulpinus*, is a large (maximum total length 760 cm, body mass 348 kg) actively swimming pelagic species classified in the Family Alopidae (Hart, 1973; Compagno, 2001; R. Froese and D. Pauly, unpubl., www.fishbase.org). The internal anatomy of the swimming musculature of *A. vulpinus* closely resembles that of the endothermic sharks (e.g., Shortfin Mako Shark, *Isurus oxyrinchus*) in the Family Lamnidae (Carey and Teal, 1969; Carey et al., 1971; Carey et al., 1985) in having the red aerobic muscle (RM) located in an axial position (i.e., closer to the vertebral column) and the circulation to this tissue is through a putative counter-current heat exchanger (retia; Bone and Chubb, 1983; Bernal et al., 2003; pers. obs.). Although morphological similarities between the Common Thresher Shark and the lamnids have been used to suggest that threshers are capable of regional endothermy, no in vivo temperature measurements exist for this species. The only two in vivo RM temperature measurements that exist for any alopidiid shark were taken from two Bigeye Thresher Sharks (*Alopias superciliosus*; Carey et al., 1971), for which the RM temperature was warmer than ambient, in one specimen, and cooler than ambient in the other. Collectively, the inconclusive RM temperature data for the Bigeye Thresher (Carey et al., 1971) and the lack of temperature measurements for the other two thresher species (i.e., Common Thresher and Pelagic Thresher, *Alopias pelagicus*) presents the question as to whether this group is capable of RM endothermy as are the lamnid sharks. The objective of this communication is to present in vivo temperature measurements for the RM and white muscle (WM) of the Common Thresher Shark and to test whether this species is capable of elevating its RM temperature elevation above ambient, indicating regional endothermy.

**MATERIALS AND METHODS**

*Specimen collection.*—Twenty-four Common Thresher Sharks were captured off the coast of Southern California from 1999–2003. Seven sharks were captured using rod and reel techniques at depths from the surface (0 m) to 30 m, whereas 17 sharks were captured using a 4 km longline (O’Brien and Sunada, 1994) during the 1999 National Marine Fisheries Service (NMFS) shark indexing survey. Longline hook-depths ranged from 35–50 m and the thermal profile of the water column was recorded using manually launched expendable bathythermographs (XBT, Sippican, Inc.; Marion, MA). When possible, after recording morphological data (e.g., total length, estimated mass, sex) and the physical condition of the animal, the sharks were tagged with NMFS conventional spaghetti tags and released. Heavy fishing tackle (24 kg) was used to collect all sharks by rod and reel in an...