U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE/NOAA FISHERIES

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CRUISE REPORT[1]

VESSEL: *Oscar Elton Sette*, Cruise SE-06-12 (SE-48)

CRUISE PERIOD: 2–29 November 2006

AREAS OF OPERATION: In and around the main Hawaiian Islands targeting seamounts, ledges, thermal fronts and eddies (Fig. 1)

ITINERARY:

02 Nov Embarked scientists Brill, Fate, Fisler, Galli, Jantz, Kikkawa, Musyl, Patrick, Wang and White. Departed Snug Harbor 1400. Transited to "Tsunami buoy" (NOAA 2.5 m DART II discus buoy no. 51407) approximately at 19°38'N, 156°30'W.

03 Nov Conducted trolling operations at around 0540 around and near the Tsunami buoy. At approx. 1852 , 450 - 18/0 circle hooks (50% were barbless and 50% barbed) were deployed (12 sec. between droppers = gangions; 12 droppers formed a "basket") at 19º30'N, 156º13'W. In other words, there were 12 baited (sanma *Cololabis saira*) droppers (ca. 6 fathoms long made of 450# monolfilament with a 12-in stainless steel leader terminating with the circle hook) clipped to the mainline (made of ca. 1200# monofilament) between successive floats (floatlines ca. 10 m polypropylene). As indicated by attached time-depth recorders, alternating the number of hooks per basket allowed us to adjust fishing depths to the desired depth range (i.e., adjusting for lunar phase). Deployment of gear started at 1852 and was finished by 2045. Details of longline deployments are given in Table 1 and in the Appendix.

04 Nov Haulback of the longline commenced at 0807 and operations were finished around 1020 at 19°23'N, 156°23'W. Catch details are provided in Tables 1 and 2. Continued trolling operations around series of fish aggregating devices (FADs) along the Kona Coast of the Big Island of Hawaii. Embarked scientists Itano, Shiels and Swimmer from the pier at Kailua-Kona at ca. 1400. Started transit to NOAA weather buoy 51003 (19°11'N, 160°44'W). Conducted continuous trolling during daylight hours of transit.

[1] PIFSC Cruise Report CR-08-015
Issued 13 January 2009

05 Nov At 0700, started trolling operations around Weather Buoy 51003. Small tunas and mahimahi were placed in the live fish tank on board the vessel to be used for various physiological experiments described in the Appendices. Near dusk, at around 1754, scientific personnel tried deep jigging around the buoy until about 1845. Indicative species around the buoy included mahimahi, ono, bigeye tuna, yellowfin tuna, rainbow runner and kahala. From 2038 to 2239, set approximately 523 hooks. Conducted a 500 m conductivity-temperature-depth (CTD) operation after deployment (2313) of longline at 19°23'N, 160°33'W and completed operation around 2352.

06 Nov Haulback commenced at 0809, and operations were completed around 1049 at 19°22'N, 160°33'W. Catch details are provided in Tables 1 and 2. Results of various experiments conducted on the cruise are given in the Appendices. Medevac initiated at around 1100 to transport injured crewmember to Honolulu to seek medical assistance. Conducted continuous trolling during daylight hours of transit.

07 Nov Commenced trolling around 0622 near the island of Oahu (ca. 21°09'N, 158°03'W). Around 0800, the *Oscar Elton Sette*'s safe boat transported injured crewmember and Chief Scientist Mike Musyl and other ship personnel to the NOAA Port Office in Honolulu. Musyl then transited to Kewalo Research Facility to pick up peristaltic pumps and tubing to use in various physiology experiments. Joint Institute for Marine and Atmospheric Research (JIMAR) scientist Lianne M^{c}Naughton transported Musyl back to the Port Office. After returning to the *Oscar Elton Sette* at around 1230, Musyl and ship personnel started transit to Cross Seamount (18°40'N, 158°17'W). Conducted continuous trolling during daylight hours of transit.

08 Nov Deployed vertical longline gear near the summit of Cross Seamount from 0513 to 0537 with attached Global Positioning System (GPS) locator beacon. Scientists affixed approx. 30 baited droppers spaced apart for about 400–600 m long of braided line which acted as the mainline. Trolling operations commenced at around 0616 and continued until 0811 when the vertical longline was retrieved using the ship's hydraulic longline reel. No samples were captured. Trolling operations continued from 0858 to 1005. Another vertical longline set was deployed from 1014 to 1021. Trolling operations continued from 1024 to 1140. Vertical longline was retrieved and no samples were captured. Trolling operations continued from 1236 to 1815. Set approximately 718 hooks starting at 1859 and finished at 2142. Conducted a 500 m CTD operation after deployment (2218) of longline at 18°54'N, 158°49'W and completed operation around 2251.

09 Nov Deployed 30 dropper vertical longline near Bishop Seamount 18°45'N, 159°00'W from 0619 to 0637. Haulback of the longline gear commenced at 0819 and operations were completed around 1303 at 18°56'N, 158°50'W. Catch details are provided in Tables 1 and 2. Trolling operations continued from 1316 to 1439. Vertical longline was retrieved from 1502 to 1528 and no samples were captured near 18°45'N, 159°01'W. Trolling operations continued from 1543 to 1844 near Daly Seamount. Set approximately 638 hooks starting at 1954 and completed

operations at 2219 near 18°19’N, 158°29’W. Conducted a 500 m CTD operation after deployment (2250) of longline and completed operation around 2325.

10 Nov Haulback commenced at 0816 and operations were completed around 1318 at 18°19’N, 158°30’W. Catch details are provided in Tables 1 and 2. Trolling operations continued from 1504 to 1820. Set approximately 695 hooks starting at 2002 and completed operations at 2244 near 18°55’N, 158°22’W. Conducted a 500 m CTD operation after deployment (2310) of longline and completed operation around 2341.

11 Nov Haulback commenced at 0806 and operations were completed around 1247 at 19°02’N, 158°29’W. Catch details are provided in Tables 1 and 2. Trolling operations continued from 1302 to 1802 while transiting back to Kailua-Kona.

12 Nov Conducted continuous trolling operations during the day while transiting back to Kailua-Kona. At approximately 1600, disembarked scientists Fisler, Itano, Jantz, Swimmer, Wang, and White at pier in Kailua-Kona. Chief Scientist Musyl and scientist Bill had a meeting to discuss pop-up satellite archival tag (PSAT) tagging issues with Dr. R. Michael Laurs at the Kona Seaside Hotel.

13 Nov At approximately 0900, embarked scientists Bernal, Garsha, Swenarton, Wegner, and Williams from the pier at Kailua-Kona. Conducted continuous trolling operations during the day while transiting to an area near McCall Seamount. From 1858 to 2150, set approximately 782 hooks near 19°12’N, 157°02’W. Conducted a 500 m CTD operation after deployment (2218) of longline and completed operation around 2256.

14 Nov Haulback commenced at 0804 and operations were completed around 1302 at 19°16’N, 157°10’W. Catch details are provided in Tables 1 and 2. Trolling operations continued during the day while transiting to near and around Cross Seamount to retrieve a high-frequency autonomous acoustic recording package (HARP) oceanographic monitor. Continued trolling operations while simultaneously towing an acoustic array to detect and identify marine mammals. From 2015 to 2238, set approximately 633 hooks near 18°37’N, 157°09’W. Conducted a 500 m CTD operation after deployment (2305) of longline and completed operation around 2334.

15 Nov Approximately at first light, scientist Garsha, technician from SIO, established communications with the HARP instrument at Cross Seamount but it failed to surface when given the command to jettison its ballast. Garsha was unsure of the failure mode but mentioned that another (virtually identical) HARP package failed to surface in Palmyra. He speculated that a component in the tropical ecosystem (e.g., growth/fouling organisms) may be correlated with the failure. However, since Cross Seamount is heavily fished using bottom longlines, it is possible that the instrument may be "tied up" with derelict fishing gear. A possible rescue scenario could involve a remotely operated vehicle (ROV) attaching a tether to the instrument which sits in about 400 m. Conducted trolling and acoustic array operations until about 1010 when haulback of the longline commenced. Retrieval

of the gear was completed around 1453 at 18°45'N, 158°17'W. Continued trolling and acoustic array operations while transiting to area near the island of Kauai.

16 Nov Began trolling and acoustic array operations at around 0700, and these activities continued until 1803 at 22°04'N, 158°55'W. Set approximately 637 hooks starting at 2101 and completed operations at 2321 near 22°27'N, 159°05'W. Conducted a 500 m CTD operation after deployment (2357) of longline and completed operation around 0025.

17 Nov Haulback commenced at 0800 and operations were completed around 1025 at 22°27'N, 159°11'W. Continued trolling and acoustic array operations while transiting to area north of the island of Kauai until around 1817. Set approximately 599 hooks starting at 2101 and completed operations at 2310 near 23°56'N, 159°55'W. Conducted a 500 m CTD operation after deployment (2343) of longline and completed operation around 0012.

18 Nov Haulback commenced at 0805 and operations were completed around 1038 at 23°56'N, 160°02'W. Continued trolling and acoustic array operations until around 1816. Set approximately 509 hooks starting at 1858 and completed operations at 2050 near 22°39'N, 159°55'W.

19 Nov At around 0637, conducted a 500 m "dawn" CTD operation and completed operation around 0734. Haulback commenced at 0805 and operations were completed around 1042 at 22°41'N, 160°01'W. Continued trolling and acoustic array operations until around 1724. At around 1732 conducted a 500 m "dusk" CTD operation and completed operation around 1832. Set approximately 689 hooks starting at 1934 and completed operations at 2204 near 22°29'N, 159°16'W.

20 Nov From 0628 to 0724, conducted a 500 m "dawn" CTD operation. Haulback commenced at 0808 and operations were completed around 1110 at 22°28'N, 159°24'W. Continued trolling and acoustic array operations until around 1812. Set approximately 560 hooks starting at 1902 and completed operations at 2105 near 21°56'N, 159°52'W.

21 Nov From 0626 to 0720, conducted a 500 m "dawn" CTD operation. Haulback commenced at 0804 and operations were completed around 1053 at 21°52'N, 159°48'W. Continued trolling and acoustic array operations until around 1727. From 1740 to 1836, conducted a 500 m "dusk" CTD operation. Handlining near offshore FADs by Port Allen (south of Kauai) continued until 2340.

22 Nov Handlining near offshore FADs by Port Allen continued until 0550. Trolling operations continued around FADs south of Kauai until about 1300. At approximately 1400, disembarked scientists Bernal, Shiels, Wegner and Williams via safe boat to the pier at Port Allen, Kauai. At around 1420, embarked scientists Bigelow, M^{c}Naughton and Shimada from the pier at Port Allen. Continued trolling operations until around 1810 while on transit to vicinity of Cross Seamount and NOAA weather buoy 51003 (19°11'N, 160°44'W).

23 Nov At around 0650, commenced trolling operations around weather buoy 51003. Conducted a 500 m CTD operation at 1457 and completed operation around 1526 at 19°10'N, 160°50'W. Continued trolling operations until around 1625 when activities were suspended due to saturation levels of caught tunas (bigeye, yellowfin and skipjack), mahimahi, and ono. From 1902 to 2148, set approximately 724 hooks near 19°01'N, 161°02'W.

24 Nov Haulback commenced at 0810 and operations were completed around 1233 at 19°00'N, 160°56'W. Continued trolling operations until around 1744.

25 Nov Began trolling operations at around 0633 and these activities continued until 1809 at 18°46'N, 158°12'W. From 1237 to 1333, conducted a 1000 m "high noon" CTD operation at 18°52'N, 158°20'W. At 1900, set approximately 824 hooks and completed operations at 2213 near 18°47'N, 157°46'W.

26 Nov Haulback commenced at 0807 and operations were completed around 1330 at 18°54'N, 157°50'W. Continued trolling operations until around 1805. From 1901 to 2156, set approximately 784 hooks near 18°17'N, 158°16'W. Conducted a 500 m CTD operation at 2236 and completed operation around 2306 at 18°18'N, 158°16'W.

27 Nov Haulback commenced at 0807 and operations were completed around 1301 at 18°20'N, 158°22'W. Continued trolling operations until around 1759. From 2135 to 2302, set approximately 374 hooks near 18°42'N, 157°01'W. Conducted a 500 m CTD operation at 2343 and completed operation around 0014 at 18°41'N, 157°00'W.

28 Nov Haulback commenced at 0811 and operations were completed around 1015 at 18°40'N, 157°03'W. Continued trolling operations until around 1755. Started transit back to Snug Harbor.

29 Nov At around 0800, arrived at Snug Harbour. Disembarked scientists Bigelow, Brill, Fate, Galli, Kikkawa, M^{c}Naughton, Musyl, Patrick and Shimada. End of cruise.

MISSIONS AND RESULTS:

a. Hearing studies on captive pelagic fishes. Tunas and mahimahi will be captured for live onboard cardiac functions and hearing experiments investigating limitations on vertical mobility and distribution as well as testing the hypothesis that these fishes locate FADs by the sound produced by these structures and their associated prey fauna.

Hearing studies had been completed on an earlier cruise. Samples were collected from wahoo (*Acanthocybium solandri*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*), mahimahi (*Coryphaena hippurus*), snake mackerel (*Gempylus serpens*), swordfish (*Xiphias gladius*), striped marlin (*Tetrapturus audax*), silky sharks (*Carcharhinus falciformis*), blue shark (*Prionace glauca*), mako shark (*Isurus oxyrinchus*), and oceanic whitetip shark (*Carcharhinus*

longimanus). See various reports in the Appendix for more information about the physiological studies.

b. Studies on cardiac function limitations in tunas and mahimahi. See a. above.

Took tissue samples from tunas, billfishes, mahimahi, escolar, lancet fish, snake mackerel, barracuda, and blue sharks (Tables 1 and 2) for ongoing physiological, biochemical, and anatomical studies. See report in the Appendix for more information.

c. Barbed/barbless hook trials (affix time depth recorders (TDRs) and hook timers to gangions). Researchers are testing the hypothesis that pelagic bycatch species can be easier dehooked and therefore released from longline fishing gear much faster, thereby reducing handling stress with the use of barbless hooks. However, for this practice to gain credibility, researchers need to adequately show that the catch rate on barbless hooks is equivalent to catch rates on barbed hooks (e.g., bait retention is similar).

Sixteen operational longline sets were conducted with 10, 39 hooks deployed with 5112 of the hooks "barbed" and 5027 "barbless." See Tables 1 and 2 and the report in the Appendix for more information.

d. Testing the efficacy of several dehooking devices. Methods to release hooked fishes and sharks in the water will be conducted with various dehooking devices.

During the first leg, we completed 4 sets and caught 13 blue sharks (*Prionace glauca*), 7 with barbed hooks and 6 with barbless hooks. The only type of dehooker used in this experiment was the pigtail dehooker. Four of the six barbless hooks were successfully dehooked using the the pigtail dehooker, while none of the barbed hooks were successfully dislodged. The two barbless hooks that failed to dislodge were caught deep within the sharks' mouths and difficult to see to engage the pigtail dehooker. See report in the Appendix for more information.

e. Shark repellent work. Participants will experiment with a chemical shark repellent as a possible methodology to reduce unwanted bycatch on longlines. To evaluate different ways of presenting the repellent near longlines and specifically bait, researchers will test different delivery systems for the chemical (e.g., treating the bait vs. slow diffusion from concentrated source).

The delivery system for the repellent and (or) repellent from Eric Stroud of Shark Defense, LLC was not operational at the time of the cruise and, therefore, this activity was postponed to a later date.

f. Secure tissue samples for ongoing genetic (striped marlin, escolar) and age/growth/reproductive studies (striped marlin, gemplylids).

Took tissue samples from tunas, billfishes, mahimahi, escolar, lancet fish, snake mackerel, barracuda, and blue sharks (Tables 1 and 2) for ongoing physiological, biochemical, and anatomical studies.

g. "Crepuscular" experiments to ascertain the light sensor sensitivity on archival and PSATs. Researchers will send the tags down the CTDs for an hour around dawn/dusk for a few days. It is envisioned that these data will aid in choosing dusk/dawn light curves and ultimately, optimization of geolocation algorithms.

   Ambient light level data were gathered from 6 archival tags (2 made by Lotek and 4 made by Wildlife Computers) and one PSAT tag from Wildlife Computers affixed on seven CTD casts down to 500 m. About half of the casts were made at around dusk and the other around dawn (one 1000 m cast was made at noontime).

i. Augment new GPS locator beacon system on longlines. With these new devices, researchers also will be able to examine the orientation of longline gear in both horizontal and vertical aspects (i.e., with TDRs and acoustic Doppler current profiler [ADCP]). This will help to gain additional insights into environmental forcings (i.e., principally currents) that can shape and deform longline gear which often deviates from a theoretical catenary configuration. ADCP data will be evaluated in terms of current vectors impacting mainline and branchlines. In addition, with the aid of TDRs and ADCP, scientists will test the orientation (i.e., depth) of monofilament droppers in relation to mainline depth to ascertain their fishing zones.

   Four GPS locator beacons from Airborne Technologies (model no. QTR-200C) were used in place of Radio Directional Finders (RDF) to monitor the movement and location of the vertical and horizontal longlines. Although the system worked to locate fishing gear, software and firmware problems prevented scientists from acquiring and downloading fine-scale location data stored in the individual units. The manufacturer is going to rectify the problem.

j. Vertical longlining during the day/night to capture young-of-the-year (YOY) billfish species for ongoing age/growth studies.

   Scientists and crew were successful in deploying vertical longline gear from the vessel. Three vertical longlines were deployed from the stern of the vessel (each about 400–600 m long with about 30 baited droppers spaced evenly along the line). GPS locator beacon was used to monitor movement of the line after the end weight (ca. 3 k) was thrown. The vertical longline was retrieved using the hydraulic reel for the regular (monofilament) horizontal longline. Although no samples were taken in this instance, scientists believe experimenting with different hook sizes may be an effective method to capture smaller specimens.

k. Measurement of in vivo read and muscle temperatures in live blue sharks. Minimally, invasive techniques will be used to measure muscle temperatures of restrained live and moribund blue shark to test the hypothesis of thermogenesis. For example, blue sharks display dive behavior (identified by electronic tags) that are very similar to several pelagic species (swordfish, mako, bigeye tuna, and bigeye thresher) that have specialized tissues and/or anatomical structures to maintain body temperature above ambient for extended periods.

Red muscle temperatures were taken from six blue sharks captured in the mixed layer. Samples consisted of four female sharks and two males. Lengths of the sharks in the study ranged from 3.5 to ca. 6 ft. All six specimens exhibited significantly higher red muscle temperatures (mean 0.50±0.09) than ambient temperature (*t*-TEST, P<<0.001, ambient measured by nearest TDR and ship's thermosalinograph). This was true for specimens "soaking" on the longline for prolonged periods. For example, as identified by hook timer data, female blue shark no. 5 (ca. 5 ft TL) was soaking for 8 hrs. 4 min. Another female blue shark (no. 3, ca. 4-5 ft. TL) was soaking for 2 hrs. 3 min. Hook timers on the other samples were not tripped or gave zero readings. Scientists will require additional muscle temperature readings from specimens diving beneath the thermocline to properly assess the study question.

l. Ship's personnel will also retrieve and redeploy (after downloading data and performing routine maintenance) a HARP oceanographic instrument at Cross Seamount.

Chris Garsha, technician from UCSD/SIO, established communications with the HARP instrument at Cross Seamount but it failed to surface when given the command to jettison it's ballast. Garsha was unsure of the failure mode but mentioned that another (virtually identical) HARP package failed to surface in Palmyra. He speculated that a component in the tropical ecosystem (e.g., growth/fouling organisms) may be correlated with the failure. However, since Cross Seamount is heavily fished using bottom longlines, it is possible that the instrument may be "tied up" with derelict fishing gear. A possible rescue scenario could involve an ROV attaching a tether to the instrument which sits in about 400 m. See report in the Appendix for more information.

m. Perform dropper sink trials outfitted with lightstick shading devices from small boats near to shore in calm waters. This experiment was shifted to the longline operations.

On 9 separate longline sets (Nov 3–Nov 26), 12 experimental lightsticks were deployed per set. Of the 12 lightsticks, 6 lightsticks were deployed in a basket near the beginning of the mainline, and the remaining 6 were deployed in a basket toward the end of the mainline. Typically, each basket consisted of 17 branchlines. Each branchline with a lightstick was associated with 2 TDRs (time depth recorders – LOTEK – LTD 1110). One TDR was placed on the branchline clip next to the mainline. The other TDR was clipped at the end of the branchline near the hook (no bait was used on any of these branchlines). For each longline set, a total of 24 TDRs were utilized. See report in the Appendix for more information.

NARRATIVE SUMMARY:

A total of 16 operational longline sets were conducted during the cruise with catch details by gear provided in Tables 1 and 2. Seventeen CTD casts were conducted to document vertical characteristics of the water column. Seven of the casts (mostly near dawn, dusk) were specifically designed to aid in a continuing study of light attenuation at depth, particularly at crepuscular times. Six archival tags and one PSAT tag were affixed to the CTD for this purpose. Barbless hooks were tested as to their efficacy to retain bait and thus catch equivalent numbers as regular barbed hooks. Biological samples for ongoing physiological studies were obtained from

select live fish. Narrative reports on the objectives and results from the various cooperative studies are provided.

RECORDS:

The following forms, logs, charts, and data records were kept and given to the Pacific Islands Fisheries Science Center upon termination of the cruise. These include all data captured onto computer storage media during the cruise. All the records are filed there unless indicated otherwise in parentheses.

SEAS system data files
Deck Log-Weather Observation Sheet
Marine Operations Log (NOAA)
Project Area and Operations Chartlets
Station Number and Activity Log
Fish catch record by species, hook number, bait disposition
Data from Temperature Depth Recorders (TDRs)

SCIENTIFIC PERSONNEL:

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Diego Bernal, Cooperating Scientist, U Mass
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Attachments

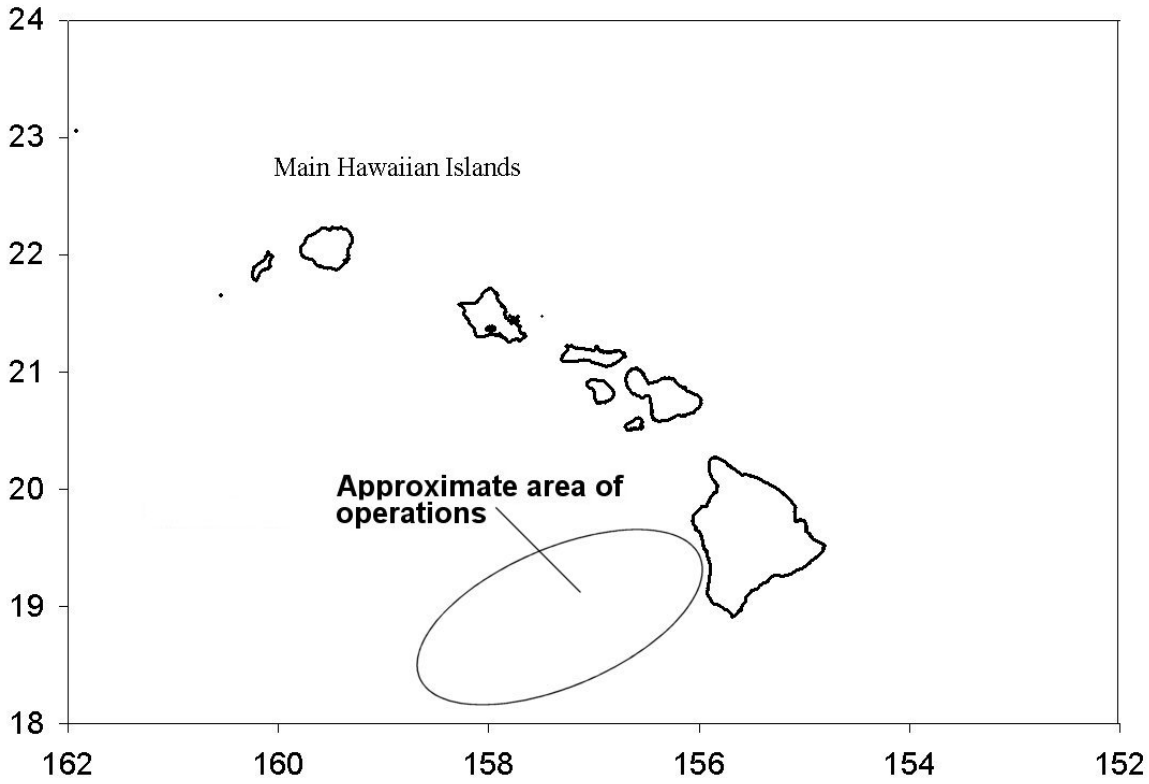

Figure 1.--Areas of fishing operation.

Table 1.--Summary of catch details from longline operations by set during Cruise SE-06-12 from November 2 to November 29, 2006. The retention rate was determined by enumerating the rubber cutouts during the haulback.

Date	Hooks				Retention rate (%)	Fish caught
	Hooks /Basket	Total	Barb	Barbless		
Nov. 4	14	450	222	228	-	2
Nov. 5	17	523	264	259	-	3
Nov. 8	17	718	354	364	98.3	8
Nov. 9	17	638	318	320	98.4	10
Nov. 10	17	695	345	350	99.7	8
Nov. 13	15	782	398	384	100	7
Nov. 14	15	633	321	312	99.0	4
Nov. 16	13	637	324	313	96.8	2
Nov. 17	11	599	309	290	100	3
Nov. 18	9	509	259	250	99.2	4
Nov. 19	9	689	352	337	100	2
Nov. 20	7	560	280	280	100	5
Nov. 23	7	724	361	363	99.2	3
Nov. 25	13	824	423	401	99.3	8
Nov. 26	13	784	391	393	99.5	5
Nov. 27	7	374	191	183	98.9	5
Total		10139	5112	5027	99.2	79

Table 2.--Summary of the catches by species and hook types during Cruise SE-06-12 from November 2 to November 29, 2006.

Group	Species	Hook type	
		Barb	Barbless
Shark	Blue	16	13
	White Tip	2	2
	Silky	3	0
	Mako	0	1
Tuna	Bigeye	2	3
	Yellowfin	1	1
	Skipjack	1	0
	Escolar	4	3
Billfish	Blue Marlin	0	2
	Stripped Marlin	1	2
	Swordfish	3	0
Others	Ono/Wahoo	0	1
	Mahimahi	4	5
	Barracuda	1	2
	Puffer	0	1
	Lancet Fish	1	0
	Snake Mackerel	5	0
Total		44	36

Dehooking Shark Bycatch to Increase Post Release Survival in the Hawaii Longline Fishery

Lesley Jantz and Tom Swenarton
NOAA Fisheries National Marine Fisheries Service

BACKGROUND

The Hawaii-based longline fishery is the largest domestic fishery in the state. Approximately 120 vessels have limited entry permits to target bigeye, yellowfin tuna (*Thunnus* spp.*)* and broadbill swordfish (*Xiphias gladius*) (Ito and Machado, 1997). This pelagic fishery targets these species by deploying approximately 2000 branchlines with baited hooks that hang vertically in the open ocean attached by a snap comprised of 30 to 50 miles of sturdy monofilament of approximately 1000 pound testing strength. Hard round buoys are deployed between a minimum of 15 branchlines to allow the deepest branchline to fish the desired depth of 60 to 250 meters (Bigelow et al., 2006).

In comparison to the total number of fish caught in the swordfish and tuna fisheries, 50% and 34%, respectively is shark bycatch (National Marine Fisheries Service, 2001). These sharks are released using various methods: severing the branchline, (abandoning the hook with line attached) hauling the shark to the vessel to slice the hook free, and dragging the shark from the stern until the hook pulls free.

Dehooking devices, originally designed for releasing hooked sea turtles may safely release sharks. In addition, it might minimize any additional trauma to the shark, potentially increase post-release survivorship, and therefore, decrease bycatch mortality.

DEHOOKING EXPERIMENT

To test the efficiency of the dehooking devices, we, Tom Swenarton and Lesley Jantz embarked upon the NOAA Ship *Oscar Elton Sette* to attempt to dehook sharks caught on the longline. The longline was deployed with 600 to 750 monofilament branchlines alternating between 18/0 barbed and barbless circle hooks. We set the gear in the evening and let the gear "soak" throughout the night until we began hauling operations at 8:00 a.m.

During the first leg, we completed 4 sets and caught 13 blue sharks (*Prionace glauca*), 7 with barbed hooks and 6 with barbless hooks. When a shark was caught on the line, the following data was collected: species, approximate length, barbed or barbless hook, type of dehooker utilized, hook position, number of trials (attempts to dehook the animal), recorded time of attempted trials, and success (did the hook come free?). The only type of dehooker used in this experiment was the pigtail dehooker.

Four of the six barbless hooks were successfully dehooked using the pigtail dehooker, while none of the barbed hooks were successfully dislodged. The two barbless hooks that failed to dislodge were caught deep within the sharks' mouths and difficult to see to engage the pigtail dehooker.

Hook Types and Placement

During the last set, a moribund female blue shark was caught on the longline. The shark was then landed and utilized in an experiment to explore the success of dehooking three different types of hooks inserted through various soft and hard tissues of the jaw. Two types of dehookers were examined–the pigtail and the auger.

Dehooking Tools

The pigtail dehooker resembles the circular curl of a pig's tail. The curl circles upon itself, creating a small clearance allowing the monofilament branchline and the wire leader to pass. Once the branchline is securely in the center of the curl, the pigtail follows down the line to engage the shank of the hook. A thrust is applied in an attempt to dislodge the hook. The auger dehooker resembles a deep socket wrench with several notches around the circumference to secure the hook in place. Instead of the thrusting motion used with the pigtail dehooker, the auger is designed to be turned in a clockwise or counterclockwise direction to release the hook.

The landed blue shark had been previously hooked and a 3.6 Japanese traditional tuna hook remained, becoming one of the three hooks used in the study. An 18 ought barbed circle hook and an 18 ought barbless circle hook completed the quiver of hooks to be inserted (Fig. 1).

Figure 1.--18/0 barbed circle hook.

The first hook examined was the 18/0 *barbed* circle hook inserted through the skin tissue on the outside corner. A large amount of skin is cinched between the barb and hook (Fig. 2) when attempting to dislodge. The pigtail dehooker failed to dislodge the hook while the auger dehooker was a success but not without inflicting tissue damage. The auger dehooker does not guide the hook out of the original insertion path but twists the hook free by force, tearing tissue cinched between the barb and the shank (Fig. 3).

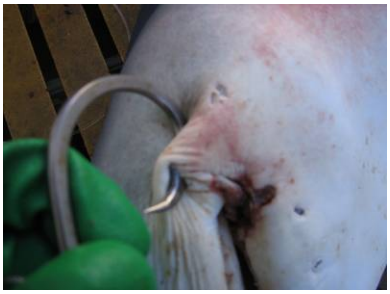

Figure 2

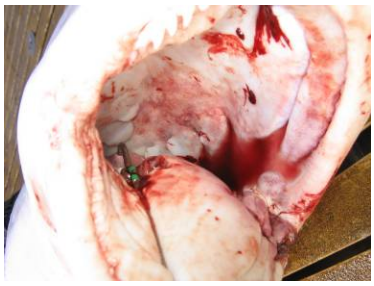

Figure 3

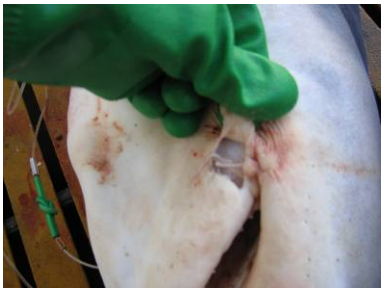

Figure 4

The 18/0 *barbed* circle hook was also placed deep inside the shark's mouth in the tongue and in the soft tissue near the esophagus (Fig. 4). The pigtail dehooker was unsuccessful in dislodging the hook in both the tongue and soft tissue. Even within these ideal circumstances, it was difficult to see the pigtail's placement in reference to the angle of the shank.

The auger dehooker was successful in dislodging the hook in the hard tongue tissue. The characteristics of the auger allow detection and grasping of the hook when inserted deep inside mouth, where hook is not visible. When attempting to remove the hook from the soft tissue flapper, the auger dehooker failed because it relies on resistance when turned in a counter or clockwise direction. Thus, when applied to a hook penetrating soft tissue, there is no resistance and the soft tissue wraps around the auger dehooker in the direction turned.

18/0 Barbless Circle Hook

Next, the 18/0 *barbless* hook was inserted through the skin tissue in the corner and through the middle of the jaw with the shank located on the inside of the shark's mouth (Figs. 5 and 6). Dislodging of the hook was successful using the pigtail dehooker in both hook placements. With no barb existing to gather and cinch tough shark tissue when resistance is applied, the 18/0 circle hook easily follows the initial path of insertion for removal.

Figure 5

Figure 6

Figure 7

When the 18/0 barbless hook was placed deep inside the shark's mouth penetrating the hard tissue of the tongue (Fig. 7), the pigtail dehooker was successful in dislodging the hook as was the auger dehooker. The absence of a barb allowed the auger dehooker to dislodge the hook without tearing any tissue. Both types of dehooker failed to remove the hook from the soft tissue found deep within the shark's mouth.

3.6 Traditional Japanese Hook

Lastly, the 3.6 tuna hook was studied and placed in the corner of the lower jaw, (Fig. 8) deep inside the mouth, and penetrating the tongue. The pigtail dehooker was successful in dislodging the hook placed in the lower jaw only. Although this hook is barbed, the shape and angle differs from the 18/0 barbed circle hook, which is advantageous during the thrusting motion of the release, whereas the pigtail does not slide away from the pointed end up the shank, therefore allowing for greater leverage and applied force. The auger dehooker was used and successful in dislodging the deeply set hook in the tongue but failed to retrieve the hook inserted into soft tissue for reasons previously discussed.

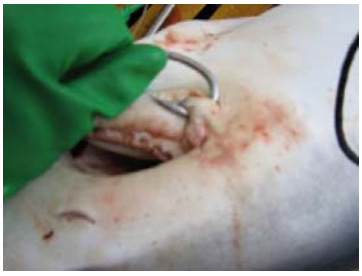

Figure 2

CONCLUSION

The hook placement and type of hook deployed dictate the type of dehooker to be utilized for successful dislodging. Experiments in this study were under laboratory circumstances–a moribund shark landed on deck. Most dehooking encounters are with live sharks that twist and jerk relentlessly, presenting a challenge to locate the hook, position the dehooker, and thrust or turn dehooker for hook release. For deeply hooked sharks, when it is often impossible to see the hook and shank, the characteristics of the auger dehooker made it possible to locate the hook as it slid and locked into a notch.

RECOMMENDATIONS FOR A PROPOSED RESEARCH DESIGN

The preliminary data and experiment clearly demonstrate the need to modify and perfect the dehooking devices.

A. Perfect the auger dehooker.

1. Soften up the ends so as not to cut the shark.
2. Add extension poles for reach, three screws on sections.
3. Widen and soften the opening to insert the monofilament or wire.
4. Design grooves along shank of dehooker for monofilament to slide into as it wraps around shank and ties down to a cleat to cinch the line at the T-bar end of the dehooker.
5. Create a locking mechanism to secure the hook once it slides into a groove.
6. Experiment with the auger design to work on soft tissue.
7. Cut the groove notches out in such a way that it is big enough for a J hook to slide into and small enough to secure the traditional 3.6 hook. The notch could initially be cut small and flared out; that way the smaller hook would slid deep into the notch and the

larger hook would be secure between the flaring ends and the gradually narrowing notch.

B. Perfect the pigtail dehooker.

1. Design a cinching mechanism to secure the pigtail in place between the shank and rounding portion of the hook.
2. Design grooves along shank of dehooker for monofilament to slide into as it wraps around shank and ties down to a cleat to cinch the line at the T-bar end of the dehooker.
3. Experiment with the pigtail design to work on soft tissue.

CONTINUED FIELD EXPERIMENTS

Although the freeboard (space between the working deck and water column) on the NOAA Ship *Oscar Elton Sette* is not ideal for longline fishing and the lack of leverage makes dehooking difficult, it is beneficial for testing the new devices and working out the kinks before approaching the commercial industry. Proposed fishing experiments on a smaller vessel chartered to longline would be an excellent opportunity to test these new devices as well.

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During the second leg of the cruise (November 13–21, 2006), two acousticians came on board with two projects. The purposes of these projects were to (1) retrieve, refurbish, and redeploy a High-frequency Acoustic Recording Package (HARP) located on Cross Seamount and (2) to make opportunistic recordings of marine mammals using a towed array in order to try to link cetacean vocalizations to visually based species identifications which would, in turn, aid in acoustic identification of species recorded by the HARP.

The first project, which involved retrieving, refurbishing, and redeploying a HARP located on Cross Seamount at a depth of approximately 400 m, took place on November 15, 2006. Initial communication to the HARP using a transducer occurred in the morning. Ranging occurred after initializing communication, yielding the distance to the acoustic recorder. Burn-release commands were given on several attempts, but the unit failed to surface. Continued ranging to the unit indicated that the unit was remaining in the same location on top of Cross Seamount. Later attempts that day to retrieve the unit via burn-release commands also failed. The unit was left in the same location in which it was originally placed a year earlier in November 2005.

The second project, which involved passive acoustic monitoring for marine mammals, took place during the second leg of the cruise between November 14, 2006 and November 20, 2006, during daylight hours and while longlining activities were not occurring. A two-element hydrophone array was towed at a distance of approximately 80 m behind the *Sette* at a speed between 9 and11.5 knots. The array was connected to a four-channel MOTU traveler which amplified and then sent signals being sampled at 192 kHz to a laptop computer. Incoming signals received from the array were continuously monitored in real-time using the acoustical software program *Ishmael*, and all cetacean sounds were recorded directly to an external hard drive. A log of acoustic effort and locations of cetacean vocalizations was kept. The goal of this project was to make opportunistic recordings of marine mammals around the area of Cross Seamount and visually identify the species of the vocalizer(s) in order to aid in acoustic identification of species recorded by the HARP located on Cross Seamount.

The towed array was hand deployed after the longline was retrieved each morning and remained out until either a fish was caught on the trolling lines or the day progressed into night and it became dark. If a fish was caught on the trolling lines, acoustic monitoring ceased in order to retrieve the array before the fish was reeled in. The array was redeployed as soon as possible and passive acoustic monitoring resumed. When a cetacean sound was observed, the acoustician started recording all signals, monitored the level of the signals to ensure appropriate received levels, and then went to the flying bridge to try to visualize and identify the species of the vocalizer(s) with 7 × 50 binoculars. Visual observations continued for at least 10 minutes before returning to acoustic monitoring to ensure the cetacean vocalizations were still occurring. If calls were still observed, visual observations resumed immediately. If no sounds were heard right away, acoustic monitoring continued for approximately 5 minutes before resuming visual observations. The second round of visual observations occurred for at least 10 minutes. On three occasions, a second scientist helped conduct visual observations.

Cetacean vocalizations were detected and recorded with the towed array on a total of six different occasions. Unfortunately, visual observations of the vocalizer(s) were made only on one occasion by a crew member with no species identification. Thus, species identification did not occur on any of the six occasions that the cetacean sounds were detected and recorded. Visual detections would have been more successful with at least one dedicated visual observer in addition to the acoustician. An array with more than two elements would have allowed for localization of the vocalizer(s) which would have further assisted in locating vocalizing cetaceans, aiding in species identification. Future attempts to try to link cetacean sounds to visually based species identification should take these two factors into consideration.

Summary Cruise Report (November 13–21, 2006)
NOAA Ship *Oscar Elton Sette*

Diego Bernal

The objectives of this study are to quantify the molecular and biochemical responses to capture- and thermal-related stress in the blood of pelagic fishes. Our work, seeks to better understand the role of physiological stress on thermally shocked blood and to determine the potential effect that longline and troll capture may have on disruptions to homeostasis. Further, from detailed analyses of soak time, gear type, and hook location, we will be able to provide data on the possible correlation between fish condition and blood stress response.

During our activities aboard the NOAA Ship *Oscar Elton Sette* (November 13–21, 2006) blood samples were collected from 1 wahoo (*Acanthocybium solandri*), 2 yellowfin tuna (*Thunnus albacares*), 1 bigeye tuna (*Thunnus obesus*), 3 skipjack tuna (*Katsuwonus pelamis*), 7 mahimahi (*Coryphaena hippurus*), 1 snake mackerel (*Gempylus serpens*), 1 swordfish (*Xiphias gladius*), 1 striped marlin (*Tetrapturus audax*), 2 silky sharks (*Carcharhinus falciformis*), 1 blue shark (*Prionace glauca*), 1 mako shark (*Isurus oxyrinchus*), and 1 oceanic whitetip shark (*Carcharhinus longimanus*). Tissue samples were collected from 2 wahoo, 3 yellowfin tuna, 1 bigeye tuna, 4 skipjack tuna, 7 mahimahi, 1 snake mackerel, 1 swordfish, 1 striped marlin, 1 blue shark, and 1 oceanic whitetip shark. Myotomal muscle temperature measurements were taken from 1 swordfish, 1 striped marlin, 2 silky sharks, and 2 blue sharks.

For all fish, 20 to 40 ml of blood were collected by either cardiac or caudal vein puncture using a heparanized 18–20 ga needle. A 3-ml sample was immediately centrifuged for 5 min at 1500 RPM (to separate red blood cells from plasma) and then stored in liquid nitrogen. The remainder of the blood was incubated for 240 min at 5-8 ºC under constant aeration and rotation. After the 240 min incubation (i.e., recovery) the blood volume was divided into two or three subsamaples (10 ml each) of which one or more were subjected to a series of thermal shock treatments while another held at 5–8 ºC as a control. The thermal shocks consisted of 60–120-min exposures to temperatures that were from 5 to 12 ºC above that of the sea surface temperature where they were captured (i.e., 25–27 ºC). Blood samples were then transferred back to control conditions (i.e., 5–8 ºC) for recovery from thermal stress. At the end of the thermal shock and every 60 min thereafter (up to 600 min) a corresponding 1.5 ml sample was taken from heat shocked blood in recovery and from the control. For all samples red blood cells were separated from the plasma by centrifugation for 5 min at 1500 RPM and then frozen in liquid nitrogen.

The following parameters will be measured in the laboratory for all plasma samples: pH, Na, K, glucose, creatine phosphate, and lactate. The detection of tissue-specific indicators of cellular disruption will be based on SDS-PAGE and western analyses of plasma proteins. Myocardial and myotomal muscle damage will be determined using antibodies that distinguish between tissue-specific troponin isoforms (e.g., cardiac vs. skeletal TnI).

The following parameters will be measured in red blood cell samples: hematocrit (done aboard ship), hemoglobin, and osmolarity. Erythrocytes will be analyzed for both RNA (northern/cDNA array) and protein (western). Analyses will include members of the *Hsp*70 and *Hsp*90 families. Met-hemoglobin will also be assessed to determine the degree of protein damage.

For all fishes that were euthanized a small 2-g sample of the heart ventricle was taken and frozen in liquid nitrogen. All tissue samples will be analyzed for the activities of key metabolic biochemical enzyme and for the presence of stress-related proteins.

We expect to complete our laboratory work for all the samples collected during this by March 2007. At that time we will provide our final report to the Chief Scientist, Dr. Michael K. Musyl.

Scripps Institution of Oceanography

Nick Wegner

Tunas, bonitos, mackerels (family Scombridae) and billfishes (families Istiophoridae, Xiphiidae) are highly specialized for fast, continuous swimming. These fishes are ram ventilators (i.e., their nonstop movement forces water over the gills thus replacing active gill ventilation, which, at faster swimming speeds, reduces drag associated with cyclic jaw movements for respiration). Of these fishes, only tuna respiration has been well studied and tuna gill design is thought to epitomize specializations for ensuring rigidity required by ram ventilation and for meeting increased oxygen demands associated with high aerobic performance. Tuna gill filaments and lamellae are fused together providing the support required to function under high velocity water flow. Tunas also possess gill microvascular specializations to increase gas exchange. Very little has been reported on the gill structure of other high-performance teleosts, including other members of the family Scombridae, and the billfishes. On this cruise, I collected gill tissue from a large variety of different scombrid and billfish species to look at specializations for increasing both gill rigidity and gas exchange.

Gill tissue was excised from freshly euthanized animals and fixed in 10% formalin buffered in seawater. A few fish were perfused with a vascular casting solution to detail the vascular pathways and microvascular specializations of the gills. The fixed tissue and vascular replica casts are currently being analyzed using light microscopy and scanning electron microscopy. Preliminary results show highly specialized gills in both non-tuna scombrids and billfishes. The large size range of individuals sampled allows for analysis of ontogenetic changes within the same species (i.e., the gills of a small 2 kg wahoo are much less rigid than larger specimens that likely encounter higher ventilatory flow rates due to faster swimming speeds).

This cruise has set the stage for additional research in this area by reporting highly specialized gills in several species that are not well studied. Additional research in this area will allow us to relate gill morphology to habitat use. For example, an exciting discovery from this cruise is the apparent similarity of the filament fusion patterns in bigeye tuna and swordfish, which both dive to great depths during the day and may encounter low ambient oxygen levels. Another area of importance is the possibility of using gill filament fusions in species identification (i.e., there appear to be marked differences in the gills of yellowfin and bigeye tunas).

I am very grateful that I was able to participate in this year's cruise and would like to participate in the future. The diversity and large size range of scombrids and billfishes caught are extremely useful to my study. Many thanks are deserved to all who made the cruise possible, especially Mike Musyl and the crew of the NOAA Ship *Oscar Elton Sette*.

Measurement of Electrical Activity from the Hearts of Pelagic Fish Species

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INTRODUCTION

Species-specific depth distribution of tuna and other commercially important species may be influenced by the physiology of the heart. Both the bluefin and bigeye tuna inhabit a wide range of depths (up to 1000 m when diving) whereas other species such as yellowfin tuna are usually found in the surface waters not deeper than 100 m.

To investigate the role of the cardiac tolerance of environmental and physiological demands in species distribution, we have studied isolated whole hearts. Hearts were studied in a working heart configuration, that is, where the input pressure to the sinus and the output pressure to the bulbus, of the purfusing physiological saline solution, are experimentally controlled. Electrocardiograms (ECGs) and monophasic action potential (MAP) recordings were made from hearts of various species. ECGs and MAP recording provide information on how heart rate, atrioventricular delay and repolarisation time of the heart varies with environmental interventions such as temperature and physiological interventions such as heart rate. MAP recordings also give an indication of the relative activity of various ion channels that flow during cardiac excitation.

Findings

Detailed data analysis of these types of records are labor-intensive and not yet complete, to date, however, we can state that:

During the cruise we were able to measure electrical activity from: $n = 6$ Yellowfin tuna – *Thunnus albacares*, $n = 2$ Bigeye Tuna – *Thunnus obesus*, $n = 6$ Mahimahi – *Coryphaena hippurus*, $n = 1$ *Escobaris*. The size of the fish ranged from 3 kg to 40 kg.

(1) It was possible to simultaneously record surface ECGs, MAPs and pressure development in the working heart configuration (Fig. 1)

(2) We were also able to simultaneously record MAPs from the epicardial and endocardial surfaces of Tuna ventricles allowing comparison of the electrical activity of the spongy and compact myocardium.

(3) A comparison of changes in ECG and MAP with heart rate over the range 0.2-1.2 Hz was made between tuna species and Mahimahi.

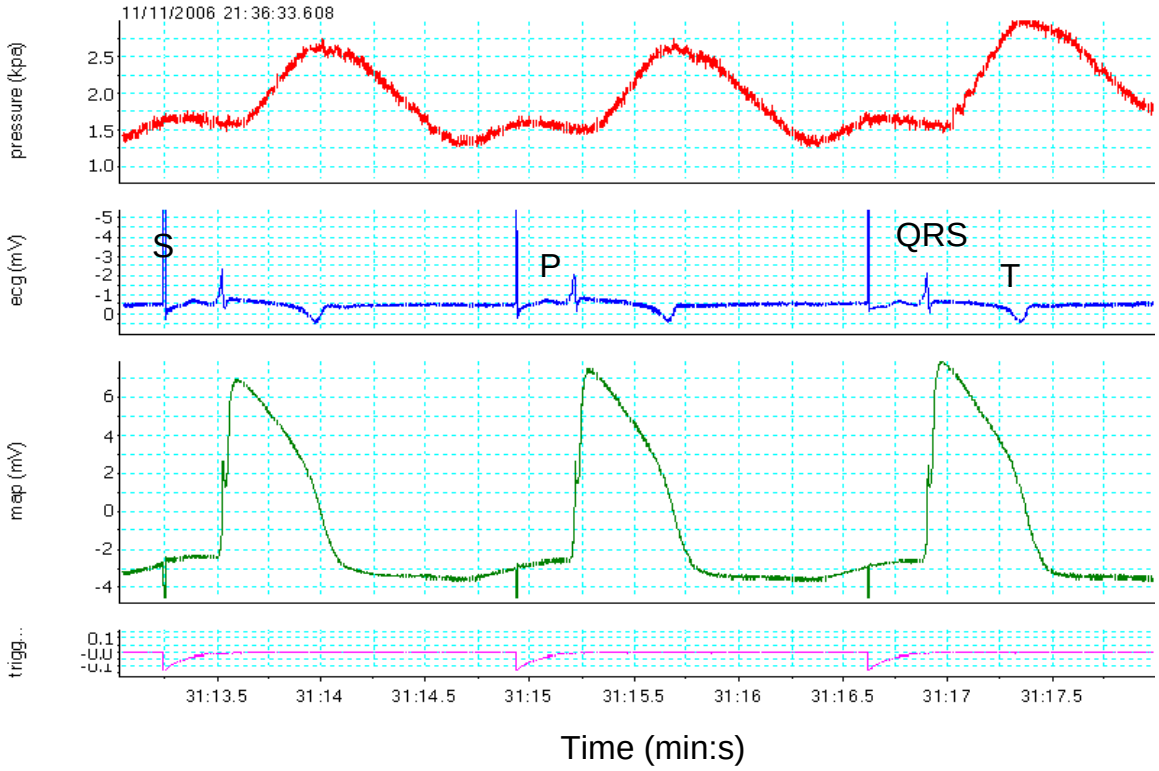

Figure 1.--Simultaneous recording of developed pressure (contractility), red trace; electrocardiogram (ECG) blue trace monophasic action potential (MAP), green trace and timing of paced stimulation pink trace, from the heart of an *Escobaris.* This figure demonstrates the relative timings of the electrical and mechanical events in response to paced excitation at 0.6 Hz at a temperature of 25 ºC. The ECG trace shows S = stimulus artifact; P = atrial excitation, QRS = ventricular excitation; T = ventricular repolarisation. The MAP trace shows the ventricular action potential in this species has a high plateau, suggesting control by L-type calcium current and delayed rectifier potassium currents, and a duration of approx. 500 ms.

CONCLUSIONS

(1) Very little is known about the comparative cardiac electrophysiology of pelagic fish species, and our study represents the first use of MAPs in fish hearts.

(2) Motion artifacts from both ship and muscle movement were, at times, problematical but not insurmountable, and the feasibility of on board measurement of ECG and MAP has been proven.

(3) Further detailed information regarding the cardiac electrophysiology of pelagic fish occupying different ecological niches awaits full analysis of our data.

(4) Availability of large holding tanks would improve efficiency by eliminating the famine/glut effect associated with fish availability.

An Investigation into the Thermal Sensitivity of Contractility and Excitation-Contraction Coupling in Pelagic Fish Cardiac Muscle

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University of Manchester

BACKGROUND TO THE STUDY

Ultrasonic telemetry studies have shown depth distribution of pelagic fish is species-specific[1,3]. While yellowfin tuna and mahimahi rarely inhabit depths below 100 m, experiencing temperatures between 17 and 30 ^{o}C[2,6], large adult bigeye tuna and swordfish routinely exploit depths of 350–1000 m, encountering water temperatures between 2.8 and 30^{o}C[1,8]. Since all pelagic fish hearts, including tuna, operate at near ambient water temperature, it has been suggested that cardiac temperature sensitivity is a limiting factor affecting vertical water movements[5]. The factors enabling bigeye tuna and swordfish to maintain cardiac function over large thermal gradients remain largely unknown. Several studies have pointed to enhanced specialisations in E-C coupling processes and the associated proteins as a possible contributing factor. For example, elevated levels of sarcoplasmic reticulum (SR) Ca^{2+}ATPase have been found in fish species which routinely inhabit the lower foraging depths[9]. Furthermore, cold tolerance of the myocardium of fish and hibernating mammals has been correlated with increased SR contribution to E-C coupling[4,10]. Thus, enhanced SR function may provide a means to sustain heart rate and cardiac performance in cold waters.

PROJECT AIMS AND METHODOLOGY

The purpose of our studies on the NOAA Ship *Oscar Elton Sette* was to test the hypothesis that depth distribution in pelagic fish species may be limited by cardiac temperature sensitivity. In addition, we propose that enhanced SR function may contribute to cardiac temperature tolerance and allow fish species to inhabit greater foraging depths. To achieve this, we assessed the temperature sensitivity of isolated cardiac muscle from various pelagic fish species with different dive profiles: two surface dwellers, the mahimahi and the yellowfin tuna, and two species which routinely dive to depths > 500 m, the bigeye tuna and the swordfish. Atrial and ventricular muscles were exposed to a temperature gradient, mimicking the temperatures associated with a physiological dive. This experiment was then repeated in the presence of the SR inhibitors, ryanodine and thapsigargin. Additionally, cardiac myocytes were isolated from the heart tissue of bigeye, yellowfin and mahimahi. The cells were transported back to the University of Manchester where confocal microscopy will be used to gather information on general morphmetrics and the presence of excitation-contraction coupling proteins.

PROBLEMS ASSOCIATED WITH WORKING AT SEA

Weighing out of chemicals for ringer solutions and blocking agents was almost impossible on the vessel, as the balance could not stabilize with the rocking of the boat. All chemicals were therefore pre-weighed on land. Muscle preparations were stretched due to the rocking motion, causing the elastic properties of the muscle to change throughout the experiment which led to alterations in the baseline level of tension. The movement of the boat also affected the ability of the isolated cells to adhere to the glass slides. Lastly, an obvious drawback to field research is the availability of fish and, as a consequence, we were limited in the number of animals we could experiment on.

RESULTS TO DATE

We are currently in the process of analyzing the data for these experiments and, as yet, cannot give definitive answers to our questions. However, the general trends are as follows:

(1) In all species and tissue types studied, reducing temperature caused an initial increase in force, followed by a progressive decline (Fig. 1).

(2) Bigeye tuna and swordfish maintained contractile function to much lower temperatures than yellowfin tuna or mahimahi.

(3) The temperature sensitivity of ventricular muscle from the pelagic species we tested correlated with their depth distribution (Fig. 1A). However, this was not the case with atrial muscle (Fig. 1B).

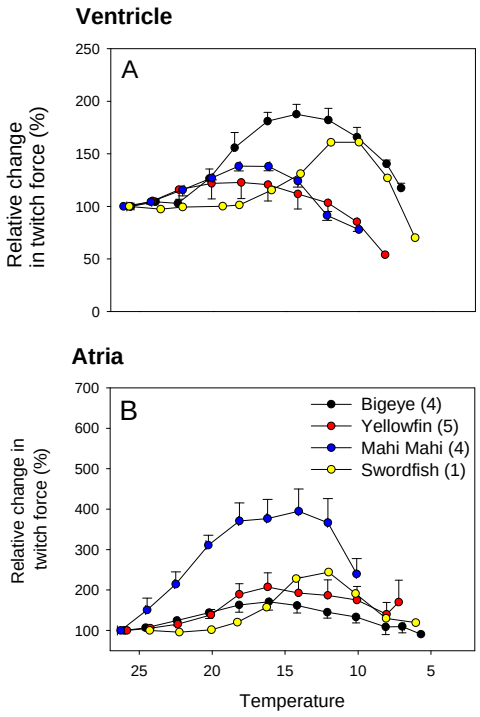

Figure 1. *Effect of temperature on the relative change in twitch force (A), average rate of rise (B) and average rate of 50% relaxation (C) in untreated ventricular tissue from the bigeye tuna (black circles), yellowfin tuna (red circles), mahimahi (blue circles) and the swordfish (yellow circles). Values are mean ± SEM; n values for each species are given in parenthesis in the figure legend.*

(1) The role of the SR under steady-state conditions at 26 ^{o}C was greatest in atrial vs.ventricular tissue and in species which dive to the lower foraging depths (bigeye tuna and swordfish) (Fig. 2).

(2) In all species, the SR plays an important role in maintaining contractile force during acute temperature change. However, SR dependence was most apparent at temperatures between 12–23 ^{o}C. Thus, the SR is unlikely to play an important role in maintaining cardiac function at temperatures lower than 12 ^{o}C.

(3) Study of the characteristics of tuna and mahi myocytes have not yet begun.

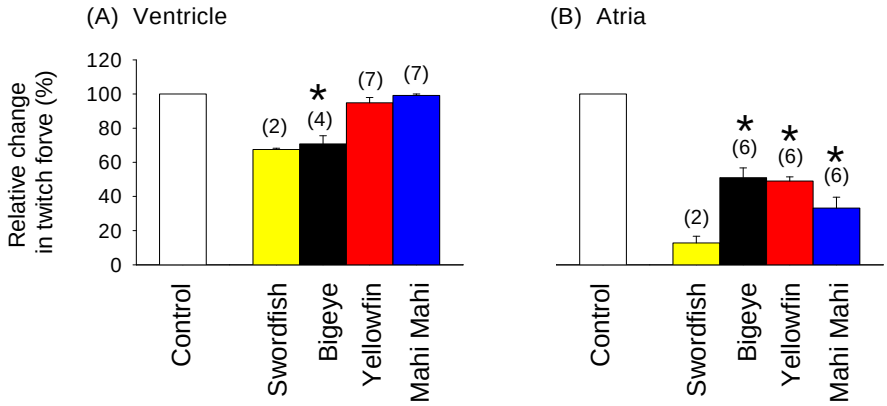

Figure 2. *Relative reduction in twitch force following SR blockade (ryanodine, 10 µM and thapsigargin, 2 µM) at 26 ^{o}C in ventricle (A) and atrial (B) tissue from the swordfish (yellow bars), bigeye tuna (black bars), yellowfin tuna (red bars) and mahimahi (blue bars). Values are mean ± SEM, n values are given in parenthesis above each bar. * denotes significant reduction in twitch force following SR blockade. Statistical analysis was not performed on the swordfish due to a low n value (2).*

FUTURE PLANS

Following these studies aboard the *Oscar Elton Sette*, Professor Brill and Dr. Shiels have organized a further collaboration to investigate these theories more thoroughly and to specifically gather more information regarding excitation contraction coupling in the swordfish. A grant proposal has been written to investigate the thermal sensitivity of bigeye tuna cardiac muscle at a number of organizational levels. This will include *in vivo* field studies, cellular and molecular investigations and is proposed to be in association with NMFS, NOAA, The University of Manchester and the University of Hawaii.

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Pop-up Satellite Archival Tags

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Based on examination of dive patterns of pop-up satellite archival tagged (PSATs) pelagic fishes, sharks and turtles (e.g., Musyl, M^{c}Naughton, Swimmer and Brill 2004), we investigated the hypothesis of the blue shark's (*Prionace glauca*) endothermic ability by measuring in situ red muscle temperature of six live-caught specimens from longline gear near Hawaii. Blue sharks, in terms of diving ability and thermal tolerances, occupy a vertical niche in the open ocean between surface dwelling epipelagic species such as the marlins, silky shark, whitetip sharks, yellowfin tuna and marine turtles and deeper diving inhabitants like swordfish, bigeye tuna, bigeye thresher shark and short-fin mako.

On a recent pelagic research cruise of the NOAA Ship *Oscar Elton Sette,* 17 longline sets were deployed in November 2006 near Hawaii. The number of hooks per set ranged from 374 to 824 with a fish-hook timer (www.mucrel.fr) on each of the droppers. The number of hooks per basket ranged 7–17 per basket. Number of hooks per basket was correlated with the phase of the moon with decreasing number of hooks per basket with the waning moon. Temperature Depth Recorders (TDRs, Starr-Oddi, DST centi-ex) were affixed on the mainline to monitor fishing depth and temperature. A thermosalinograph (TSG) aboard the ship continuously measured SST (^{o}C). Briefly, live blue shark were hoisted on board using a sling and quickly restrained with mattresses (see also Moyes et al., 2006). Two small incisions (ca. 1-2 cm) were routed for the thermocouple; one along the side (mid-base) of the dorsal fin and the other at the insertion of the pectoral fin. A general purpose thermocouple probe (08516-55, type K, response time rated at 15 sec in liquid) fitted to a Fluke 51-Series II thermocouple thermometer (type K) fitted was placed into red muscle and left for approx. 30 to 45 sec. Specimens were then released.

Samples consisted of four female sharks and two males captured in the mixed layer. Lengths of the sharks in the study ranged from 3.5 to ca. 6 ft (see Table 1). In situ red muscle temperature differences between pectoral and dorsal areas were not significantly different (*t*-TEST, $P>0.05$) among samples. 'Ambient' temperature, whether measured by the nearest TDR to capture location (on the longline) or by TSG was not significantly different (*t*-TEST, $P>0.05$). Therefore, red muscle temperatures were averaged for each specimen and then compared to 'ambient' temperature (i.e., average of TDR temperature and TSG). All six specimens exhibited significantly higher red muscle temperatures (mean 0.50 ± 0.09) than ambient temperature (*t*-TEST, $P<<0.001$). This was true for specimens "soaking" on the longline for prolonged periods. For example, as identified by hook timer data, female blue shark no. 5 (ca. 5 ft TL) was soaking for 8 hrs. 4 min. Another female blue shark (no. 3, ca. 4-5 ft. TL) was soaking for 2 hrs. 3 min. Hook timers on the other samples were not tripped or gave zero readings. We will require additional muscle temperature readings from specimens diving beneath the thermocline to properly assess the study question.

Table 1.--Blue Shark hooking properties, Cruise SE-06-12.

Position	Sex	Size (ca ft)	Date	Basket	Dropper number	Hook Timer	Fishing depth (m)	TDR temp. (ºC)
18,59-161,03	Female	4-5	11/24	94	2 of 7	0:00	~45	26.8
18,58-161,01	Male	6	11/24	107	5 of 7	0:00	~55	26-26.8
18,55-158,04	Female	4-5	11/26	9	4 of 13	2:03	~40-42	26.6
18,55-158,04	Male	6	11/26	17	3 of 13	Untripped	~40	26.6
18,54-161,03	Female	5	11/26	54	12 of 13	8:04	~42-50	26.3
18,22-158,30	Female	3.5-4	11/27	18	13 of 13	0:00	30-34	26.7

Longline Catch Details

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The number of hooks per set ranged from 374 to 824 with a fish-hook timer on each of the droppers. The number of hooks per basket, except for the first set, was an odd number and ranged 7–17 per basket. Number of hooks per basket was correlated with the phase of the moon with decreasing number of hooks per basket with the waning moon.

Length of the mainline and the line cast rate were effectively determined by adapting a bicycle computer to the longline lineshooter. The bicycle computer setup was calibrated during the cruise with known lengths of the monofilament mainline. In addition, with a portable handheld GPS unit, the position of each buoy was determined during deployment.

Within a longline set, barb and barbless circle hooks were alternated consecutively and for the barbless hooks, cutouts from rubber inner tubes were used to keep the bait on the barbless hooks.

Longline summary table in the number of hooks and catches by set during cruise SE-06-12, Novrmbrt 2-29, 2006. The retention rate was determined by enumerating the rubber cutouts during the haul back.

Date	Hooks				Retention rate (%)	Fish caught
	Hooks /Basket	Total	Barb	Barbless		
Nov. 4	14	450	222	228	-	2
Nov. 5	17	523	264	259	-	3
Nov. 8	17	718	354	364	98.3	8
Nov. 9	17	638	318	320	98.4	10
Nov. 10	17	695	345	350	99.7	8
Nov. 13	15	782	398	384	100	7
Nov. 14	15	633	321	312	99.0	4
Nov. 16	13	637	324	313	96.8	2
Nov. 17	11	599	309	290	100	3
Nov. 18	9	509	259	250	99.2	4
Nov. 19	9	689	352	337	100	2
Nov. 20	7	560	280	280	100	5
Nov. 23	7	724	361	363	99.2	3
Nov. 25	13	824	423	401	99.3	8
Nov. 26	13	784	391	393	99.5	5
Nov. 27	7	374	191	183	98.9	5
Total		10139	5112	5027	99.2	79

Summary of the catches by species and hook types during cruise SE-06-12 Cruise, November 2-29, 2006.

Group	Species	Hook type	
		Barb	Barbless
Shark	Blue	16	13
	White Tip	2	2
	Silky	3	0
	Mako	0	1
Tuna	Bigeye	2	3
	Yellowfin	1	1
	Skipjack	1	0
	Escolar	4	3
Billfish	Blue Marlin	0	2
	Stripped Marlin	1	2
	Swordfish	3	0
Others	Ono/Wahoo	0	1
	Mahimahi	4	5
	Barracuda	1	2
	Puffer	0	1
	Lancet Fish	1	0
	Snake Mackerel	5	0
Total		44	36

The nominal difference in the catches between barb and barbless circle hooks is 8. Catches were higher with barbed hooks but because of the low catches, the results suggest no difference between the two hook types.

Shaded Lightstick Experiments

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During the November 2006 Longline Cruise, the sink rates of branch lines with experimental and control lightsticks were measured. The goal of these experiments was to test how placing shades on lightsticks affected the sinking rates and position of dropper lines relative to the main lines. (NOTE: lightsticks were not activated due to NOAA restrictions).

On 9 separate longline sets (Nov. 3–Nov. 26), 12 experimental lightsticks were deployed per set. Of the 12 lightsticks, 6 lightsticks were deployed in a basket near the beginning of the mainline, and the remaining 6 were deployed in a basket toward the end of the mainline. Typically, each basket consisted of 17 branchlines. Each branchline with lightsticks was associated with 2 TDRs (time depth recorders – LOTEK – LTD 1110). One TDR was placed on the branchline clip next to the mainline. The other TDR was clipped at the end of the branchline near the hook (no bait was used on any of these branchlines). For each longline set, a total of 24 TDRs were utilized.

The 6 lightsticks tested were organized so that the first lightstick deployed in a basket was a control lightstick (LP Electrolume), the second was a lightstick (LP Electrolume) modified with a wide shade, the third was a control, the fourth a control, the fifth was a lightstick modified with a narrow shade, and the sixth was a control lightstick. This configuration allows user to examine the mean depth of experimental lightsticks vs. control lightsticks, the difference between depth of neighboring shaded and control vs. difference between depth of control vs. control lightsticks, difference in depth between mainline and dropper w/shaded lightstick vs. difference in depth between mainline and dropper with control lightsticks. In addition, we can also examine differences in the mean sink rate of shaded lightsticks vs. control lightsticks and the differences in sink rates between shaded and control vs. difference in rates between control and control.

Data from the time depth data logger have been downloaded, and the data is currently being analyzed.

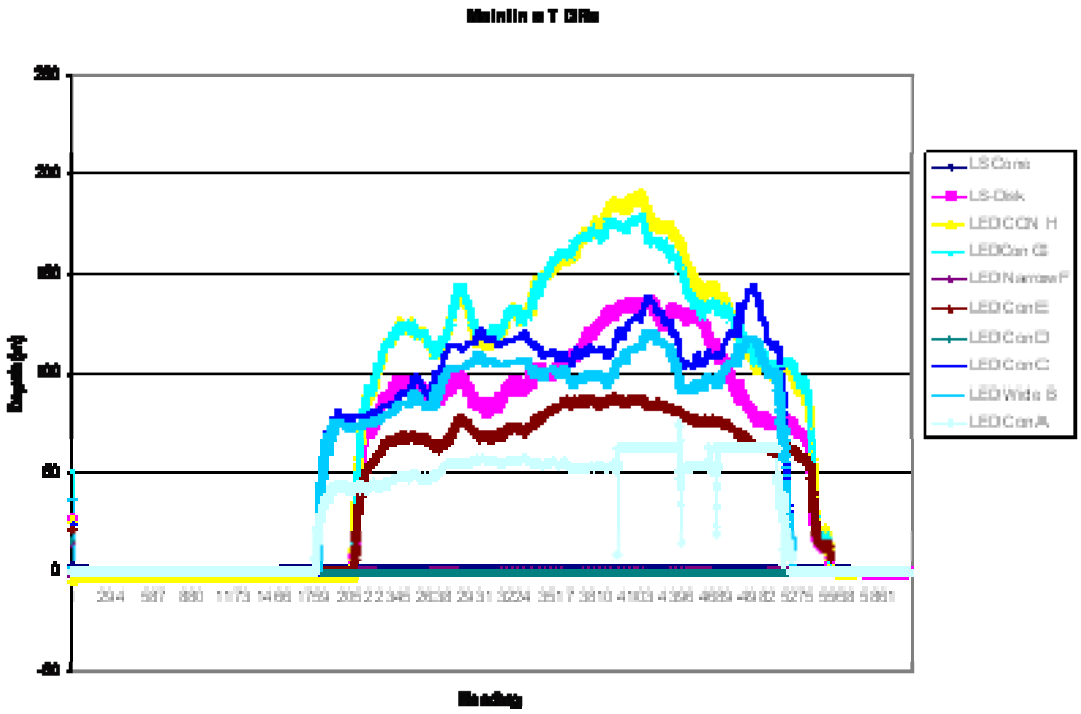

Figure 1.--Sample data from Mainline TDRs.