Improving the Utility of the CATs Video Cam and Tri-axial Accelerometer for Examining Foraging in Top Marine Predators

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LONG TERM GOALS

This project is aimed at improving the use of video accelerometry tags for understanding animal location, movements and foraging behaviors. The project aim is to test the second generation of CATS camera tags, a state-of-the-art archival inertial measurement tag with HD video and satellite for measurements of foraging and swimming performance in marine vertebrates. The CATS units are capable of recording motion with 9-degrees of freedom at high temporal resolution. Tri-axial accelerometers, magnetometers and gyroscopes record motion at 100 Hz for durations, depending upon how programmed for up to a week. In addition to the inertial measurement unit, the packages include a high resolution pressure-sensor (depth) and a speed sensor, based on a rotating turbine wheel. 18 hours of video can be recorded simultaneously with a duty cycle spread throughout the daily diary package data record. As these units collect large volumes of data no current technology is able to relay it via telemetry to satellite, and it is necessary to physically recover the units. These units will incorporate a "pop-off"-mechanism, whereby a galvanic release will activate after a set duration (1-3 days) upon which they will float to the surface and transmit their location via the Argos satellite. Units will be recovered at sea via boat. Testing of attachment strategies and performance will be conducted in the California Current (in Monterey Bay) and in laboratory settings.Our main goal will be to characterize the foraging performance of top marine predators in combination with inertial measurement units coupled with HD video.

OBJECTIVES

1. Project Original Duration: 6/01/2015- 11/30/2015 (6 months)
2. Stanford University researchers (Dr. Barbara Block and Jeremy Goldbogen) and University of Santa Cruz researcher, Dr. Daniel Costa) will test and improve the utility of the CATS video Cam tags for measuring foraging behavior, speed and accelerometry measurements in marine vertebrates (sharks, cetaceans, pinnipeds and tuna).
3. Cats cameras currently record 18 hours of video and 3-7 days of data continuously (tag size is 38 x 130 mm, wider at base, and 280 gr). Current generations tags have data being recorded at 40 Hz, pressure, temp and light at 10 or 20 Hz. Data acquired will be analyzed with

custom software that provides sensor data and visualization. This will allow researchers to examine video feeds while examining with maximum precision the data sensor information. We will test increased data acquisition in mammals up to 100 Hz and will utilize at least 4 tags for these deployments to test of the next generation of cameras. Tags can be redeployed multiple times

4. Purpose of our grant is to order the latest generation of tags and to perform deployments, tests and to discern the quality of the tags for examining locomotory movements of the animals being investigated

APPROACH

Specific Deployment Activities to date and Overall Progress as of November 2015:

a) Tags were ordered soon after arrival of the funding in summer quarter.

b) Tags arrived in September and October of 2015 putting us a bit behind but deployments were initiated on white sharks, cetaceans, elephant seals, and bluefin tunas.

c) Currently a total of six deployments have occurred (3 humpbacks), (4 white sharks, 1 salmon shark), (1 elephant seal), (2 bluefin tuna). The deployments have progressed well on the humpbacks and sharks, and a 3 day elephant seal deployment has been successful.

d) Some tags have performed flawlessly, while others do have issues with performance that are currently being investigated.

e) Data analyses have not yet occurred. Speed, acceleration range and accuracy values derived from experimentally validated data speed and pitch will be examined

f) We proposed to describe deployment difficulty and provide recommendations for improved procedures. We have already run into a few problems involving deployments that we've discussed with the engineers. Particularly some issues with downloading, power management and programming.

g) Analyses will proceed after the field season.

RESULTS

Deployment Summarys

Most of the field deployments of CATS tags have occurred in October 2015 and have required preparation of the tag, specific deployment options on each species for attachments, and some investigation of proper programming (data interval, sampling rates), and continued efforts are on-going in November with more deployments occurring particularly on the sharks and elephant seals. To illustrate deployment efforts and shapes of tags- the figures below provide examples on work thus far for white shark, bluefin tuna and elephant seals.

Figure 1. Panels illustrate attachment of shark CATS data logger and camera, accelerometer tag to a mature white shark off California.

Figure 2. Deployment of second generation CATS tuna camera tag on Atlantic bluefin tuna in October 2015

Figure 3. Deployment on elephant seal with translocation protocol in October 2015.

WORK COMPLETED

Results to Date:

Some tags and deployments have performed flawlessly. To date 3 deployments have worked perfectly on the humpback whales, 3 on white sharks, 1 on salmon sharks, and 1 on an elephant seal. Additional deployments have resulted in front and back facing cameras on bluefin tuna. One concern from tuna and cetacean deployments that went to depths over 200m is potential leakage in the package at a port- an area where a better design of the package closure is needed. The tags are in the second generation and have some bugs with the programming, and display, and packaging- engineers from the company are looking at the problematic tags to figure out solutions. Data analyses have not yet occurred. Speed, acceleration range and accuracy values derived from experimentally validated data speed and pitch will be examined. The second generation tag is using wi fi display and control which is an improvement on first generation tags. This enables putting the instruments out shipboard without having to hook up to a computer on the deck. We proposed to describe deployment difficulty and recommendations for improved procedures. We have already run into a few problems involving deployments that we've discussed with the engineers. Particularly some issues with downloading, power management and programming. Further analyses will proceed after the field season.

Improving External Tag Retention for Tuna

We are also doing some work on tags in the laboratory. That is an additional effort partially being supported by funding (most is from Monterey Bay Aquarium).

1. Designing of a novel tag holder for tuna telemetry

The idea of this novel tag design is to use the hydrodynamic forces appearing when tuna swim to facilitate tag attachment on the dorsal fin without physically bolting on the tag. For this purpose the shape of tag has been designed to generate inverted lift force in the same way as the spoiler on a racing car does. This will reduce or minimize the number of pins penetrating the fin that is a common practice for fin-mount tags today and is a subject of growing criticism in studies of marine charismatic species like dolphins, tunas, and sharks. Specific tag design was elaborated with the purpose of attachment of accelerometer and video camera to the tuna. The challenge in tag development for small tunas (~1 m FL) is the size of their dorsal fin that limits the dimensions of the equipment on-board as well as the size of a tag itself. Accelerometer version of tag included two 39x28x15 mm accelerometers, while accelerometer&camera version of tag included 39x28x15 mm accelerometer and bullet cam 22 mm diameter and 80 mm length.

2. CFD testing of tuna tag prototype

CAD model of symmetrical version of tag (two accelerometers) attached to the tuna was tested in CFD environment with the Solidworks package under the experimental conditions as following:

Thermodynamic parameters – Static Pressure: 101325.00 Pa, Temperature: 293.20 K

Velocity parameters – 8 m/s

Turbulence parameters – Turbulence intensity: 0.10 %, turbulence length: 0.002 m

CAD model of tuna without tag was tested under the same conditions to calculate the impact of attached tag in terms of drag. Increment of the drag force associated with the attached tag was 16% for the simulated speed of swimming 8 m/s.

The data obtained are estimation of tag performance for the certain flow regime, i.e. tuna gliding at the constant speed. The size of the computational domain and, consequently, accuracy of calculation of the forces and moments influencing attached tag was limited by the computational resources of a personal computer. Getting more realistic data on tag performance requires utilization of a computer cluster.

Figure 4. Pressure distribution on tag attached to the 2nd dorsal fin of tuna.

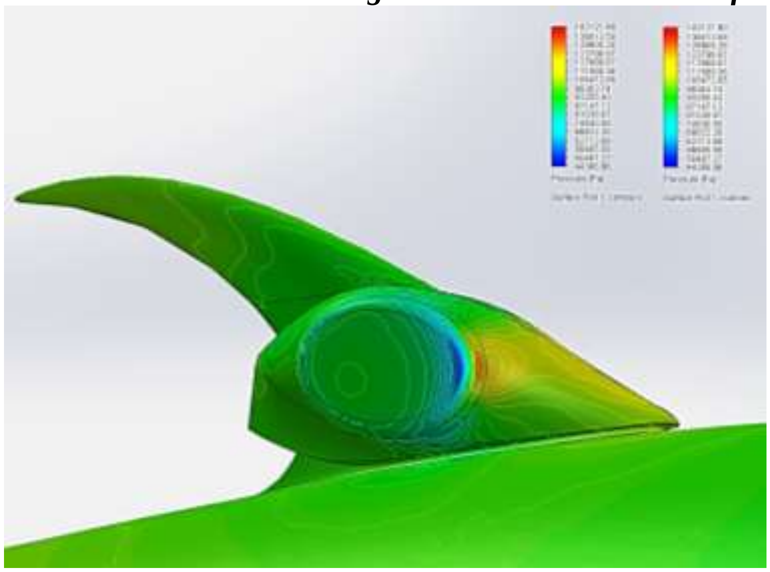
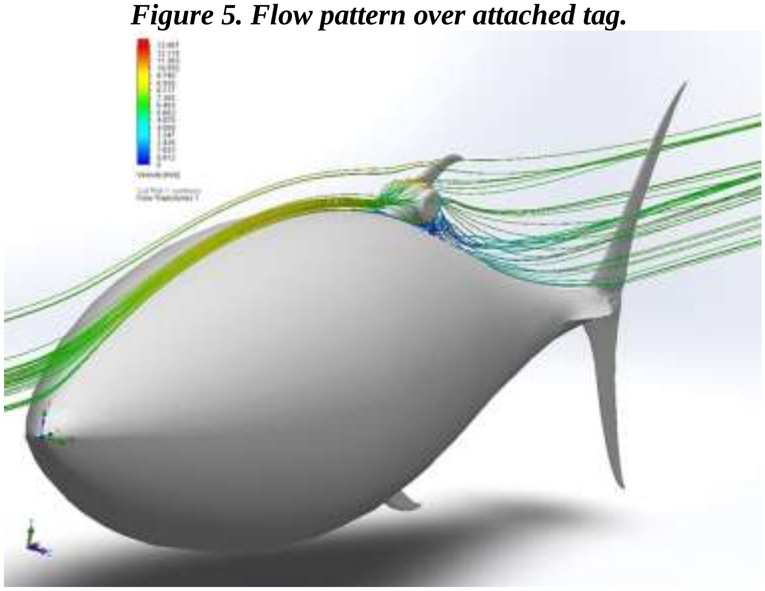


Figure 5. Flow pattern over attached tag.



3. Tag manufacturing

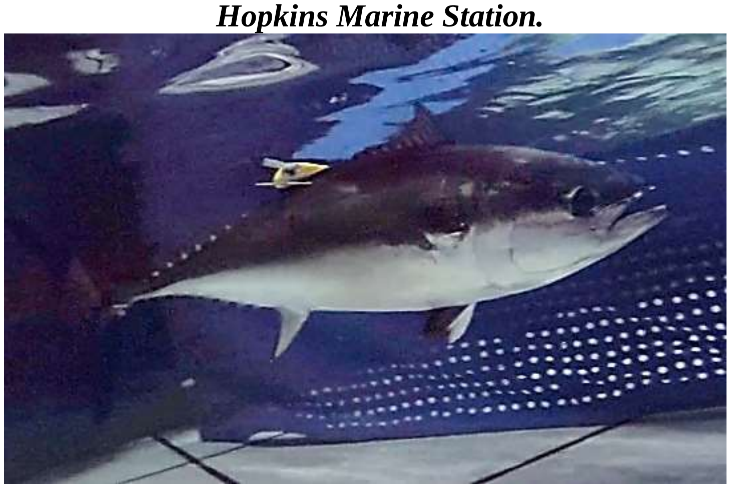
Tag models were printed with the Makerbot™ 3D printer using the PLA filament material. To prevent damage of fish skin by the rigid tag, the inner surface of tag contacting with the fin was covered by the 1.5 mm blue foam layer. Accelerometers as well as Hedcam™ action cameras were mounted in tag notches matching the size of equipment.

Figure 6. Camera&accelerometer version of tag attached to the fin model.

4. Tag testing on tunas in tank

New tags were tested on BFT and YFT in our tanks at the Hopkins Marine Station's Tuna research and conservation Center. Fish size varied a bit but did not exceeded 1m. Three different tags were used: symmetrical one (two accelerometers), the same with the winglets, and asymmetrical one (accelerometer + camera). All tags were slightly bigger than expected size of the fin and did not match the fin shape properly. A strip of was added foam between the tag and fin. Time of a tag attachment varied from 3 to 5 min. Tag remained attached even when fish was surfacing, so the tag was in between the water and air, thus having the high range of dynamic loads. It worked also for moderate accelerations and when the fish swam on the side. The main disadvantage of current tag design was a mismatch between tag and fin size. I had to use a stripe of foam that compromised the idea of the best fit dramatically. As a result there was a gap between tag and fin that could promote the premature detachment.

Figure 7. Symmetrical (two accelerometers) version of tag attached on BFT in T2 tank in Hopkins Marine Station.



5. Outlook

We tested first prototypes of ergonomic, non-invasive tags for tunas. Overall, there were quite tough operational conditions for tags, but we reached our primary goal: the novel tag design looks promising for the further development. The next step is expected to test tags that matches not only the fin shape but also the natural flexibility of the fin.

This work was done in collaboration with TRCC, Monterey Aquarium, and Lathrop Library, Stanford.

To date on these projects we have the following training on going:

3 Postdoctoral Fellows
4 Undergraduates
3 Graduate students

IMPACT/APPLICATIONS

NA

RELATED PROJECTS

NA

REFERENCES

No citations