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TAGGED SPECIES DETECTION: APPROACH TO MONITORING MARINE SPECIES AT MARINE HYDROKINETIC PROJECTS

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ABSTRACT

Verdant Power, LLC (Verdant) is licensed to operate an array of up to 30 kinetic hydropower turbines in East River, NY. During the licensing process, National Marine Fisheries Service (NMFS), the federal regulatory agency responsible for protecting Endangered Species Act (ESA)-listed Atlantic and shortnose sturgeons, expressed concern regarding the potential interaction of these species with the turbines. To advance understanding of potential interactions, Verdant, partnering with the marine fishery community through the Atlantic Cooperative Telemetry (ACT) Network, installed 3 VEMCO fixed detection devices near the Project to collect presence and distribution data on sturgeon tagged by the ACT researchers.

During the 25 months that the receivers have been deployed, 22 tagged fish ranging in size from <50 cm to >150 cm have been detected including 15 Atlantic sturgeon. These data have provided valuable spatial and temporal distribution information and represent the first documented proof that sturgeon migrate through the East River.

INTRODUCTION

The introduction of Marine Hydrokinetic (MHK) technologies into the East River, New York City, poses a new and unknown risk to fish populations. These unknown risks remain obstacles to the broad deployment of MHK devices [1]. To characterize this risk, a basic understanding of the MHK technologies involved, typical environmental conditions and target species distribution and spatial movements must be factored into the analysis. MHK technologies refer to a group of devices that extract energy directly from the kinetic energy present in moving water. Some devices, such as the turbine developed by Verdant, are designed to extract energy from tidal flows in a manner similar to the way a typical wind-turbine operates. The Verdant turbine is an open bladed horizontal axis, downstream type whose design is such that as the flow direction changes from flood to ebb tide, the turbine yaws to align with the flow. The Verdant turbine features a 5 m diameter rotor with a blade profile that allows it to rotate at a fixed speed of 40 rpm. As such, the tip speed ratio varies from 10.5 (V_w = 1 m/s) to 4.2 (V_w = 2.5 m/s) and the tip speed at rated power is 5 (V_w = 2.1 m/s) which would be the optimal tip speed ratio of 5. Since the turbine rotates at a fixed speed, the maximum tip speed = 10.5 m/s (23.5 mph).

The East River is a 17-mile long tidal strait connecting the waters of Long Island Sound with those of the Atlantic Ocean in New York Harbor (Figure 1). It separates the New York City Boroughs of Manhattan and the Bronx from Brooklyn and Queens and is a saltwater conveyance passage for tidal flow. The East River bifurcates to flow around Roosevelt Island, forming the East and West Channels. Verdant has received the first US Federal Energy Regulatory Commission (FERC) Hydrokinetic Pilot License (P-12611).The license allows for the operation of a commercial array of up to 30 kinetic hydropower turbines in the East Channel of the East River, known as the Roosevelt Island Tidal Energy (RITE) Project. While there had been no documented observations of sturgeon in the East River, two ESA-listed sturgeon species, Atlantic and shortnose, are known to occur in New York Harbor and Long Island Sound. Sturgeon of both species tagged in the Hudson River have been captured in Long Island Sound [2], [3].

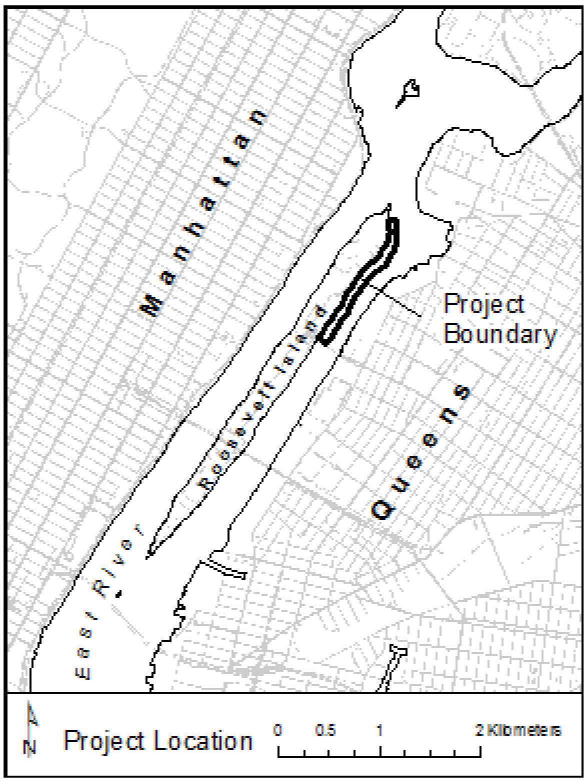

FIGURE 1. LOCATION OF VERDANT POWER RITE PROJECT IN THE EAST RIVER, NEW YORK CITY

Both Atlantic and shortnose sturgeon are large, long lived species known to occur in the Hudson River and Long Island Sound. Currently, there are over 1,500 Atlantic sturgeon, 350 shortnose sturgeon, over 2,000 striped bass along with bluefish, winter flounder, American shad and other fish tagged by ACT collaborators along the Atlantic Coast. While information on the tagged fish is shared among a group of marine researchers known as the Atlantic Cooperative Telemetry (ACT) Network, it remains the intellectual property of each researcher. Verdant maintains three acoustic tag receivers and periodically downloads the data. If a tag is detected, contact is made with the researchers in the ACT Network for identification. Given the tag number, the origin of the tagged fish can be determined and direct contact is made with the researchers who tagged the fish to provide information as to when and where the fish was detected. Similar acoustic tracking consortiums exist throughout the world.

MATERIALS AND METHODS

Passive acoustic monitoring is used to quantify the presence of tagged individuals. Underwater omni-directional acoustic receivers (VEMCO VR2W) have been deployed in the RITE Project area since 2011. The VEMCO VR2W is a submersible, single-channel acoustic receiver that consists of a hydrophone, receiver, identification detector, data logging memory, and battery, housed in a submersible case. It operates on a factory set frequency, can decode uniquely coded pingers and sensor transmitters from VEMCO acoustic tags, and records the tag code number and the date/time of detections. This information is stored in memory until downloaded. *Bluetooth* wireless communication is used to download the data; however, the unit must be out of the water for data uploads. It can store up to eight megabytes of data, which equates to more than one million valid detections. If a valid detection is received every 30 seconds, it will require about a year to fill the memory. Battery life is approximately 15 months.

Verdant Power has installed three VEMCO VR2W receivers in and around the RITE Project (Figure 2). Two of the receivers, VR2W RITE N and VR2W RITE S, were deployed in May 2011 in the East Channel of the East River from existing buoys at the RITE Project site. The third receiver,VR2W-W, was deployed in August 2011 in the West Channel of the East River using a concrete bottom mount, adjacent to an unused pier on Roosevelt Island. The primary receiver frequency is 69 kHz.

To confirm receiver operation throughout the data collection period, two unique test tags, TT-1 and TT-2 were deployed for data quality control. TT-1 was deployed in the East Channel from an existing buoy equally spaced between VR2W RITE N and VR2W RITE S. TT-2 was deployed in the West Channel attached to the concrete bottom mount with VR2W-W. The detection of a signal from both test tags, continuously present near the respective receivers, confirms continuous receiver operation throughout the reporting period.

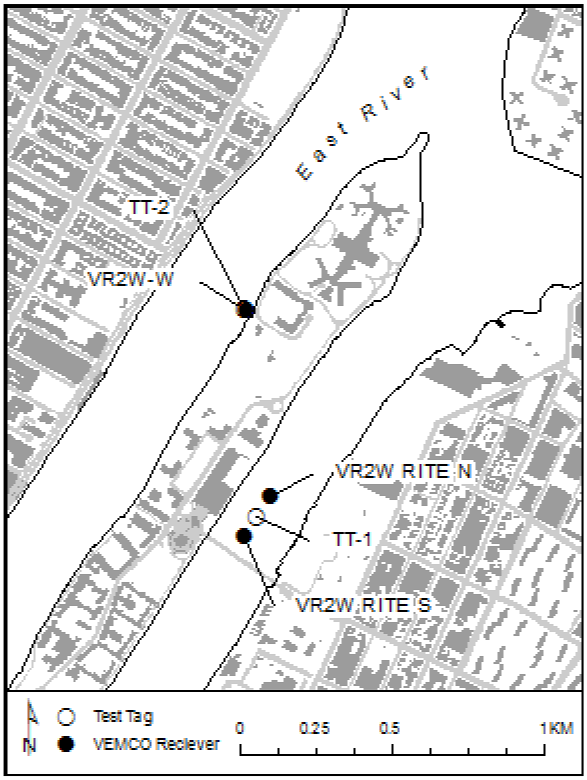

FIGURE 2. RITE VEMCO RECEIVER (3) AND TEST TAG (2) DEPLOYMENTS

To verify the range of detection of the East Channel receivers, Verdant conducted a mobile survey using a test tag in August 2011 that covered the reach of river proximate to the Project site and East Channel receivers (Figure 3). Near the end of an ebb tide, a vessel departed from Hallet's Cove, Station 1, and begin moving south towards the project site. At each station [1N – 4N] along the route, see Figure 3, the vessel stopped and remained stationary for a few minutes. The survey continued south of the Roosevelt Island to stations 1S and 2S. At the slack tide, the vessel returned north to the stations [5N – 7N] on the incoming flood and return to Hallet's Cove. The VEMCO data were then downloaded from the VR2W RITE N and VR2W RITE S receivers and analyzed. As shown on Figure 3, the estimated range of each receiver is 400 m (1300') in all directions, larger than the river width at each deployment location. This exercise confirmed the applicability of the two locations to detect tagged species as they pass in proximity to the RITE Project site. A similar exercise cannot be conducted in the West Channel to verify range, since it is the main navigation channel and small vessel movement in this pattern would be hazardous. A "detection event" indicates that a tagged fish was somewhere in the range of the receivers. The exact location both within the water column and within the cross section and thus a detection event means that a tagged fish came within 400 m of the proposed site of the operating turbine system. Per the guidance of VEMCO, individual tag identifications with only a single detection should be considered as false detections. VEMCO recommends, at minimum, one pair of detections less than thirty minutes apart.

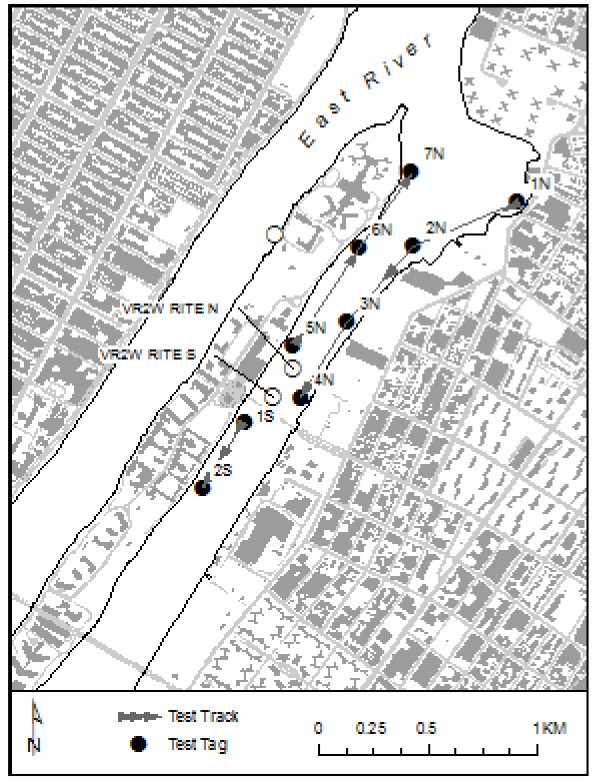

FIGURE 3. RITE PROJECT VEMCO RECEIVER RANGE, TEST TAG VERIFICATION – AUGUST 2011

The most recent data download represents the period May 2012 through August 2013, and covered the period of Superstorm Sandy during October 28-31, 2012. While the area in and around the Project experienced a significant localized storm surge of approximately 2 meters above normal tidal range, the VEMCO receivers remained in place and functional after the storm.

A summary of receiver deployments and downloads is provided in Table 1. Both VR2W RITE N and VR2W RITE S were deployed in May 2011. The West Channel receiver (VR2W-W) was deployed in late August 2011. Data collection continues at this time on all three receivers, with data continuity verified from the two test tags.

The maintenance of these detection stations requires the retrieval of each receiver (utilizing a diver) for onshore data transmission via *Bluetooth* link. Data download times are relatively short (<10 min) and receivers are immediately redeployed following successful transmission.

Yearly battery replacement and maintenance are required for proper operation.

The opportunity for Verdant to participate in a study of tagged species detection was facilitated by the existence of the Atlantic Cooperative Telemetry (ACT) Network. The process includes:

- Screening of the data to ensure test tag detection and isolate possible tags;
- Transmittal of the tags for verification through ACT;
- Researcher contact to identify tag, species, length and release date and location;
- Summary and reporting in relationship to RITE site and tidal conditions.

To date, this effort has been effective in the mutual provision of detection events to the researchers in the ACT Network in exchange for specific species identification of fish of interest at the RITE site.

RESULTS

All data collected from the East Channel receivers (VR2W RITE N and VR2W RITE S) represent 839 days of in-water detection time while data collected from the West Channel receiver (VR2W-W) represents 727 days of in-water detection time (Table 1). During this period there was no disruption in data continuity. Site specific information is available for the Atlantic sturgeon detected in the study (Table 2). This migration data is valuable to determine potential impacts of Verdant's MHK turbines on this species.

A total of 15 Atlantic sturgeon have been detected traversing the East River within 400 m of one of the three receivers (Table 2). Of those, one fish was detected in both the East and West Channels (detected May 5, 2012 in both channels) and one fish was detected in the West Channel on June 23, 2012 and again a year later on June 21, 2013. There were seven detections of other tagged species including four striped bass, one alewife and two American shad. One of the striped bass was detected in both the West and East Channels on October15 and 17, 2011, respectively. No tagged shortnose sturgeon have been detected traversing the project.

Detections occurred in both the East and West Channels, although more than twice as many Atlantic sturgeon were detected in the West Channel as the East (Table 2). The cross sectional areas of the two channels are roughly equal, as both channels have similar widths of approximately 240 m and depths of 10 m. The volume of water passing through both channels is equal to within approximately 5%. However, the West Channel has a slightly higher average flow speed which may account for more sturgeon traversing that channel. The direction of movement could not be determined as tags were simultaneously detected at both receivers deployed in the East Channel.

TABLE 1. SUMMARY OF RECEIVER DEPLOYMENTS AND DOWNLOADS IN THE EAST RIVER FROM MAY 2011 THROUGH AUGUST 2013

Receiver Download Date	VR2W RITE N	VR2W RITE S	VR2W RITE W
5/12/11	Deploy	Deploy	--
6/9/11	28 days	28 days	--
8/17/11	70 days	70 days	Deploy
12/19/11	--	--	111 days
5/21/12	278 days	278 days	154 days
8/18/12	89 days	--	--
8/27/13	374 days	463 days	463 days
Total Elapsed Time	**839 days**	**839 days**	**727days**

Atlantic sturgeon detections were concentrated in the mid-March to June period and October (Figure 4). Most Atlantic sturgeon were detected in the East River in June (7), then October (3) with two detected in May and one in each month of March, April and July. Superstorm Sandy occurred on October 29, 2012 and could have affected the 2012 data.

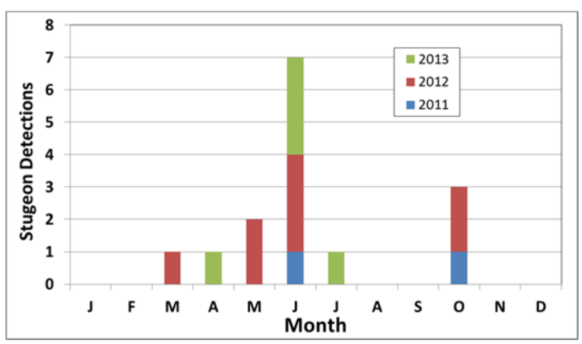

FIGURE 4. ATLANTIC STURGEON DETECTIONS BY MONTH IN THE VICINITY OF THE RITE PROJECT IN THE EAST RIVER, MAY 2011 TO AUGUST 2013

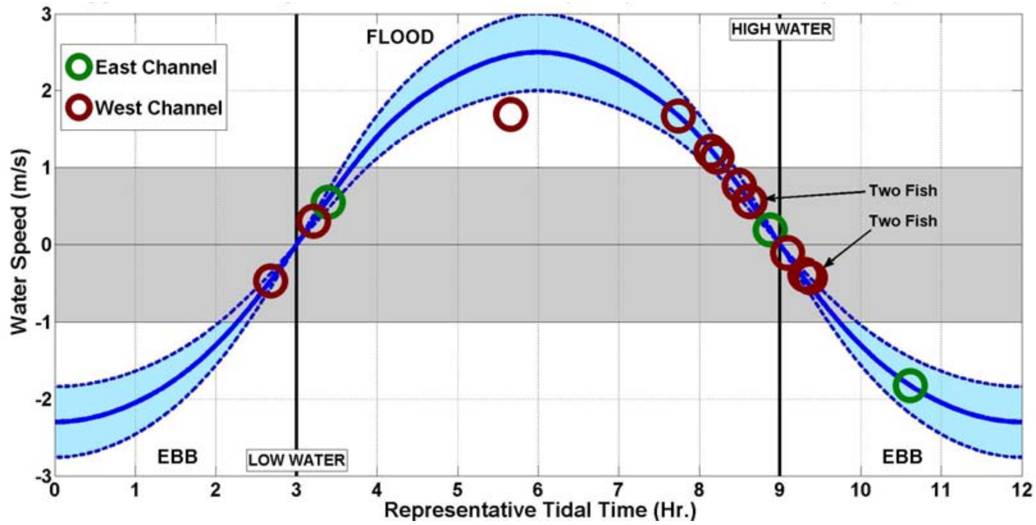

FIGURE 5. ATLANTIC STURGEON DETECTIONS RELATIVE TO TYPICAL TIDAL CYCLE IN THE VICINITY OF THE RITE PROJECT, EAST CHANNEL (3 IDS) AND WEST CHANNEL (12 IDS), EAST RIVER, MAY 2011 TO AUGUST 2013

TABLE 2. ATLANTIC STURGEON DETECTED IN THE VICINITY OF THE RITE PROJECT IN THE EAST RIVER, MAY 2011 TO AUGUST 2013

Date Detected	Channel Detected	Duration	Tide
June 6, 2011	East	1 Hr. 55 Min.	Slack
May 5, 2012	East	2 Min. 4 Sec.	Ebb
Oct. 10, 2012	East	1 Hr. 57 Min.	Slack
Oct. 19, 2011	West	9 Min. 2 Sec.	Slack
March 18, 2012	West	1 Min. 52 Sec.	Slack
May 5, 2012	West	6 Min. 49 Sec.	Slack
June 15, 2012	West	1 Min. 5 Sec.	Flood
June 19, 2012	West	1 Hr. 57 Min.	Slack
June 23, 2012	West	6 Hr. 16 Min.	Slack
Oct. 11, 2012	West	2 Hr. 50 Min.	Slack
April 7, 2013	West	1 Hr. 57 Min.	Slack
June 1, 2013	West	8 Min. 59 Sec.	Slack
June 20, 2013	West	48 Min. 28 Sec.	Flood
June 21, 2013	West	50 Min. 10 Sec.	Slack
July 7, 2013	West	9 Min. 35 Sec.	Slack

Detections of Atlantic sturgeon were mostly at slack or near slack tide when the Verdant turbines do not operate. Figure 5 depicts a typical East River tidal cycle range overlaid with the occurrence of the sturgeon during the tidal cycle. One sturgeon traversed through the East Channel during the ebb tide while two were detected in the West Channel during the flood tide. Of the 15 Atlantic sturgeon detected, only one had a chance to encounter an operating turbine as the turbines do not operate when the velocity is less than 1 m/s (shaded area) and there are no turbines in the West Channel. Unlike Atlantic sturgeon that were mostly detected at or near slack tide, striped bass, alewife and shad were recorded at flood, ebb and slack tide.

The detections of Atlantic sturgeon ranged from 6 hours and 16 minutes to 1 minute (see Table 2). For the 15 sturgeon detected, the average time in the project area was just over 2 hours. However, one sturgeon was detected in the area for over 6 hours and one for almost 3 hours while all the other 13 were there less than 2 hours. The majority of the sturgeon (7) were in the area for less than 10 minutes.

The time of day the sturgeon were detected migrating through the project area ranged from 3 am to midnight. Seven of the 15 sturgeon were detected during the day and the other 8 were detected at night.

Except for a short duration test August 31 to September 9, 2012, there were no operating tidal turbines in the water while these data were collected. During this short period of testing, no tagged fish detections occurred.

DISCUSSION

During the 25 months tagged sturgeon have been monitored in the vicinity of the Project in the East River, data have been collected that provide a previously unknown understanding of their use of this tidal strait. Prior to this study, researchers speculated with indirect evidence that sturgeon use this waterway to migrate between the New York Harbor and Long Island Sound [3]. Atlantic sturgeon, a large fish even amongst sturgeon species [4] undertake northerly summer and southerly winter coastal migrations [5]. Atlantic sturgeon remain in their natal estuary for months to years before emigrating to open ocean as subadults [6], [7], [8]. After emigration from the natal estuary, subadults and adults travel within the marine environment, using coastal bays, sounds, and ocean waters [9], [10],, [3], [5]. Dunton et al. [5] found Atlantic sturgeon were largely at water depths less than 20 m and formed aggregations at the mouths of bays (Chesapeake and Delaware bays) or estuaries (Hudson and Kennebec rivers) during the fall and spring then dispersed throughout the Mid- Atlantic Bight during the winter. Depth, temperature, and salinity were found to be significantly related to the distribution of Atlantic sturgeon along the Coast [5]. In addition, water temperature plays a primary role in triggering the timing of spawning [11]. Female sturgeon move downstream and out of the Hudson River soon after spawning in late April while males remain in the river until fall [12]. The sturgeon movements through the East River, primarily late spring and fall, coincide with their movements out of the Hudson River and observed coastal migration patterns.

While a large population of shortnose sturgeon occurs in the Hudson River from Troy Dam to the waters near Staten Island in New York Harbor [13], no shortnose sturgeon were detected traversing the East River. These fish are amphidromous, spending most of their lives in freshwater but occasionally migrating to estuaries [14]. Shortnose sturgeon have been captured near the confluence of the East River and New York Harbor and at least two shortnose sturgeon tagged in the Hudson River have been recaptured in the Connecticut River, although it is not know if these fish traveled through the East River, or exited through New York Harbor and into the Atlantic Ocean. Most shortnose sturgeon captured in the Hudson River estuary have been adults ([15].

The presence of tagged fish varied; however, most detections were short from less than 1 hour up to 6 hours, indicating a migratory pattern rather than residence. Most Atlantic sturgeon tags were detected at or near slack tide when the turbines do not operate. However, detection efficiencies can vary greatly with tidal periodicity. Maximum flood and ebb tides would be the noisiest and could decrease detection range to less than 400 m. While tag detection tests were conducted, they were performed on the slack side of the tides and do not represent all tidal conditions. However, Verdant deployed an array (24) of split-beam transducers to continuously monitor the Project area and results demonstrated movement patterns that were similar to those observed during the tag species detection study where most fish passed through the site at slack tide and few when tidal velocities were at maximum [16].

Verdant plans to continue deployment of the receivers for tagged species detection recognizing the ongoing success of this tagged species detection plan relies on the ongoing cooperation and sharing of tagged species identification by researchers in the community. This 25-month effort to detect sturgeon in the East River demonstrates that access to integrated telemetry data is beneficial. Recognizing that tag identifications are the intellectual property of the researchers, MHK developers and others planning receiver deployment must work within the framework of a cooperative agreement in order to guarantee continued access to data.

CONCLUSIONS

During 25 months, tagged Atlantic sturgeon have been monitored in the vicinity of the Project in the East River, and data have been collected that provide a previously unknown understanding of their use of this tidal strait. Of the 15 Atlantic sturgeon that traversed the East River, this study demonstrated only one would potentially encounter an operating tidal turbine (water velocity>1 m/s).

Tagged species detection is a cost-effective method for MHK developers to collect valuable site specific information on distribution of targeted species, but only if cooperative agreements with tagging research networks are established. In this arrangement, both entities benefit, the MHK developer, from specific site data and the research network receiving spatial and temporal information at additional receiver array locations. However, the success of this relationship is predicated on continuing support of funding through competitive grants that support the researchers' costs of tagging activities. Total costs are substantial as most tagging is done from research vessels with multiple researchers involved, therefore incurring labor, vessel and equipment cost that frequently exceed $100,000 per year. In addition, there is an exhaustive ESA permitting process required for tagging and additional costs to secure funding through competitive grants. Continued cooperation in the telemetry networks should be encouraged and MHK developers and others planning receiver deployment need to enter into upfront agreements with telemetry network researchers and encourage funding of ongoing tagging research activities.

ACKNOWLEDGEMENTS

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