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Mapping Physical Characteristics of the Columbia River Mouth Using Transmittered Diving Waterbirds

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LONG-TERM GOALS

The long-term goal of the project "Mapping Physical Characteristics of the Columbia River Mouth Using Transmittered Diving Waterbirds" is to investigate the use of diving waterbirds as sensor platforms to collect physical oceanographic data. Waterbirds may offer novel sampling opportunities in coastal waters, including areas difficult to access or under hydrologic conditions where traditional sampling equipment is difficult to safely or successfully operate. Our efforts are specifically designed

to support the RIVET II River Mouth and Inlet Dynamics Departmental Research Initiative (DRI) at the Mouth of the Columbia River (MCR).

OBJECTIVES

The objectives of this project are to:

- Investigate the use of cormorants (*Phalacrocorax* spp.) as platforms to measure conductivity, temperature, and depth across the MCR
- Collaborate with other RIVET II scientists to incorporate data collected into the development and/or validation of spatially-explicit models of salinity, bathymetry, frontal features, or other physical features for the MCR.

APPROACH

The spatial distribution of individual foraging cormorants can be precisely mapped using Global Positioning System (GPS) tags. GPS-tagged cormorants can then be fitted with an additional sensor tag(s), or birds can be fitted with single tags that integrate both GPS functionality and sensor capability, to collect a variety of spatially-explicit physical oceanographic data. Bathymetry can be sampled using tags that record and archive a pressure-derived measurement of depth. Salinity and temperature patterns can be measured by affixing tags incorporating a conductivity meter and temperature sensor.

Nesting cormorants are attractive candidates for this type of sampling because archival tags can be recovered by re-capturing the bird when it returns to the nest following foraging bouts. Cormorants nesting at East Sand Island (river kilometer 8 in the MCR) sample a large portion of the estuary and near-shore areas surrounding the MCR. Through unrelated ecological research funded by other sources, we have access to cormorants nesting at this site and are able to leverage that access and infrastructure to capture cormorants, affix tags, release tagged individuals, and recapture those individuals following the data collection period. Tag deployment and recovery can occur with a high rate of success (minimal tag loss) while nesting cormorants are incubating eggs and/or rearing younger chicks (typically from early May until late June). Tags can be affixed to birds using a backpack harness configuration, so that the tag(s) rides on the back of the bird, out of the water when the bird rafts on the surface (Courtot et al. 2012).

For studies funded under the RIVET II program, we selected commercially available tags that had previously demonstrated successful deployments on diving waterbirds for the majority of our deployments. Our primary choice of supplier for GPS tags was Earth and Ocean Technologies (E&OT; Kiel, Germany). These tags integrated GPS capability with sensors to measure pressure (depth) and temperature into a single, compact package. The temporal response of temperature and pressure measurements in these tags is quite good (stabilization time < 2 sec). Four conductivity/temperature/depth (CTD) tags from Star-Oddi (Garðabær, Iceland) were purchased to relate conductivity to temperature on a sample basis, although stabilization time on the temperature measurement was relatively poor (up to 20 sec). Two additional GPS-only tags were purchased from Skorpa Telemetry (Aberfeldy, Scotland) to evaluate a novel GPS technology ("Snap" technology) that offered a potential low-power, long-life GPS alternative.

WORK COMPLETED

Due to delays in the manufacturing process, the majority of tags were delivered to us in the middle of July, 2013, late in the 2013 cormorant breeding season. We conducted six tag deployments before the end of the cormorant breeding period in 2013, when further deployments were rendered unfeasible due to loss of fidelity by adult cormorants to their nest site. Nonetheless, these pilot deployments in 2013 were useful for focusing our deployment strategy in 2014. Tags from E&OT demonstrated capability to collect temperature and pressure data with fine scale geospatial resolution. Tags from Skorpa demonstrated ability to collect GPS data; however, improved manufacturing processes appear to be needed to ensure suitable (waterproof) packaging. Consequently, 2014 deployments relied exclusively upon E&OT tags for GPS information. A single Star-Oddi CTD tag deployment in 2013 indicated robust collection of sensor data. A subsample of deployments in 2014 included both E&OT and Star-Oddi tags on the same animal. Additionally, pilot deployments in 2013 also demonstrated that Brandt's cormorants (BRAC; *P. penicillatus*), never previously tagged at this site or using a backpack configuration, were amenable to the tagging program proposed. Previous experience tagging double-crested cormorants (DCCO; *P. auritus*) at the site had already demonstrated that this species was amenable to the proposed tagging. Deployments in 2014 were split between the two cormorant species to provide better geographic coverage across the MCR, with Brandt's cormorants expected to forage more often in marine waters and double-crested cormorants more often in fresher waters.

RESULTS

In 2014, cormorant tagging began in late May and continued until early August; georeferenced temperature and depth data were recovered from 32 deployments (15 BRACs and 17 DCCOs), with conductivity (CTD) data collected during 13 of those deployments. Cormorants exhibited high nest site fidelity during deployments (Figure 1). Archival tags were recovered for > 85% of deployments. Typical deployment duration was 3-7 days, with tags deployed on 3-6 birds simultaneously at any given time. Cormorant sampling was clustered in time and space but widespread across the MCR (Figure 2). Individual cormorants conducted one or more extended foraging bouts per day, with each bout including tens of dives in a given location within the MCR study area (Figure 3). Subsequent foraging that day or on successive days was sometimes nearby, but often relatively distant. Cormorants performed both mid-water and benthic dives to forage, with the foraging activity of Brandt's cormorants generally in more marine environments than that of double-crested cormorants, as expected. Dive depths for both species of cormorant frequently tracked water depth in the given area; Brandt's cormorants were recorded to dive as deep as 40 meters (Figure 4).

Calibration and further preparation of raw data and data analyses are ongoing.

Figure 1. Tagged Brandt's cormorant sitting on its nest during the tag deployment period.

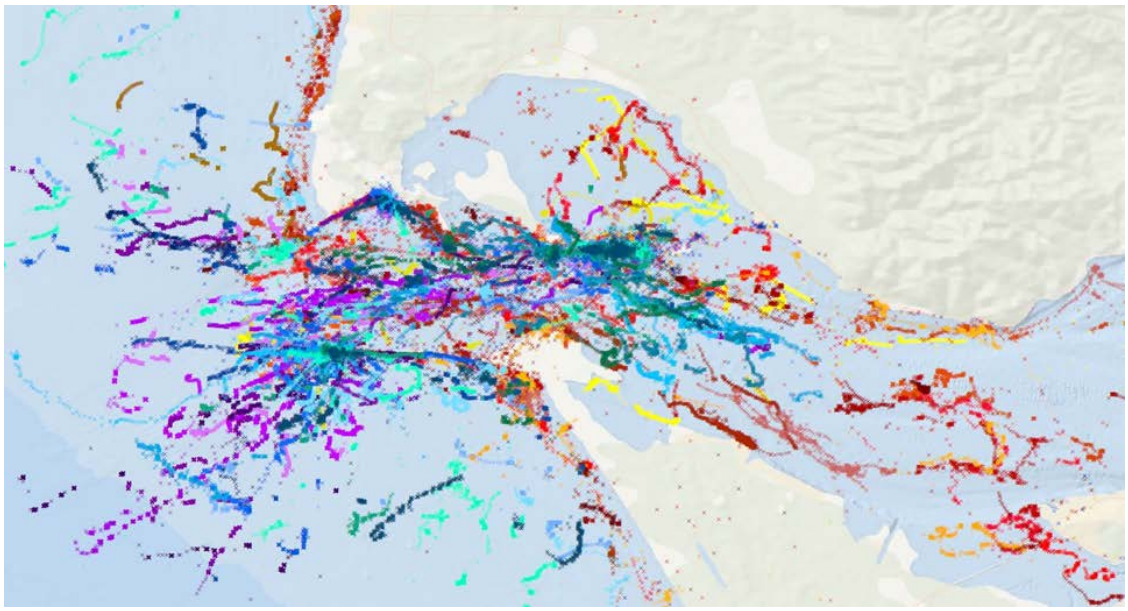

Figure 2. Locations of cormorant activity at the mouth of the Columbia River. Locations for each individual bird are shown in a distinct color. Brandt's cormorants are shown in shades of blue, green, and purple; double-crested cormorants are shown in shades of red, yellow, and brown.

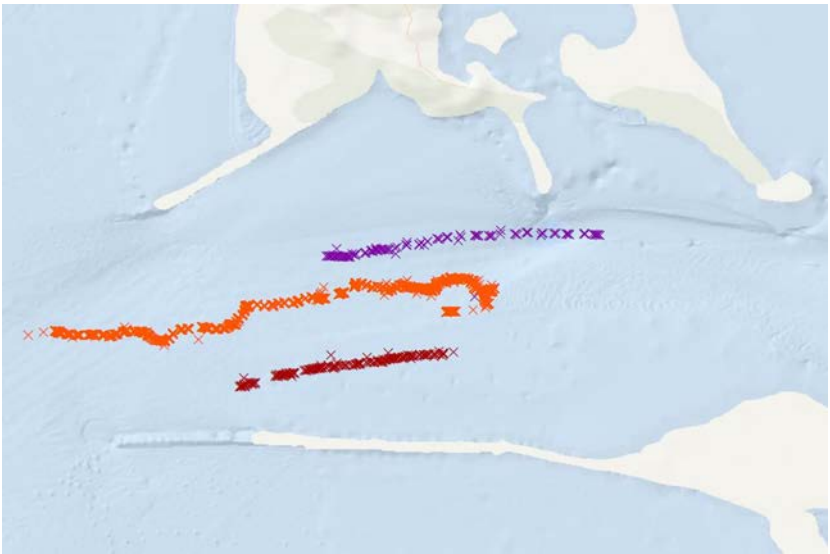

Figure 3. Selected diving bouts of cormorants at the mouth of the Columbia River. Each bout is shown in a distinct color; points are GPS locations taken during intervals at the surface between dives. Each diving bout represents 21 – 128 minutes of diving activity and 16 – 91 dives.

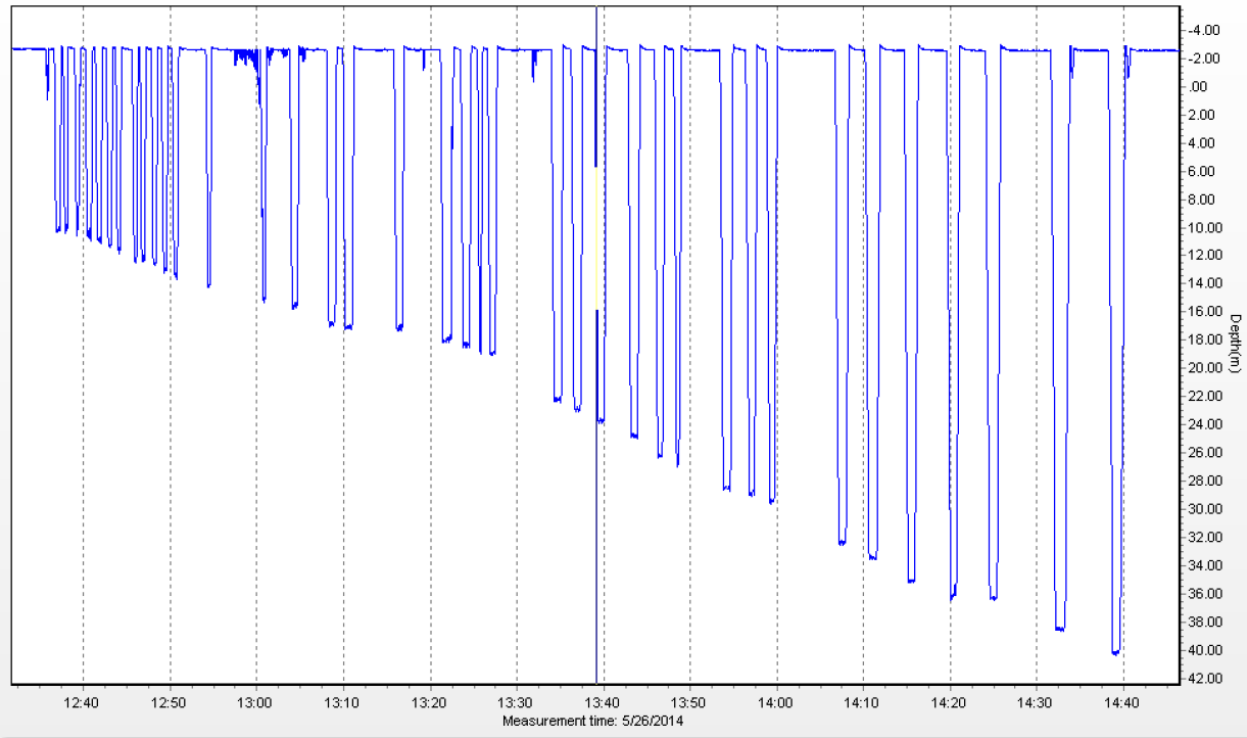

Figure 4. Dive depths (y-axis) recorded for a foraging Brandt's cormorant as a function of time (x-axis) during a diving bout between the north and south jetties of the MCR.

IMPACT/APPLICATIONS

The data collected during the 2014 breeding season demonstrates the potential use of cormorants to measure various physical oceanographic parameters. We were successful in capturing nesting adult cormorants and outfitting them with GPS units to track their position, and attaching multiple sensors of different types to collect oceanographic data. Cormorants sampled a substantial portion of the Columbia River mouth, including sites with different depths, temperatures, and salinities. Further analyses are ongoing to explore the utility of collected data to quantify bathymetry and salinity distributions at the MCR.

RELATED PROJECTS

We are collaborating closely with Dr. James Lerczak (Oregon State University), another participant in ONR's RIVET II MCR DRI, on all aspects of this work. He will lead data analysis efforts for the data collected in 2014. Characterization of MCR frontal features visualized by Dr. Merrick Haller (Oregon State University) using wave imaging radar will also be explored in the coming months.