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Short Note

Acoustic Detections of Cetaceans from a Towed Recording System on a Trans-Pacific Rowing Expedition

Jay Barlow[1] and Erden Eruç[2]

[1]*Unaffiliated, San Diego, CA, USA*
E-mail: jaybarlow33@yahoo.com
[2]*Ambassador for Ocean Recovery Alliance, President at Around-n-Over, PO Box 19662, Seattle, WA 98109, USA*

Trans-oceanic rowing has developed as an extreme sport and as an activity used to draw attention to worthy causes. The Ocean Rowing Society International (ORSI, oceanrowing.org) tracks many ocean crossings and races each year. From 22 June 2021 to 24 March 2022, one of the authors (EE) rowed solo from Crescent City, California, to Legazpi, the Philippines, with stops in Waikiki, Hawaii, and Guam, Mariana Islands, in a custom 7-m rowboat. Because rowboats are inherently much quieter than engine-powered vessels, such trans-oceanic rowing trips offer a unique opportunity to collect high-quality acoustic recordings in areas that are seldom frequented by other vessels. On the first two legs of this voyage (from California to Hawaii and from Hawaii to Guam), the vessel occasionally towed an underwater recording device. Herein, we present results from a preliminary analysis of recordings made during that voyage to identify acoustic detections of odontocetes (toothed cetaceans, including dolphins, beaked whales [family Ziphiidae], and sperm whales [*Physeter macrocephalus*]).

The acoustic recording system consisted of a SoundTrap ST300HF hydrophone recorder (Ocean Instruments Inc., Auckland, NZ) towed inside a streamlined flooded housing (Barlow, 2021). The towline initially consisted of a 10-m vertical line, a 2.7-kg spherical lead weight, and a 25-m horizontal towline (both towlines were 3-mm braided Kevlar). The towline was connected to the stern of the vessel, but this configuration greatly affected the direction of travel with waves. To reduce drag, the 10-m downline was shortened to 5 m. The 3-mm Kevlar downline was severely abraded over time with what appeared to be bite marks (likely from sharks) and was replaced with 6-mm Dyneema line. Acoustic data were digitized by the ST300HF at a rate of 288 kHz, which provided a usable recording range from 20 Hz to 144 kHz. Recordings were continuous when the recorder was deployed, with files broken into 2-min segments. Data were typically downloaded from the recorder to a computer solid-state drive after each significant deployment. Recordings were backed up onto an external hard disk. The depth of the towed hydrophone recorder was measured with a Sensus dive recorder (ReefNet, Inc., Mississauga, ON, Canada). A depth threshold of 1 m was used to determine when the towed recorder was actually recording useful data. The location of the vessel was determined from an onboard GPS enabled tracker. GPS data were transmitted by satellite to a database on land.

Acoustic data were processed with *PAMGuard* software (Gillespie et al., 2009), which stitched the 2-min files into a continuous record for analysis. The *PAMGuard* 'Click Detection' module was used to automatically detect the impulsive sounds that are characteristic of odontocetes' echolocation pulses. Detected pulses were initially classified into ranges based on peak frequencies (4 to 15, 15 to 30, 30 to 50, 50 to 65, and > 80 kHz). After this initial pre-processing, acoustic data were viewed in *PAMGuard Viewer* software to identify odontocetes' detection events in a semi-automated mode. First, the 'Click Template Classifier' module in *PAMGuard Viewer* was used to automatically identify pulses that were similar to beaked whales and sperm whales using an algorithm that is based on wave-form correlation. Then, an experienced analyst (JB) viewed the identified clicks in the *PAMGuard Viewer* 'Click Detection' window (in 2-min segments) to identify clicks that were likely to have been made by odontocetes. In this amplitude vs time window, clicks are depicted as symbols with symbol shape and color denoting their peak frequencies. Clicks with a waveform correlation that was above a given threshold (compared to idealized beaked whale and sperm whale waveforms) were displayed as a symbol with a different color and shape. Series of clicks that were associated in time were manually linked as *PAMGuard* events. Events were labeled as being either beaked whales (characterized by long pulses with a distinct frequency upsweep), sperm whales (low-frequency pulses with peak frequencies less than 15 kHz), and delphinids (short impulsive signals with a peak frequency greater than 20 kHz). The acoustic data were not analyzed to detect the low-frequency signals that are characteristic of baleen whales (typically < 3 kHz). Locations for acoustic detection events were based on the recorded transect location that was closest to the start of each event.

The rowing transects from California to Guam (when the towed recorder was aboard) totaled 7,694 nmi (14,250 km) (Figure 1). The towed hydrophone was found to affect the heading of the vessel more than anticipated; therefore, it could only be deployed when waiting on para-anchor during adverse conditions and when the combined effect of waves, wind, and drag allowed an acceptable heading. This led to fewer deployments than planned (Figure 1), particularly on the first leg of the voyage from California to Hawaii. Recordings totaled 170 h (equivalent to ~7 d of continuous recording). The mean depth of the recorder was 19.6 m.

Forty-four acoustic detection events were found in the acoustic data (Table 1). These included 11 beaked whale detections (Figure 1), one sperm whale detection (Figure 1), and 32 delphinid detections (dolphin species, including larger dolphins such as killer whales [*Orcinus orca*], pilot whales [*Globicephala melas*], and false killer whales [*Pseudorca crassidens*]; Figure 2). Species attributed to beaked whale echolocation pulses were validated independently by a second analyst (Jennifer Keating McCullough). The beaked whale species included Blainville's beaked whale (*Mesoplodon densirostris*, a tropical species), Cuvier's beaked whale (*Ziphius cavirostris*, a species with a broad distribution from cold temperate to tropical), the Cross Seamount beaked whale (a species with a tropical and warm temperate distribution and known only by its sound; McDonald et al., 2009), one unidentified beaked whale, and one possible beaked whale. The unidentified and possible beaked whale events occurred a few minutes after the detection of a confirmed beaked whale species (Blainville's beaked whale and Cross Seamount beaked whale) and are almost certainly the same species (although this could not be discerned from the signals alone). One of the Cuvier's beaked whale detections was ~2.5 h after a previous detection of the same species and very likely represents a second foraging dive from the same group. The sperm whale detection was 97 min long, which reflects the long range at which this species can be detected. Some of the delphinid encounters were also quite long. Breaking these into separate events was, to some extent, arbitrary.

The ability to map beaked whale distributions from their acoustic signatures is relatively recent. In a review of known beaked whale pulse types, Baumann-Pickering et al. (2013) found that beaked whale species produce recognizably different types of echolocation pulses. Some of the echolocation pulse types that have been attributed to beaked whales (such as the Cross Seamount beaked whale) have not yet been definitively matched to a known beaked whale species. Acoustic studies of beaked whale distribution have been largely limited to the

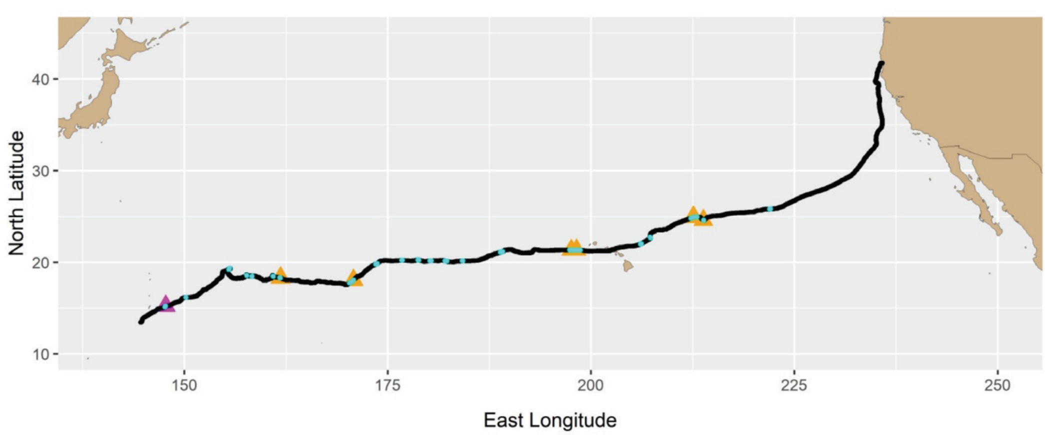

Figure 1. Rowed path from Crescent City, California, to Guam, Mariana Islands (black line); sections with a towed hydrophone (cyan); and acoustic detection locations for beaked whales (n = 11; orange triangles) and sperm whales (n = 1; magenta triangle). Some detections are too close to each other to be discerned on this scale.

Table 1. Times and locations for acoustic detection events. Positive latitudes are North, and negative longitudes are West.

Unique ID	Date/ (d/mo/y)	Time (UTC)	Event code	Species name	# detected echolocation signals	Latitude (º)	Longitude (º)
21	15/8/2021	0636 h	Del	Delphinid	97	24.591	-146.180
22	15/8/2021	0847 h	Md	Blainville's beaked whale	64	24.599	-146.176
15	19/8/2021	0952 h	Del	Delphinid	263	24.953	-147.106
16	19/8/2021	1021 h	Del	Delphinid	198	24.953	-147.106
17	19/8/2021	1307 h	Del	Delphinid	4,501	24.952	-147.155
18	19/8/2021	1429 h	Del	Delphinid	1,682	24.951	-147.169
19	20/8/2021	0058 h	Md	Blainville's beaked whale	579	24.911	-147.351
4	20/8/2021	0114 h	UnidBW	Unidentified beaked whale	5	24.911	-147.351
5	20/8/2021	0505 h	BWC	Cross Seamount beaked whale	239	24.905	-147.470
20	20/8/2021	1321 h	Del	Delphinid	6,012	24.845	-147.640
23	31/8/2021	1239 h	Del	Delphinid	3,974	22.739	-152.751
24	1/9/2021	0643 h	Del	Delphinid	12,263	22.670	-152.711
25	11/10/2021	2240 h	Del	Delphinid	2,099	21.328	-161.411
26	11/10/2021	2321 h	Del	Delphinid	249	21.330	-161.426
27	12/10/2021	0424 h	Del	Delphinid	4,545	21.346	-161.610
2	12/10/2021	0937 h	BWC	Cross Seamount beaked whale	156	21.340	-161.764
28	12/10/2021	0943 h	BW?	Possible beaked whale	28	21.339	-161.772
3	13/10/2021	0553 h	Del	Delphinid	14,966	21.344	-162.369
1	13/10/2021	0815 h	Md	Blainville's beaked whale	726	21.335	-162.430
30	13/10/2021	1105 h	Del	Delphinid	14,827	21.316	-162.516
31	26/10/2021	0746 h	Del	Delphinid	13,512	21.132	-171.029
32	26/10/2021	0908 h	Del	Delphinid	922	21.133	-171.065
33	12/11/2021	0923 h	Del	Delphinid	646	20.265	178.732
6	30/11/2021	0525 h	Md	Blainville's beaked whale	210	18.067	170.804
66	30/11/2021	0930 h	ZC	Cuvier's beaked whale	51	18.014	170.748
7	30/11/2021	1136 h	Del	Delphinid	4,331	17.984	170.725
8	1/12/2021	1324 h	Del	Delphinid	2,786	17.757	170.333
9	1/12/2021	1804 h	Del	Delphinid	1,820	17.732	170.267
67	17/12/2021	2025 h	ZC	Cuvier's beaked whale	63	18.281	161.853
68	17/12/2021	2259 h	ZC	Cuvier's beaked whale	17	18.285	161.793
69	29/12/2021	1624 h	Del	Delphinid	2,152	18.467	158.317
70	29/12/2021	1754 h	Del	Delphinid	1,036	18.466	158.293
71	2/1/2022	1526 h	Del	Delphinid	415	18.585	157.651
72	3/1/2022	0531 h	Del	Delphinid	242	18.542	157.642
73	3/1/2022	1427 h	Del	Delphinid	10,413	18.564	157.647
74	13/1/2022	0453 h	Del	Delphinid	410	19.226	155.450
75	13/1/2022	0659 h	Del	Delphinid	2,234	19.234	155.464
76	13/1/2022	1859 h	Del	Delphinid	79	19.260	155.508
77	4/2/2022	0610 h	Del	Delphinid	185	15.234	147.710
10	4/2/2022	0742 h	SW	Sperm whale	13,500	15.220	147.701
12	4/2/2022	1348 h	Del	Delphinid	5,252	15.204	147.642
13	4/2/2022	1420 h	Del	Delphinid	2,193	15.204	147.642
14	4/2/2022	1508 h	Del	Delphinid	89	15.203	147.634
11	4/2/2022	1527 h	Del	Delphinid	2,528	15.203	147.634

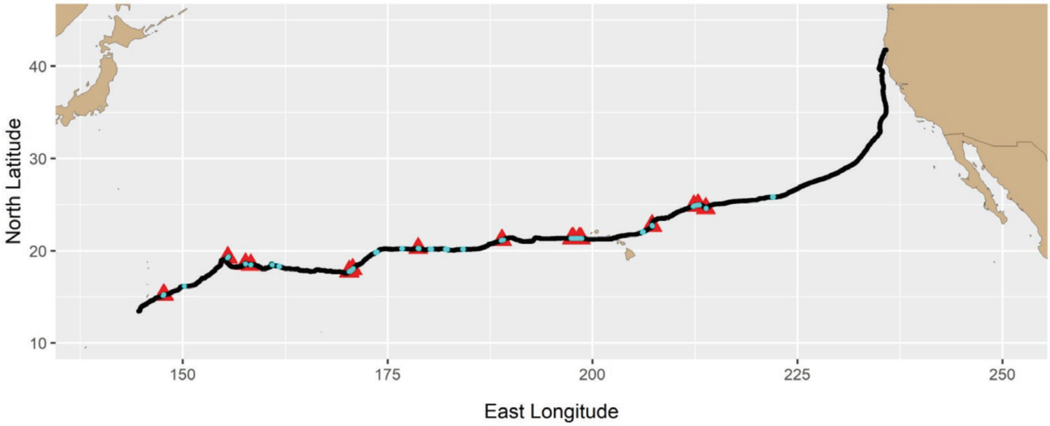

Figure 2. Rowed path from Crescent City, California, to Guam, Mariana Islands (black line); sections with a towed hydrophone (cyan); and acoustic detection locations for delphinid cetaceans ($n = 32$; red triangles). Some detections are too close to each other to be discerned on this scale.

margins of continents and islands and on seamounts (Baumann-Pickering et al., 2014), where seafloor recorders can be easily placed at depths where beaked whales forage. Recently, however, the development of drifting and towed acoustic recording systems have allowed the extension of these distributional studies to the deeper waters of the vast abyssal plains that comprise most of the major ocean basins (Griffiths et al., 2019; Barlow et al., 2021). Although efforts have begun, large gaps still exist in our knowledge of beaked whale distributions (MacLeod et al., 2006).

In this study, we have used a vessel of opportunity to acoustically sample abyssal areas that have never before been surveyed for beaked whales. Our data show the first observations of Cross Seamount beaked whales 500 nmi northeast of Hawaii; whereas earlier studies found them only in Hawaii and western Pacific waters (Baumann-Pickering et al., 2014; McCullough et al., 2021a, 2021b), and off Baja California, Mexico (Simonis et al., 2020). Delphinids were even more common in our recordings than beaked whales, although we were not able to determine the species. The dolphins are typically hard to identify based only on their echolocation clicks; therefore, an approach based on multiple types of sound (including clicks, whistles, and burst pulses) has showed great promise in other areas (Rankin et al., 2017). Before this advanced approach can be applied to our survey area, the classification algorithms need to be trained with a dataset of known-species sounds from this same area. We hope that future analyses of our recordings can help fill in some of the gaps in what we know about delphinid distributions.

Perhaps our most important contribution is in highlighting the potential for gathering valuable acoustic data via vessels of opportunity. We anticipate that this is just the beginning of such endeavors. Acoustic recordings and transect lines will be made available to other researchers upon request.

Acknowledgments

This Pacific crossing by EE was an Explorers Club Flag Expedition (https://www.explorers.org/about/in-the-field), which substantiates its scientific merits. Generous donations from Dr. Michael Williamson of WhaleNet and Peter Ackroyd put the expedition in motion. Multilingual lesson plans that Ocean Recovery Alliance developed based on this expedition broadened the educational reach of Around-n-Over. Exploring by the Seat of Your Pants connected the expedition with classrooms. Numerous unsung heroes on the home front—in Crescent City, in Waikiki, in Guam, and in the Philippines—stepped forward to make this expedition a success. John Atkins (Ocean Instruments) graciously provided the ST300HF recording system used in this study. Jennifer Keating McCullough aided the data transfer from Hawaii and assisted in validating the species identifications for beaked whales.

Literature Cited

Barlow, J. (2021). *Design of a flooded housing for a towed autonomous hydrophone recording system* (NOAA Technical Memorandum NMFS-SWFSC-647). National Oceanic and Atmospheric Administration, U.S. Department of Commerce. 12 pp. https://doi.org/10.25923/rmzp-fh90

Barlow, J., Cheeseman, T., & Trickey, J. S. (2021). Acoustic detections of beaked whales, narrow-band high-frequency pulses and other odontocete cetaceans in the Southern Ocean using an autonomous towed hydrophone recorder. *Deep Sea Research Part II: Topical Studies in Oceanography*, *193*, 104973. https://doi.org/10.1016/j.dsr2.2021.104973

Baumann-Pickering, S., Roch, M. A., Brownell, R. L., Jr., Simonis, A. E., McDonald, M. A., Solsona-Berga, A., Oleson, E. M., Wiggins, S. M., & Hildebrand, J. A. (2014). Spatio-temporal patterns of beaked whale echolocation signals in the North Pacific. *PLOS ONE*, *9*(1), e86072. https://doi.org/10.1371/journal.pone.0086072

Baumann-Pickering, S., McDonald, M. A., Simonis, A. E., Solsona Berga, A., Merkens, K. P., Oleson, E. M., Roch, M. A., Wiggins, S. M., Rankin, S., Yack, T. M., & Hildebrand, J. A. (2013). Species-specific beaked whale echolocation signals. *The Journal of the Acoustical Society of America*, *134*(3), 2293-2301. https://doi.org/10.1121/1.4817832

Gillespie, D., Mellinger, D. K., Gordon, J., McLaren, D., Redmond, P., McHugh, R., Trinder, P., Deng, X. Y., & Thode, A. (2009). *PAMGuard*: Semiautomated, open source software for real-time acoustic detection and localization of cetaceans. *The Journal of the Acoustical Society of America*, *125*(4), 2547. https://doi.org/10.1121/1.4808713

Griffiths, E. T., Keating, J. L., Barlow, J., & Moore, J. E. (2019). Description of possible species-specific echolocation pulses of Hubb's beaked whale in the California Current. *Marine Mammal Science*, *35*(3), 1058-1069. https://doi.org/10.1111/mms.12560

MacLeod, C., Perrin, W. F., Pitman, R., Barlow, J., Ballance, L., D'Amico, A., Gerrodette, T., Joyce, G., Mullin, K. D., Palka, D. L., & Waring, G. T. (2006). Known and inferred distributions of beaked whale species (Cetacean: Ziphiidae). *The Journal of Cetacean Research and Management*, *7*(3), 271-286. https://doi.org/10.47536/jcrm.v7i3.737

McCullough, J. L. K., Oleson, E. M., Barlow, J., Allen, A. N., & Merkens, K. P. (2021a). *An acoustic survey in the main Hawaiian Islands using drifting recorders* (PIFSC Administrative Report H-21-04). Pacific Islands Fisheries Science Center. 26 pp. https://doi.org/10.25923/rzzz-0v38

McCullough, J. L. K., Wren, J. L., Oleson, E. M., Allen, A. N., Siders, Z. A., & Norris, E. S. (2021b). An acoustic survey of beaked whales and *Kogia* spp. in the Mariana Archipelago using drifting recorders. *Frontiers in Marine Science*, *8*, 761. https://doi.org/10.3389/fmars.2021.664292

McDonald, M. A., Hildebrand, J. A., Wiggins, S. M., Johnston, D. W., & Polovina, J. J. (2009). An acoustic survey of beaked whales at Cross Seamount near Hawaii. *The Journal of the Acoustical Society of America*, *125*(2), 624-627. https://doi.org/10.1121/1.3050317

Rankin, S., Archer, F., Keating, J. L., Oswald, J. N., Oswald, M., Curtis, A., & Barlow, J. (2017). Acoustic classification of dolphins in the California Current using whistles, echolocation clicks, and burst pulses. *Marine Mammal Science*, *33*(2), 520-540. https://doi.org/10.1111/mms.12381

Simonis, A. E., Trickey, J. S., Barlow, J., Rankin, S., Urbán, J., Rojas-Bracho, L., & Moore, J. E. (2020). *Passive acoustic survey of deep-diving odontocetes in the California Current ecosystem 2018: Final report* (NOAA Technical Memorandum NMFS-SWFSC-630). National Oceanic and Atmospheric Administration, U.S. Department of Commerce. 48 pp.