Differential vulnerability to ship strikes between day and night for blue, fin, and humpback Whales based on dive and movement data from medium duration archival tags

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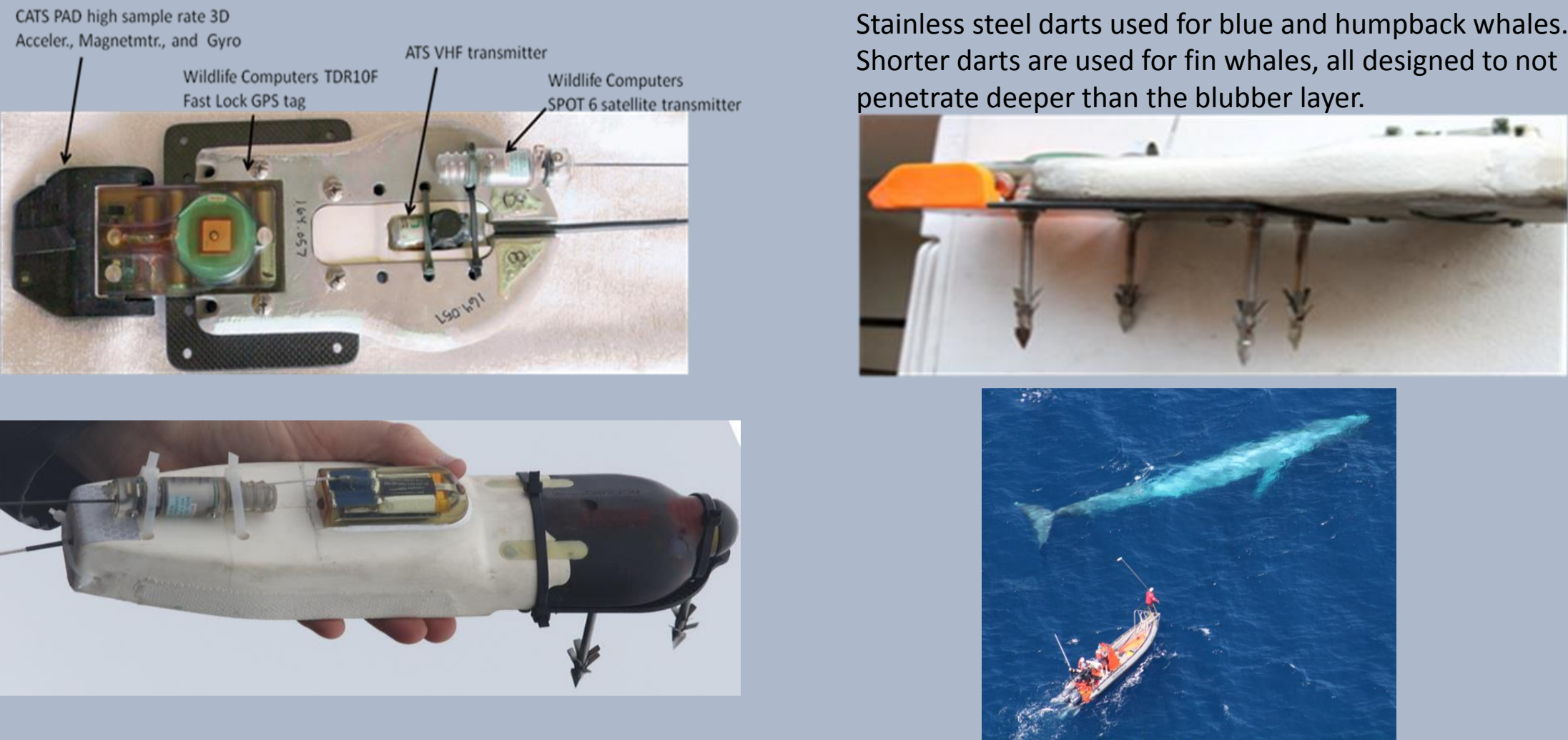
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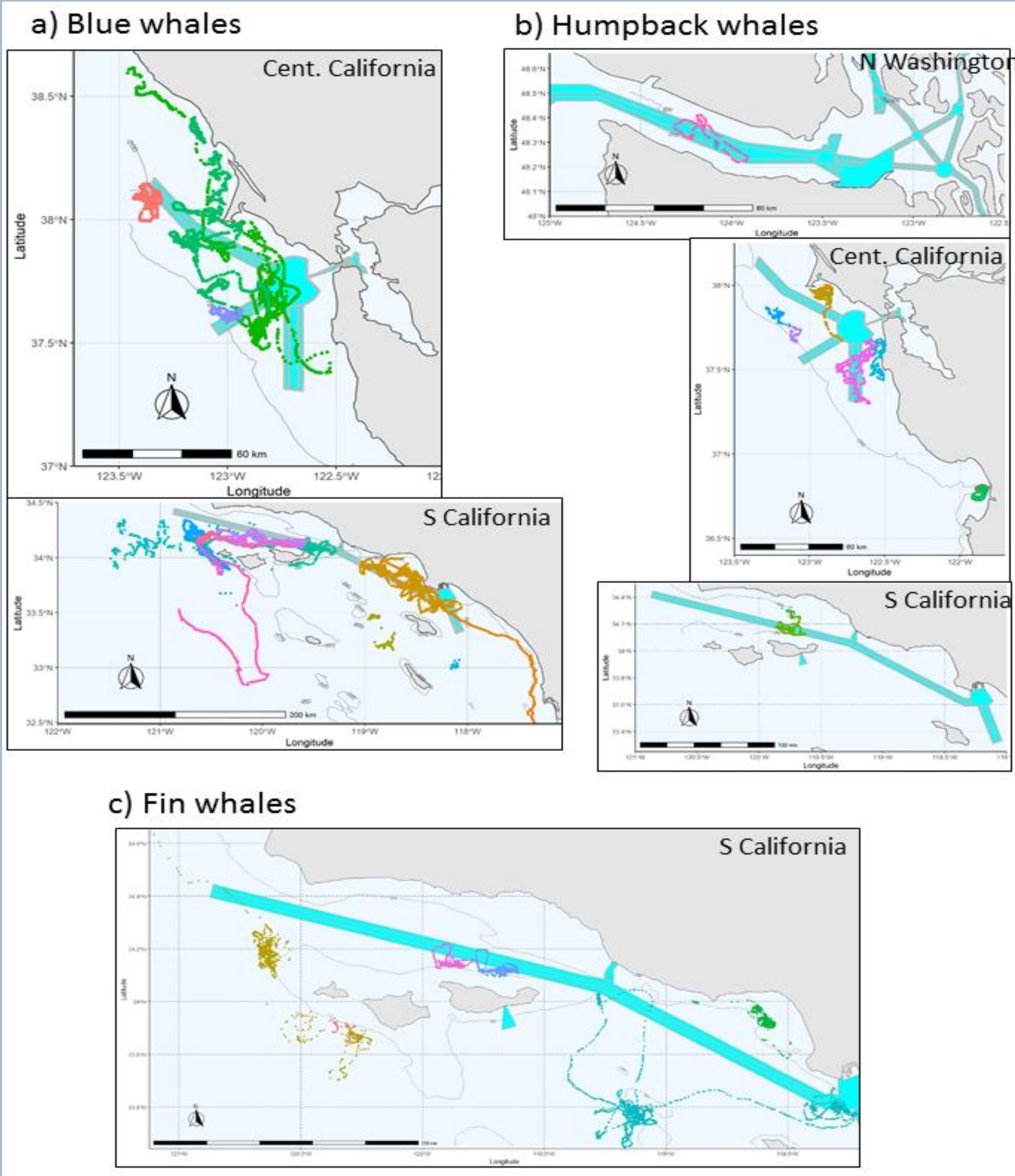
Abstract

We examine the dive and movement behavior of blue, fin, and humpback whales along the US West Coast in regions with high ship traffic where ship strikes have been identified as a major concern. All three species are known to feed in coastal waters near areas of high ship traffic:1) the Southern California utilized by ships using the ports of LA/Long Beach, 2) the Gulf of the Farallones west of the ports in San Francisco Bay, and 3) the Strait of Juan de Fuca, the main access for ports in Vancouver and Puget Sound. We analyzed data from 33 archival tag deployments representing over 3,000 of data that were attached with suction cups or short darts for periods >24 hours and recorded depth (≥1 Hz), fast-lock GPS positions and other deployment-specific sensors. There were clear differences among the three species but all showed a distinct diurnal difference in diving behavior. While dive depth varied among animals based on where prey was located, whales spent a high proportion of their time closer to the surface where they would be more vulnerable to ship strikes at night than in the day. This was most pronounced for blue whales where vulnerability was twice as high at night compared to the day. We also found differences in movement patterns of whales between day and night. Movements were more localized to specific areas in the day near prey resources while at night these movements often involved directional movements (though sometimes circling back to the same area by the end of the night). We show how in several specific areas like the Santa Barbara Channel, these differences in movements and locations translate to a very different overlap with shipping lanes at night compared to the daytime locations, which is the basis for most sighting data.

Approach

Two types of archival tags deployed , TDR10 (above) and Acousonde (below), adding satellite transmitter, attachment plate and stainless steel darts and GPS unit.

CATS PAD high sample rate 3D Acceler., Magnetmtr, and Gyro
Wildlife Computers TDR10F
Fast Lock GPS tag
ATS VHF transmitter
Wildlife Computers SPOT 6 satellite transmitter

Stainless steel darts used for blue and humpback whales. Shorter darts are used for fin whales, all designed to not penetrate deeper than the blubber layer.

Deployments and movements were off California and Washington

a) Blue whales

b) Humpback whales

c) Fin whales

KEY FINDINGS

There were significant differences among species (blue, fin, and humpback whales) in their diving behavior and movements that alter their vulnerability to ship strikes.

All three species were more vulnerable to ship strikes at night than in the day including spending up to twice as long near the surface at night.

At night whales often did not feed, they engaged in different diving behavior, and also tended to take more directional movements than in the day.

Daytime positions were not very good predictors of locations of whales at night.

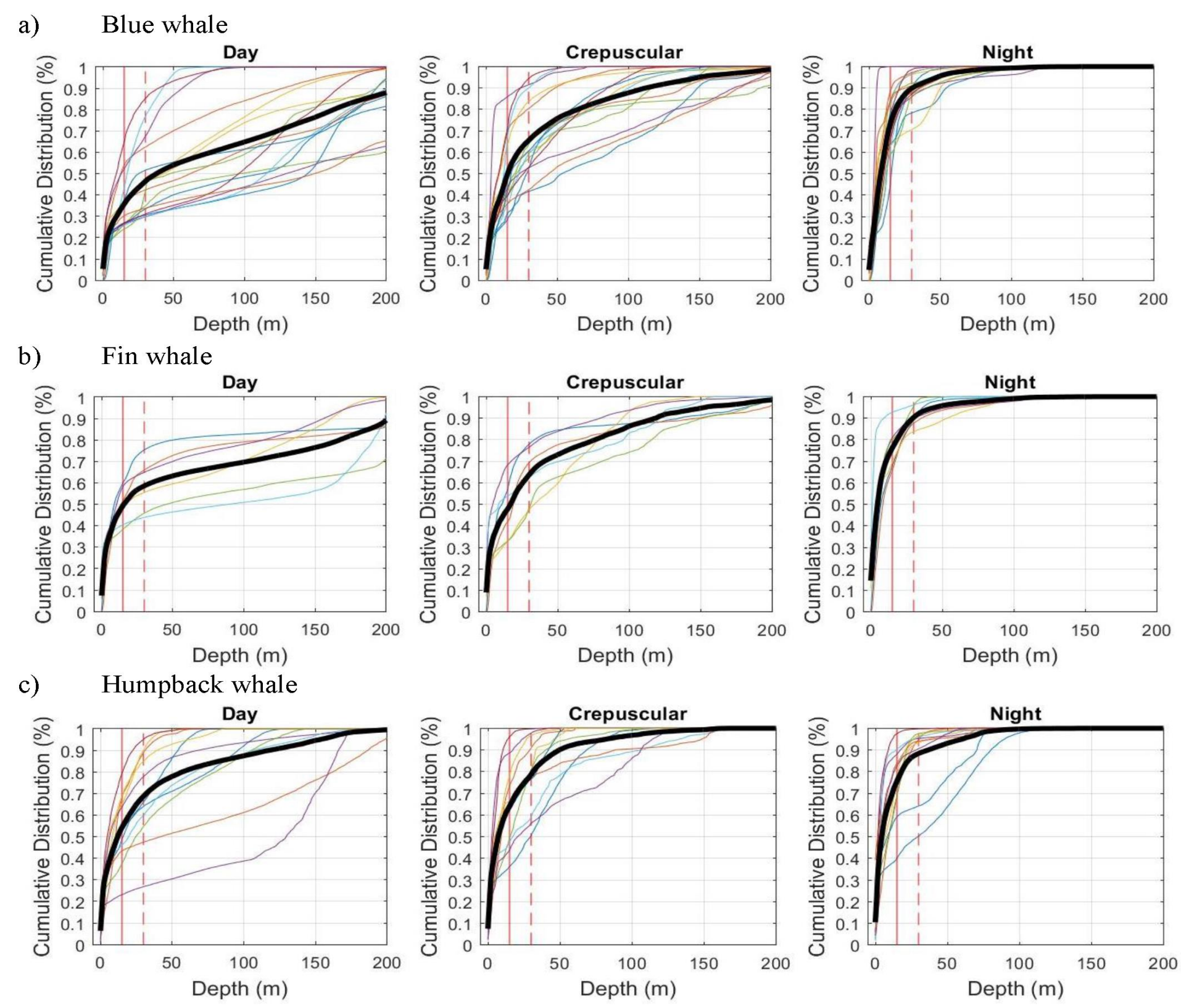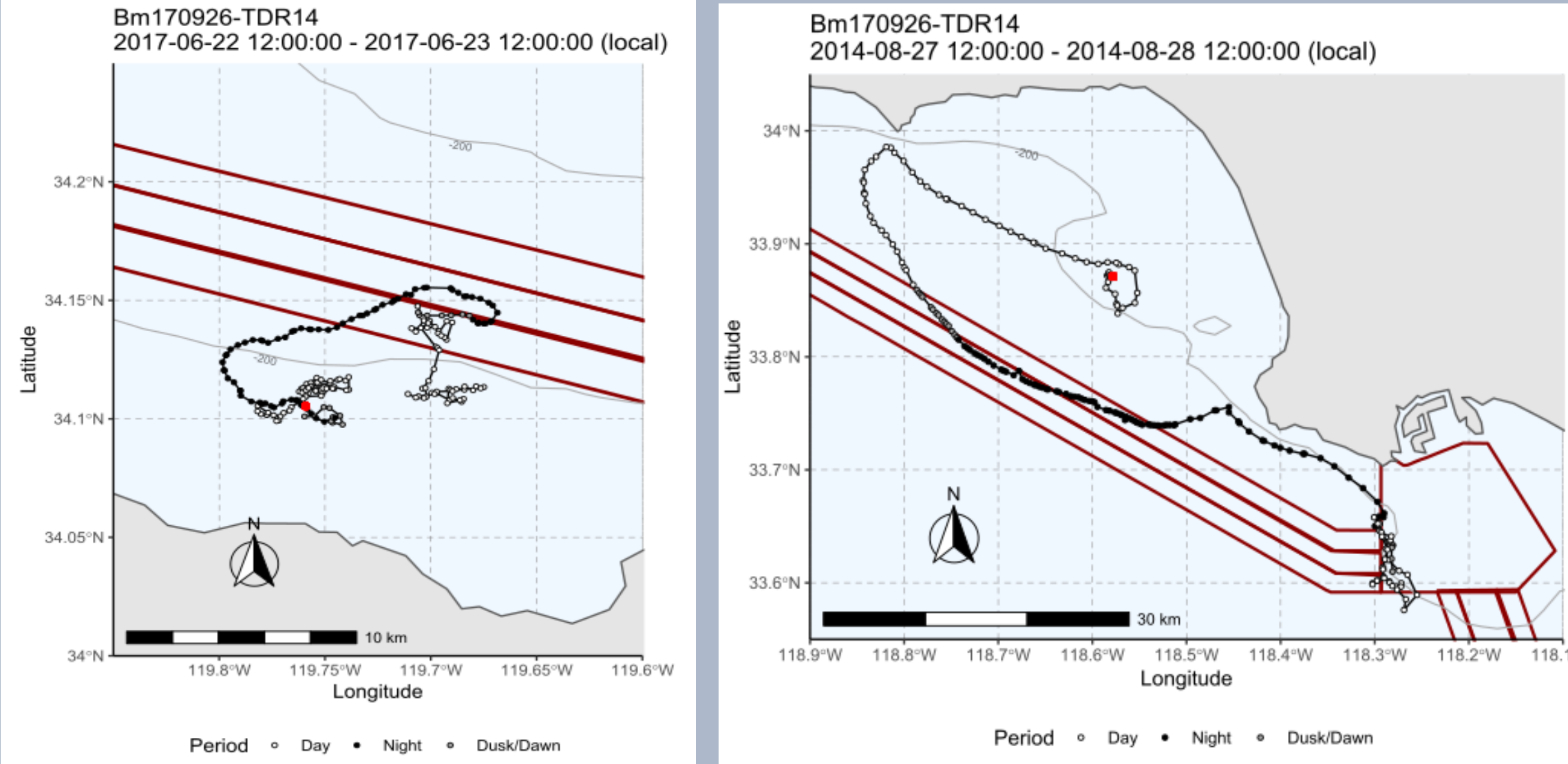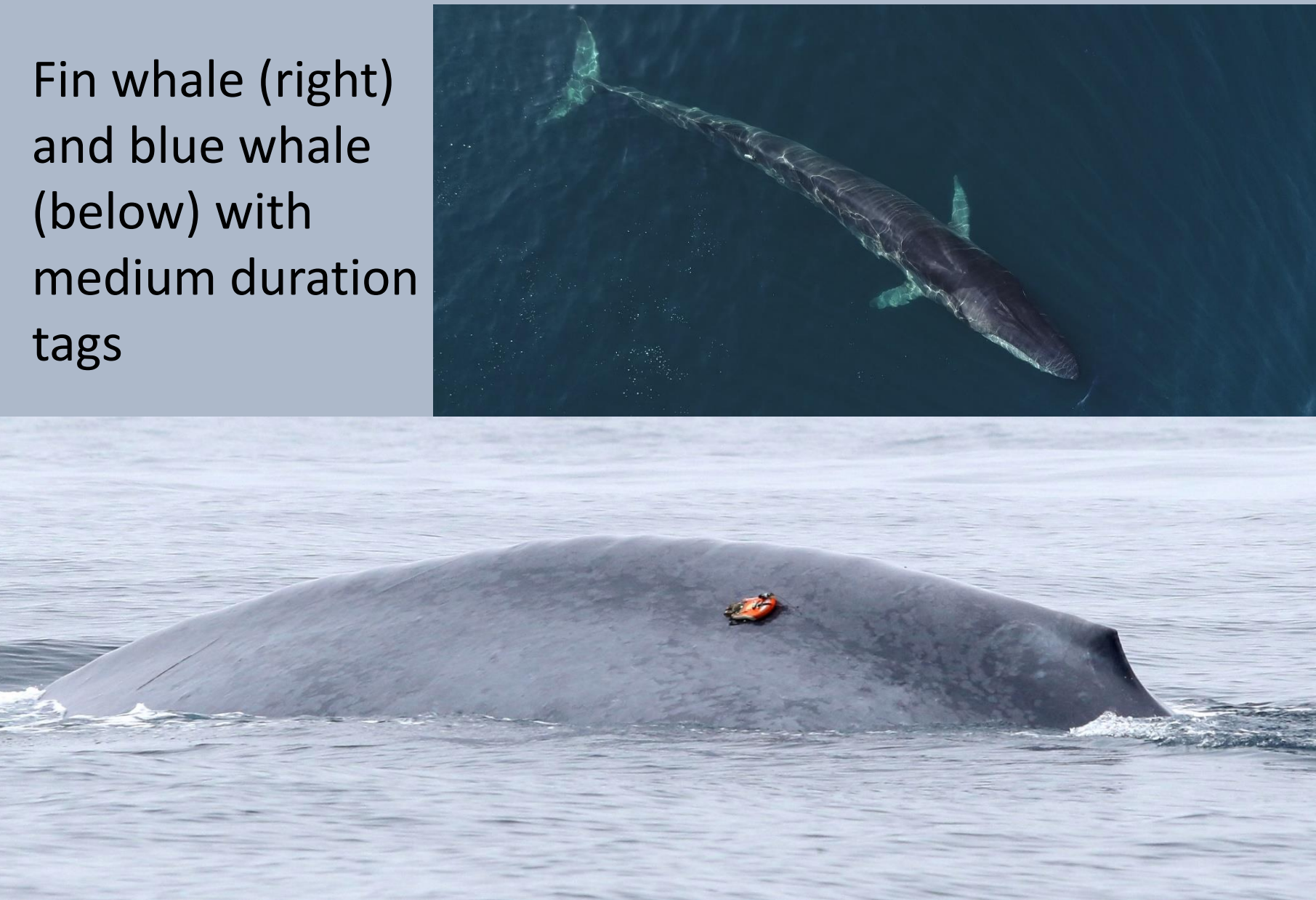## Cumulative time at depth varies by species and time of day

Figure 2. Cumulative time at depth and shallower by species and broken into 3 periods (day, crepuscular, and night). The 9 plots (3 species and 3 time periods) show cumulative time on Y axis and depth on X axis showing faint tracings for each individual deployment and bold tracing showing average for all deployments on that species in that time period. These represent time periods where the animal was along the US West Coast and exclude migrating animals. Average for each species/period weighting each individual equally (treating long deployments with equal weight as shorter ones). Vertical lines show 15 and 30 m depths as discussed in Methods.

Examples of positions and behavior near shipping lanes between day and night

Bm170926-TDR14
2017-06-22 12:00:00 - 2017-06-23 12:00:00 (local)

Bm170926-TDR14
2014-08-27 12:00:00 - 2014-08-28 12:00:00 (local)

Period ● Day ● Night ● Dusk/Dawn

Differences in depths by species and day versus night

Species	Blue whales	Fin whales	Humpback whales	All
Deployments	16	6	11	33
Total hours for depth analysis	1,980	530	489	2,999
Day				
Total hours day	1122.8	301.3	241.1	1,665
Mean depth day	80.9	67.0	34.2	
SD depth day	35.3	14.4	21.9	
% Risk day (30 m)	46%	59%	69%	
% Risk day (15 m)	36%	49%	54%	
Night				
Total hours night	690.4	186.5	204.1	1,081
Mean depth night	13.6	11.5	12.5	
SD depth night	6.8	6.9	8.1	
% Risk night (30 m)	90%	90%	88%	
% Risk night (15 m)	73%	76%	76%	
Crepuscular				
Total hours crepuscular	166.8	42.2	43.7	253
Mean depth crepuscular	37.2	38.9	19.1	
SD depth crepuscular	21.1	10.6	14.4	
% Risk crepuscular (30 m)	66%	64%	79%	
% Risk crepuscular (15 m)	50%	48%	64%	

Fin whale (right) and blue whale (below) with medium duration tags

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