

A Synopsis of Hawaiian Humpback Whale Movements, Including Migration Routes to Foraging Destinations During 24 Years of Satellite-monitored Tracking

L.M. Irvine, D.M. Palacios, B.A. Lagerquist, T.M. Follett, C.E. Hayslip, M.H. Winsor, and B.R. Mate

Humpbacks tagged in Hawaii favored Maui Nui and Penguin Bank; most migrated toward SE Alaska/northern British Columbia and the Aleutian Islands

Methods

- Oregon State University (OSU) attached satellite transmitters to 103 humpback whales off Hawaii
 - 87 were deployed off Maui (in 1997, 1998, 1999, 2000, 2015, and 2018)
 - 10 were deployed off Kauai (in 1995, 1996, and 1997)
 - 6 were deployed off Hawaii Island (in 1996).
- Tags deployed prior to 2018 consisted of Telonics ST10 (externally-mounted) and ST15 (implantable) location-only (LO) tags (Mate *et al.* 2007)
- In 2018, 5 Duration (DUR) and 20 Dive Monitoring (DM) tags were deployed and transmitted dive duration, number of acceleration jerk peaks (Allen *et al.* 2016, Irvine *et al.* 2019), and maximum dive depth (DM tags only), via Argos
- Results are presented by seasonal phase: breeding, migration and feeding

Results

- Tracking periods ranged from 0.1 to 160.0 d (mean = 28.0, SD = 35.8 d)
- DM and DUR tags summarized dives for a mean of 60.6% of the tracking duration
- Tagged whales visited a mean of 3.4 islands. Most heavily used areas were Penguin Bank and Maui Nui (Figure 1).
- Feeding-area movements were localized for whales using SE Alaska/northern British Columbia, and broadly distributed for those using central/eastern Aleutians (Figure 2)
- Aleutian and Bering Sea feeding grounds are connected
- Movement speed was low on breeding and feeding areas, and more rapid during migration (Table 1)
- Photo-ID (using Happywhale*): 31 matches outside Hawaii of 173 fluke IDs from 2015 and 2018
 - Feeding areas: southern British Columbia/Washington (N = 5), northern British Columbia (N = 2), northern Gulf of Alaska (N = 9), southeast Alaska (N = 7), western Gulf of Alaska (N = 2), Russia (N = 4)
 - Breeding areas: Cabo San Lucas, MX (N = 2)

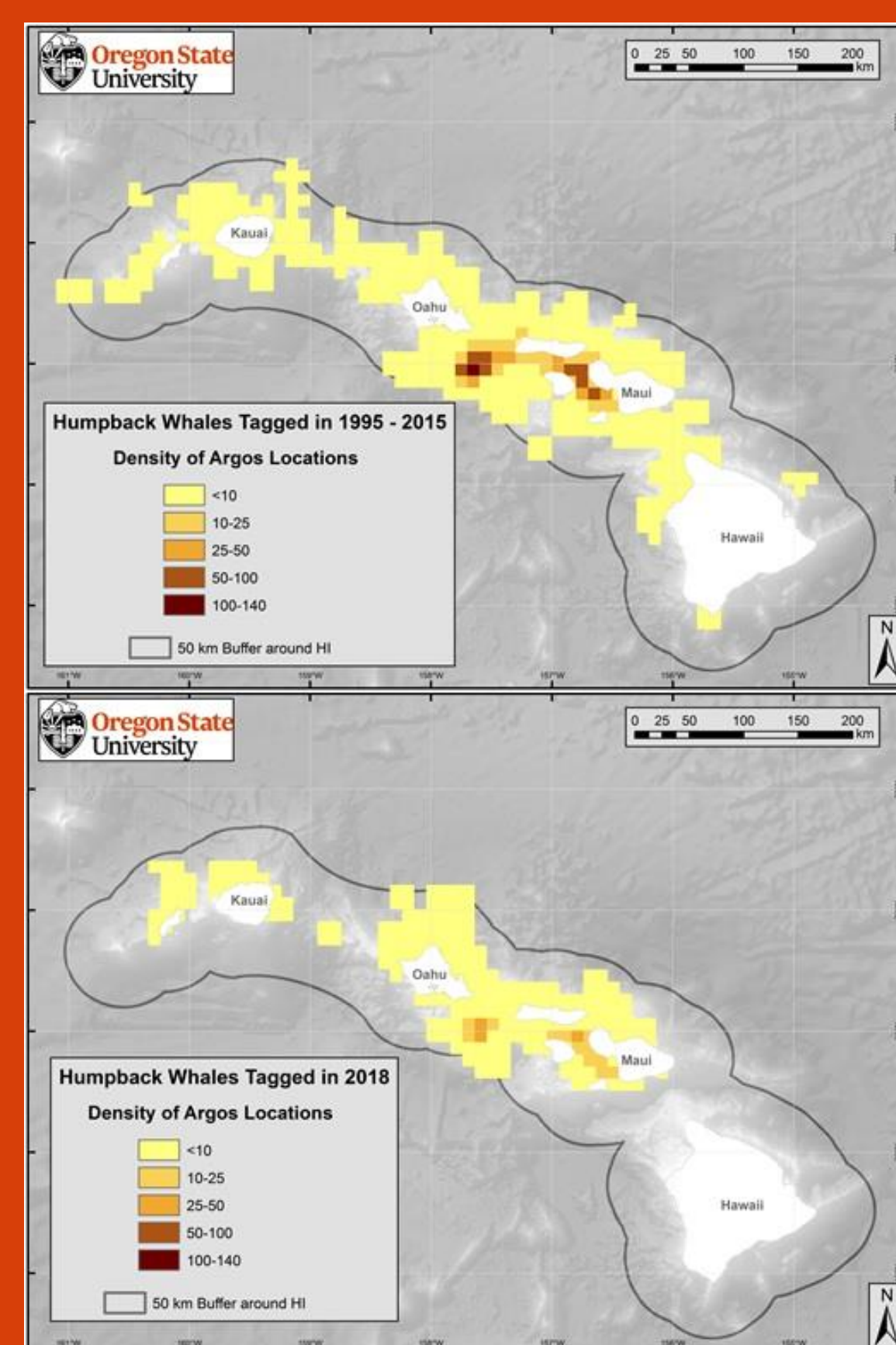


Figure 1. Kernel density of Argos locations for humpback whales tagged in Hawaii and tracked for at least 10 days. Black polygon denotes a 50-km buffer around the islands used to determine residence. Grid cell size is 0.1 x 0.1 degrees. Whales heavily used Penguin Bank and Maui Nui areas.

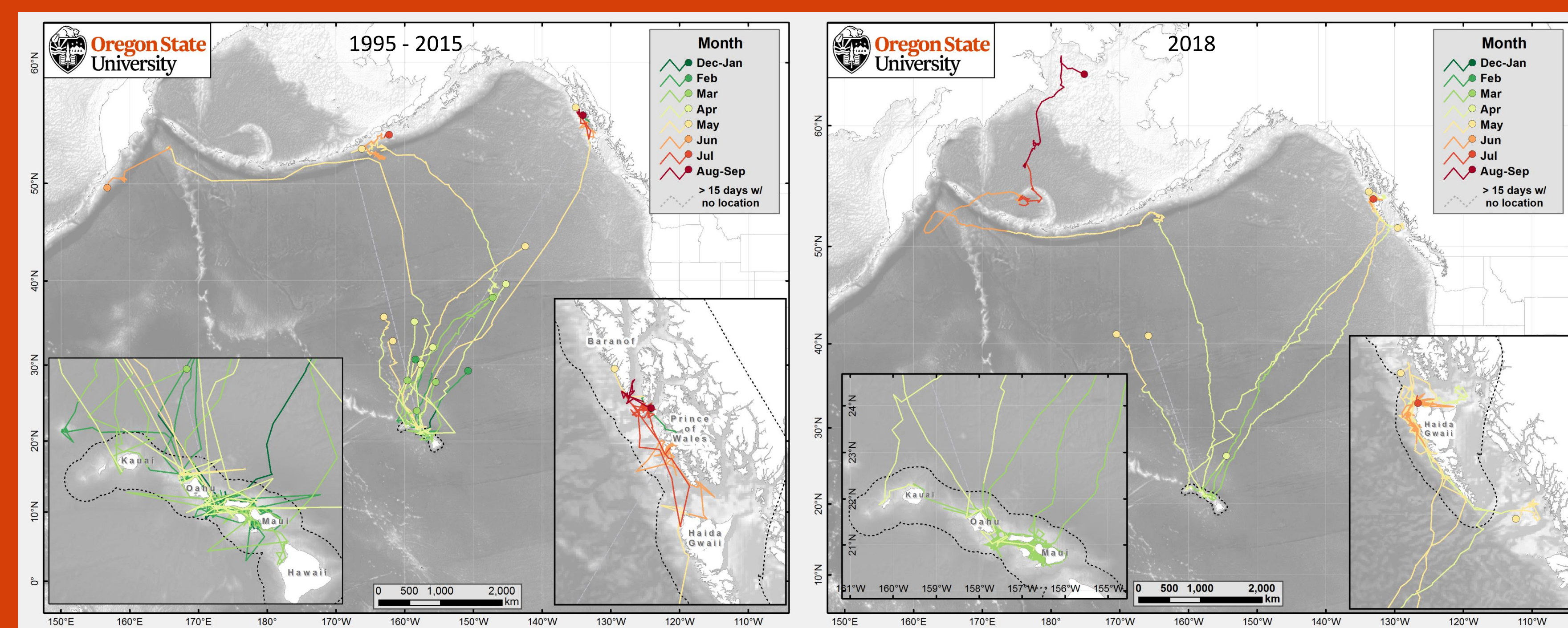


Figure 2. Satellite tracks for humpback whales tagged in Hawaii highlighting migration and movement in the feeding areas for whales that moved outside a 50-km buffer around Hawaii (N = 25).

Dive behavior during the three seasonal phases had distinct characteristics but its overall range was similar.

Breeding

- Long duration dives were common (8.5% > 15 min)
- Mainly shallow dives (51.2% < 50 m)
- Acceleration peaks distributed throughout all dives

Migrating

- Some long duration dives (4.9% > 15 min)
- Many shallow dives (34.0% < 50 m) but a surprising number of deep dives
- Increased acceleration peaks occurred during deep dives

Feeding

- Few long duration dives (0.7% > 15 min)
- Fewer shallow dives (29.7% < 50m)
- Acceleration peaks focused in deep dives (feeding)

Table 1. Summary of tracking data for tags deployed on humpback whales off Hawaii, during winter and spring 1995 – 2018. Results are presented by seasonal phase: breeding, migration, and feeding.

Breeding area (N = 78 LO, 20 DM, 5 DUR tag)		
Residence time (N = 25)	mean (range)	12.3 d (1.1 - 42.8 d)
Departure date (N = 25)	range	20 Dec - 3 May
Speed (N = 74)	mean (SD)	2.31 km/h (1.45 km/h)
Dives	N (DM only)	14,446 (10,136)
Migration (N = 19 LO, 5 DM, 1 DUR tag)		
Duration (N = 7 full migration tracks)	mean (range)	34.5 d (27 - 50 d)
Speed (N = 22)	mean (SD)	4.40 km/h (2.38 km/h)
Dives	N (DM only)	12,521 (6,726)
Feeding areas (N = 3 LO, 3 DM, 1 DUR tag)		
Speed (N = 7)	mean (SD)	2.40 km/h (1.53 km/h)
Dives	N (DM only)	20,224 (12,674)

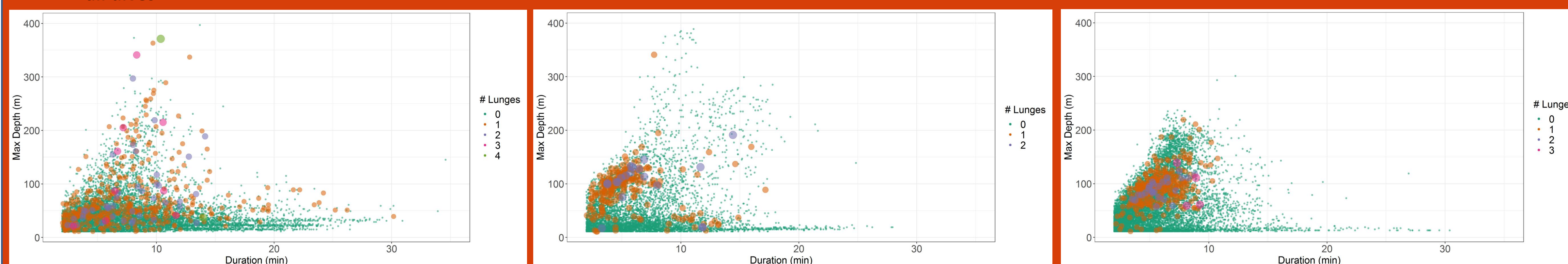


Figure 3. Depth and duration of dives made by DM-tagged humpback whales tracked during three seasonal phases of movement. Size and color of points indicate the number of peaks in accelerometer Jerk that were detected during the dive. Whales were tagged in Hawaii during March 2018 and migrated during April and May.