**2.1 Acoustic detection of beaked whales**

The Pacific Missile Range Facility (PMRF) is an instrumented U.S. Naval range extending 70 km NW of the island of Kauai, Hawaii and encompassing 2,800 km2. The range includes a cabled hydrophone array (Fig. 1) with hydrophones at depths ranging from approximately 650 m to 4,700 m. Hydrophones had a sample rate of 96 kHz, with the high pass filter on each phone set at either 50 Hz, 100 Hz, or 10 kHz.  Up to 62 of the range hydrophones at a time can be recorded simultaneously by the Naval Information Warfare Center (NIWC). The Navy Acoustic Range WHale AnaLysis (NARWHAL) algorithm suite includes a Blainville’s beaked whale detector that first compares signal-to-noise (SNR) thresholds within the expected beaked whale click frequency range (16 - 44 kHz) versus the bandwidth outside the click in a running 16384-pt fast Fourier transform (FFT) spectrogram. The detected clicks are then passed to a 64-pt FFT stage that measures power, bandwidth, slope, and duration characteristics to classify the clicks to species. This process is followed by an automated routine in Matlab (Mathworks 2019) used to group detections of individual beaked whale echolocation clicks into Group Vocal Periods (GVPs). If a group of whales is detected by more than one hydrophone, the GVP is assigned to the hydrophone that recorded the most clicks. The data are then aggregated to indicate the presence or absence of the start of a GVP for each hydrophone within each half-hour period. In the present study, we used data collected before and during Submarine Commander Courses (SCCs) at the PMRF. SCCs occur biannually in February and August. SCCs typically last 6-7 days, and the period before the onset of the SCC is recorded for a minimum of 2 days.

**2.2 Modelling received levels of hull-mounted mid-frequency active sonar**

Classified ship positional data and other activity that occurs on the range during each SCC are provided by PMRF. This data indicate the locations of the ships during the training periods and also indicate the start and stop times of each individual training event, but no information is provided on the start and stop of sonar use. Periods of active sonar are determined by running the sonar detector tuned to MFAS, as part of the NARWHAL algorithm suite. Using these data, the locations of all surface ships are noted for each half-hour period and the closest ship to each hydrophone is determined. Propagation modelling is used to calculate the expected received level of hull-mounted mid-frequency active sonar at the location of each hydrophone from the closest ship during each half-hour period of each SCC. The propagation modelling is done using the parabolic equation propagation model in the program Peregrine (OASIS; Heaney and Campbell, 2016) to estimate the transmission loss between the ship and the hydrophone; this was then converted to a received level at the hydrophone location based on the source level of the sonar. However, if the distance between the ship and the hydrophone was less than the depth of the water column, the parabolic equation overestimates transmission loss at that angle and so a simple sonar equation was used to estimate transmission loss instead. Transmission loss is estimated using a 200 Hz band around the center frequency of the sonar type (here, 3.5 kHz). Transmission loss is estimated at depth since Blainville’s beaked whales don’t begin clicking until they have reached approximately XX m depth of their foraging dive and spend most of their foraging dive at around 1000 m (REF). For hydrophones shallower than 1000 m the received level is estimated at a point 20 m above the sea floor with a +- 10 m buffer, while for hydrophones deeper than 1000 m the received level is estimated at 1000 m depth with a +- 10 m buffer. The location of the beaked whale foraging group is assumed to be within 4-6 km of the hydrophone with the most click detections, as beaked whale echolocation clicks attenuate beyond that distance (McCarthy et al 2011; Marques et al 2009). Therefore the transmission loss is estimated along the radial from the ship to the hydrophone from a distance of 1 km before the hydrophone to 1 km past the hydrophone in 200 m increments. The maximum modeled received level along that radial was determined for each hydrophone and half-hour period and aggregated with the data on beaked whale group detections. Uncertainty in the modelled received level was not considered.