

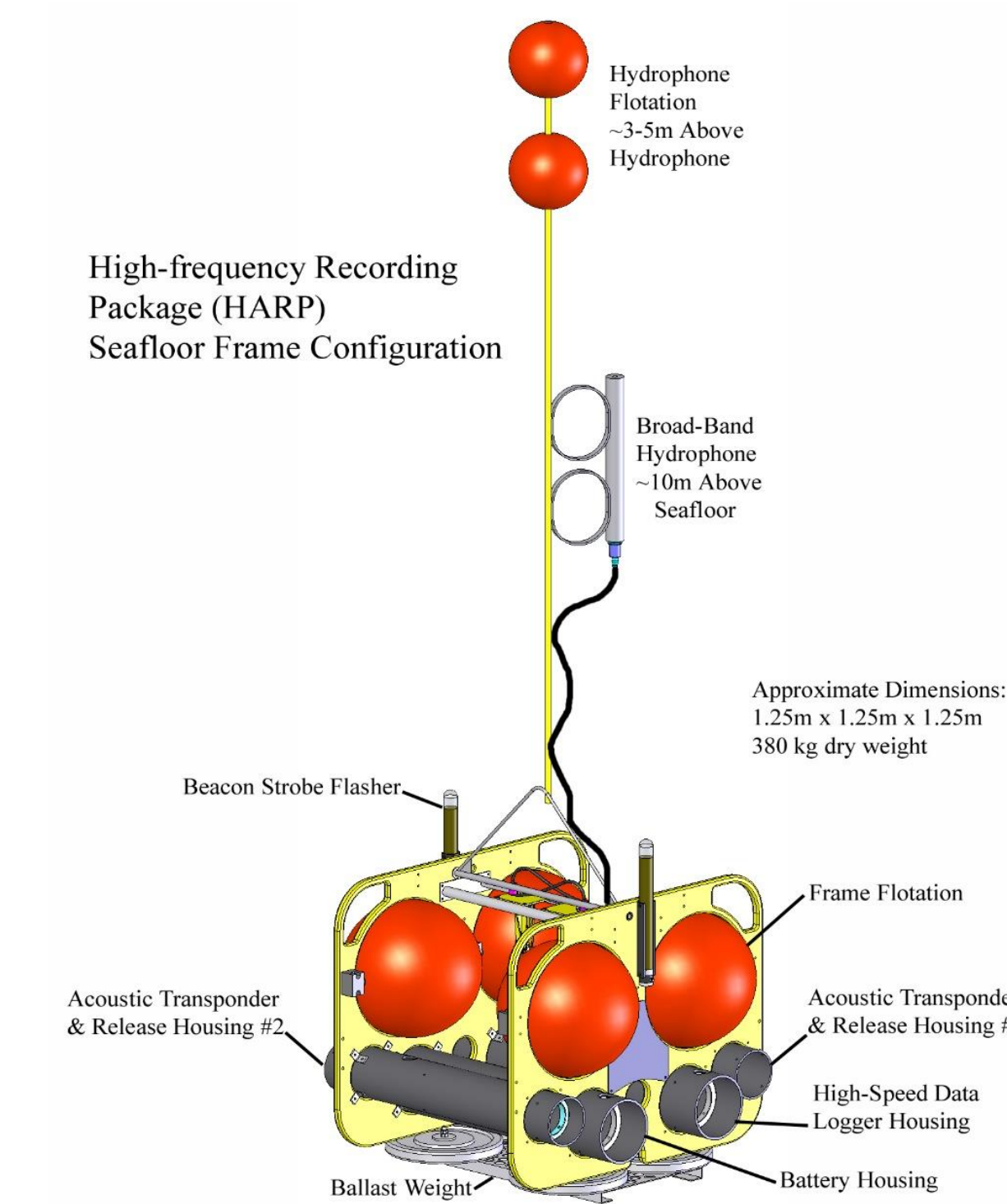
Abstract

Dolphin populations were monitored at five sites in the Gulf of Mexico from 2010 to 2013, using High-frequency Acoustic Recording Packages (HARPs). Two sites on the continental shelf allowed monitoring of near-shore species, including bottlenose dolphin (*Tursiops truncatus*) and Atlantic spotted dolphin (*Stenella frontalis*). Three sites located on the continental slope focused on pelagic species including Risso's dolphin (*Grampus griseus*), pilot whales (*Globicephala* sp.) and oceanic stenellids (*Stenella* spp.).

HARPs passively recorded delphinid echolocation clicks continuously for up to ten months at a time. Ship-based towed array recordings of echolocation clicks produced by visually identified species were also collected in the region. Echolocation clicks from these identified recordings were compared to those detected in long term recordings. Frequency content and inter-click interval were used to putatively identify echolocation clicks to genus or species.

The probability of detecting echolocation clicks at each HARP site was modeled using a Monte Carlo simulation framework. These probabilities were then used to estimate the true number of clicks produced at each site on a weekly basis for long term trend analysis. Diel and seasonal patterns are visible in the click time series¹, as are potential longer term trends in the multi-year records at some sites.

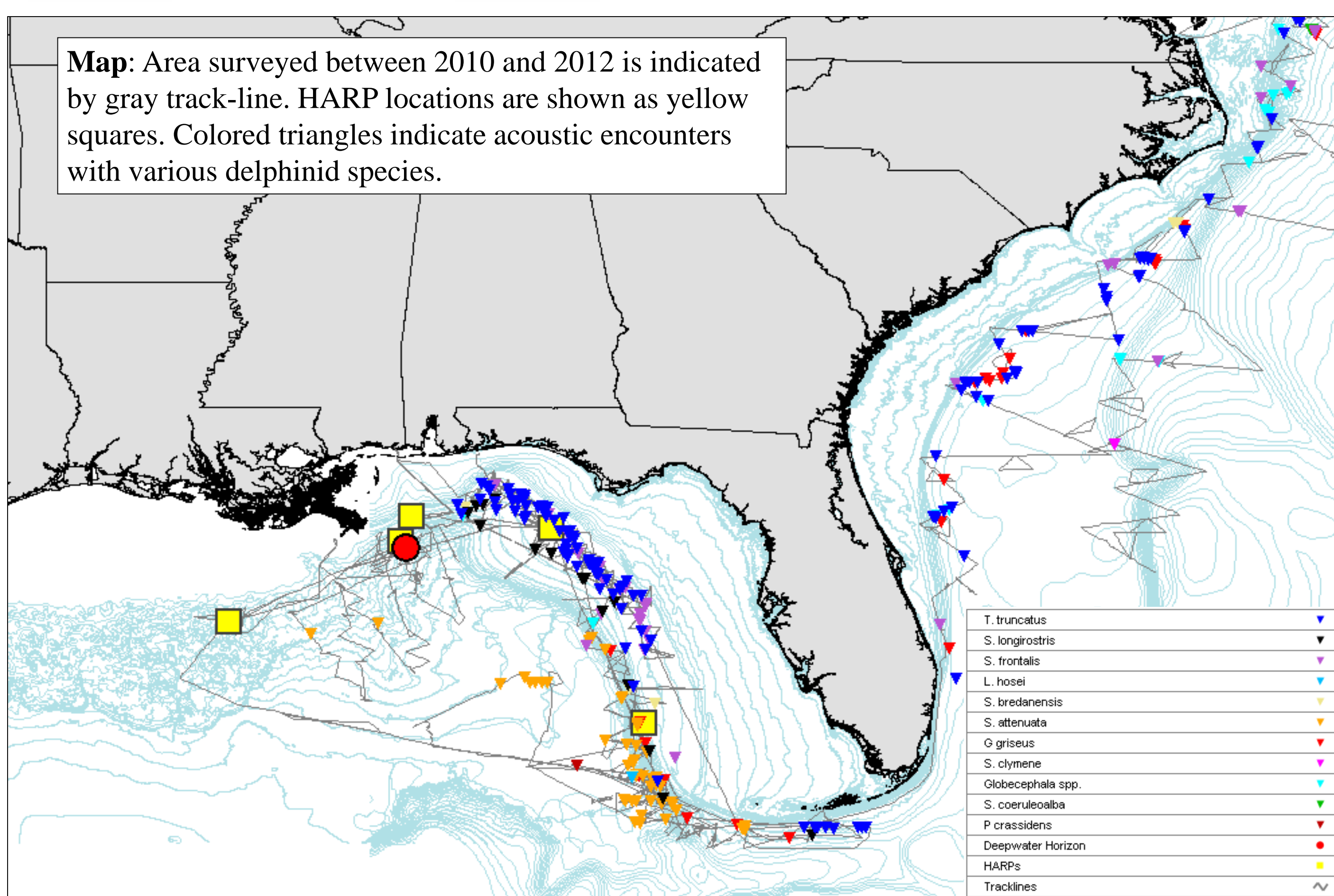
Passive Acoustic Monitoring: HARPs and Towed Arrays



Stationary, bottom-mounted HARPs (*left*) monitored five sites year-round for over three years. HARPs provide a long-term acoustic record from a single location. Instrument depths range from 90 to 1200m. HARPs sample continuously at 200 kHz, for an effective recording range of ~ 0 to 100 kHz. Most delphinid echolocation clicks fall at least partially within this frequency band.

Towed arrays were used to obtain recordings of visually identified delphinid species

Towed array recordings were collected in partnership with NOAA Southeast Fisheries' Marine Mammal Program during summer surveys from 2010 - 2012.



Matching Species to Click Types

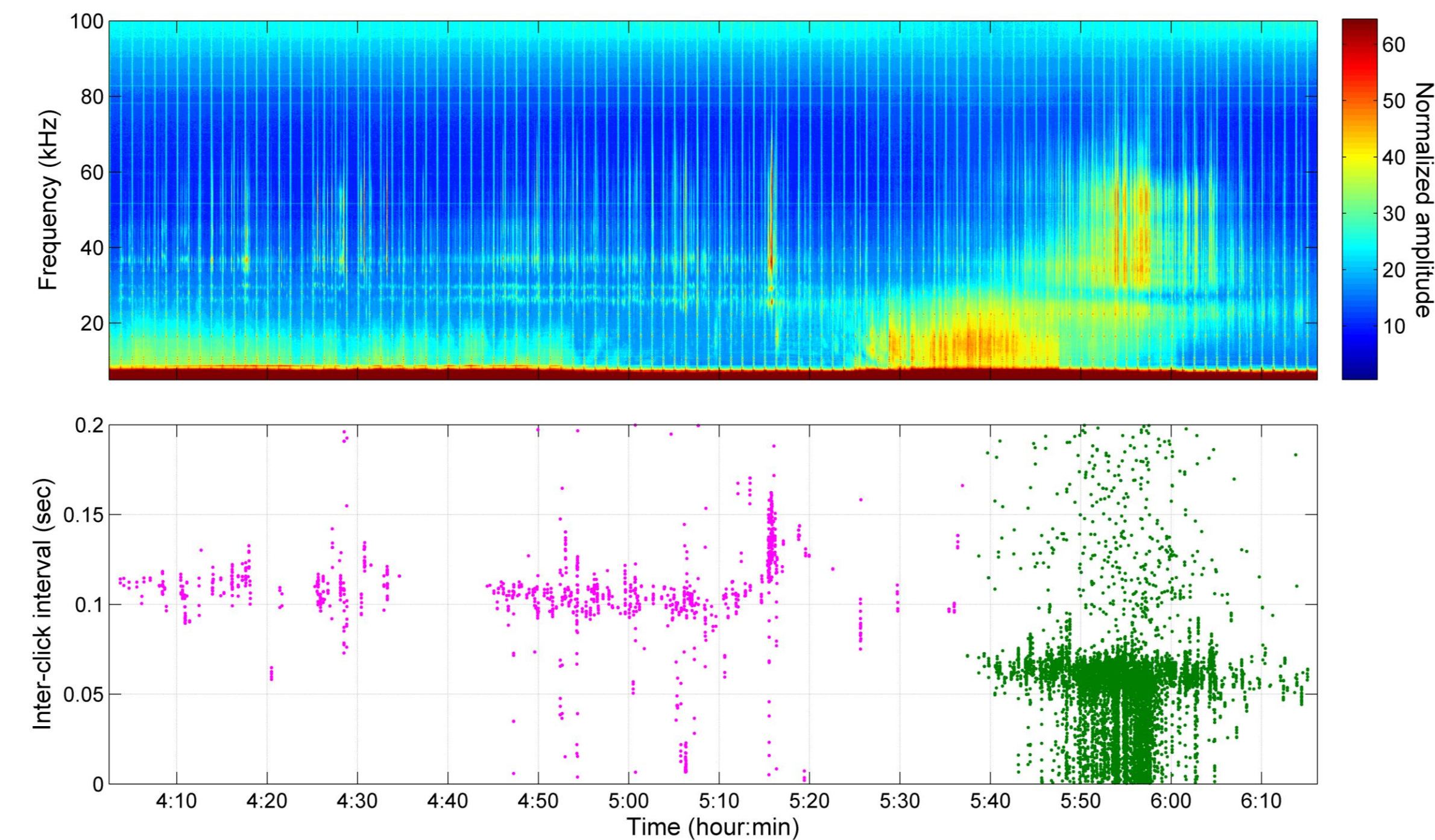
At least fourteen species of delphinids are found in the Gulf of Mexico, twelve of which are only found offshore (Mullin & Fulling, 2004). We extract click information from our HARP recordings, and use frequency content and inter-click interval to identify encounters to genus or species.

Pelagic species include:

- Pantropical spotted dolphin (*Stenella attenuata*)
- Spinner dolphin (*Stenella longirostris*)
- Rough-toothed dolphin (*Steno bredanensis*)
- Fraser's dolphin (*Lagenodelphis hosei*)
- Short-finned pilot whale (*G. macrorhynchus*)
- Clymene dolphin (*Stenella clymene*)
- Striped dolphin (*Stenella coeruleoalba*)
- Risso's dolphin (*Grampus griseus*)
- Melon-headed whale (*Peponocephala electra*)
- Pygmy killer whale (*Feresa attenuata*)
- False killer whale (*Pseudorca crassidens*)
- Killer whale (*Orcinus orca*)

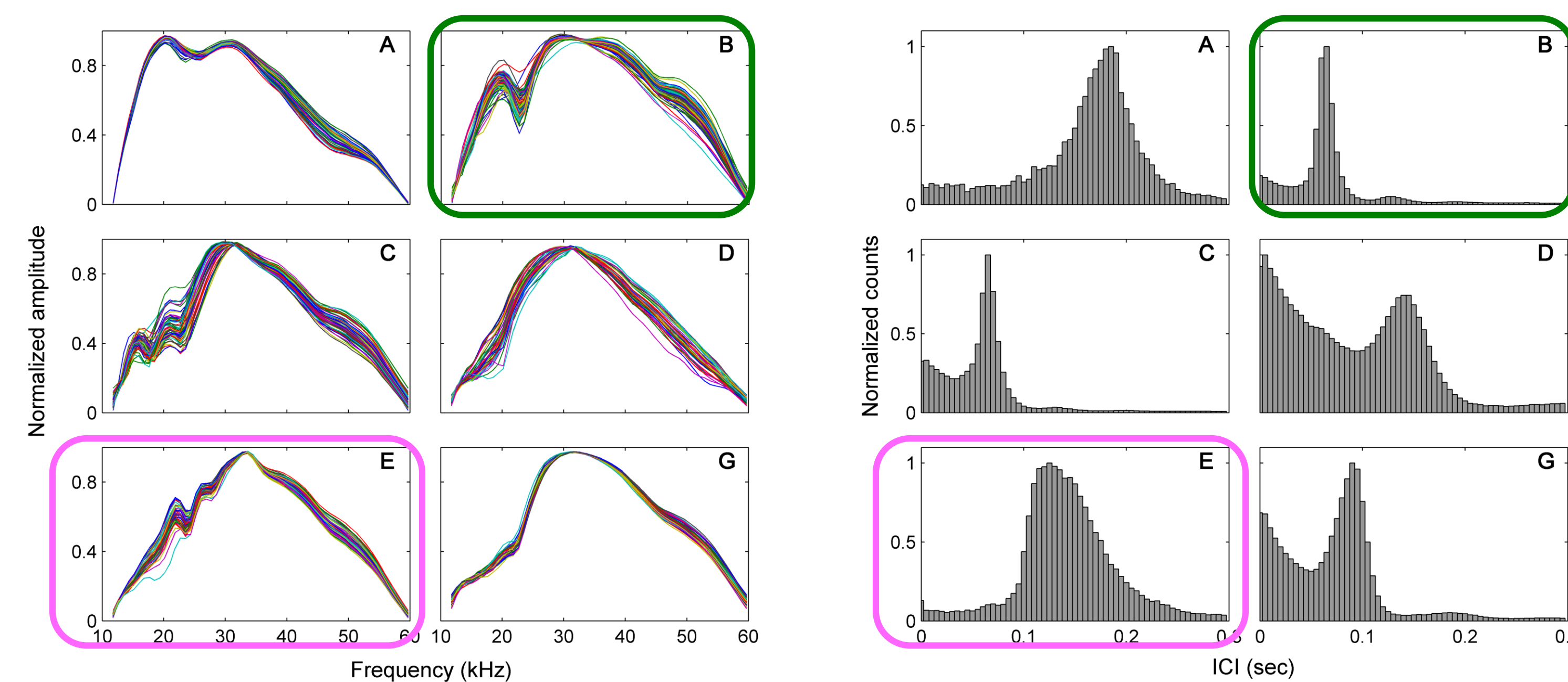
Coastal species include:

- Bottlenose dolphin (*Tursiops truncatus*)
- Atlantic spotted dolphin (*Stenella frontalis*)



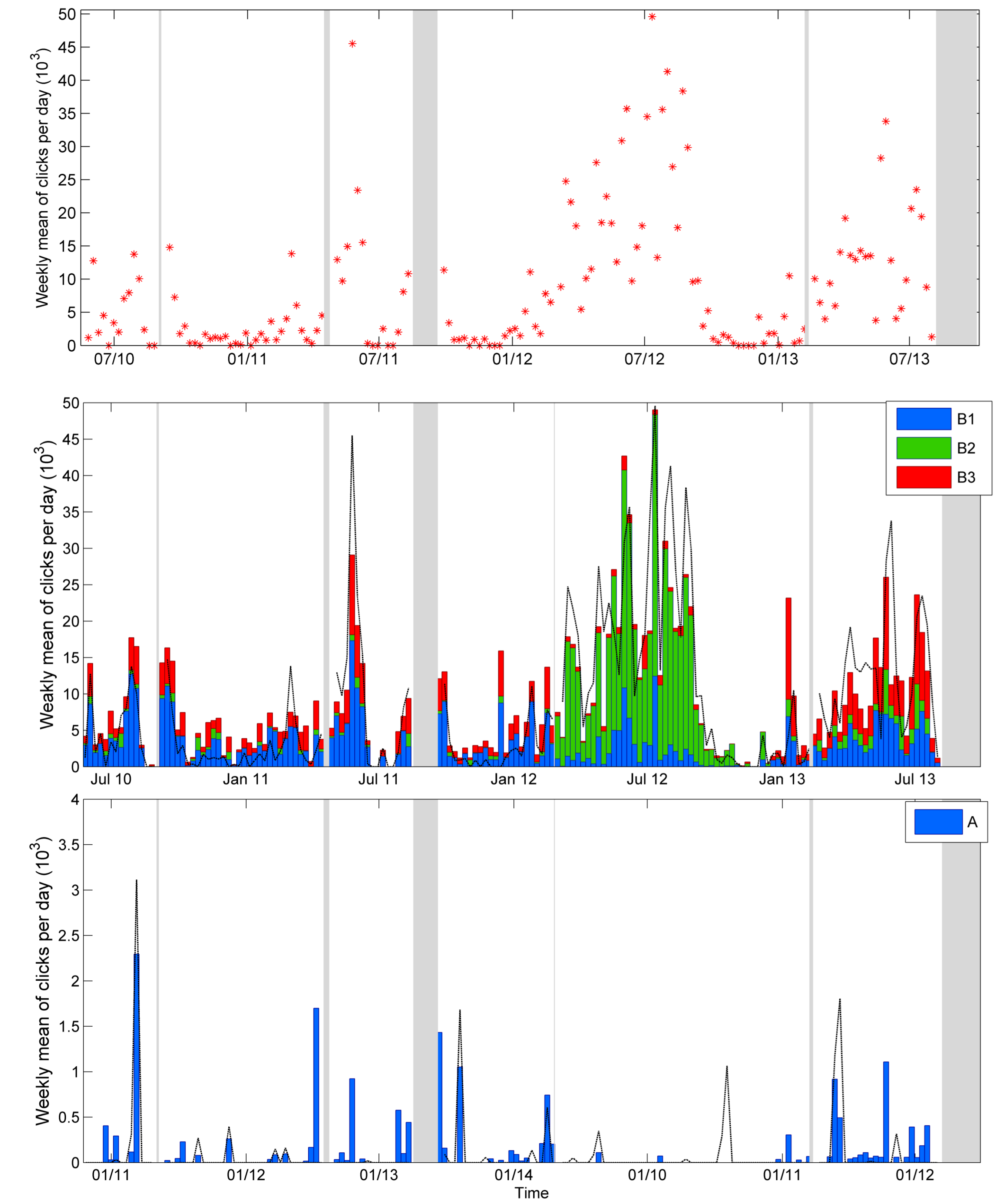
Above: Example of HARP time-series from the Mississippi Canyon site, showing encounters with two different species as determined by click type (pink and green). Top panel shows a long term spectral average, used for looking at frequency content of the signals, while the lower panel shows inter-click interval (ICI) over time (first difference of detection times).

Below: Extracted frequency spectra (*left*) and interclick interval distributions (*right*) associated with the click types shown above. These are obtained by combining data from across the three year time series. Green and pink boxes highlight the two types shown in the timeseries above. Type B is associated with stenellid dolphins, and type E is associated with Risso's dolphin (Soldevilla et al., 2008).



Automated detection and classification

Once click types have been defined, detections throughout recordings at all sites are classified automatically by type. In the series of panels below, the top pane shows a timeseries of total click counts detected at the Mississippi Canyon site. The lower panels show counts for specific click types after classification. In this case, the abundant click types B, associated with stenellid dolphins, obscure trends in rarer click types prior to classification.



Next steps:

- Refine and expand classification.
- Estimate species-specific densities on a weekly basis for each site by combining:
 - Site/species-specific detection probabilities
 - Vocal activity estimates and click rates
 - Maximum detection range
 - Group sizes