# Inch Cape Offshore Wind Farm

New Energy for Scotland

Offshore Environmental Statement:
**VOLUME 2E**
**Annex 14A.2: White-Beaked Dolphin Acoustic Analysis**

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## 14A.2 Analysis of Acoustic data of White-Beaked Dolphins During Surveys at Proposed Neart na Gaoithe and Inch Cape Offshore Wind Farms

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### 14A.2.1 Introduction

The white-beaked dolphin (*Lagenorhynchus albirostris*) is endemic to the North Atlantic Ocean, with a mainly northerly distribution over colder continental shelf waters. UK populations comprise a significant proportion of the worldwide population, and an estimated 80 per cent of the European population (UKBAP, 2008); they are found mostly in the waters off Scotland and north east England. The white-beaked dolphin (WBD) is also one of three cetacean species designated as search features for Scottish Marine Protected Areas (MPAs). In spite of their importance however, little is known about their ecology, fine scale distribution or abundance, due in part to the difficulties involved in conducting surveys for them.

White-beaked dolphins are the species of dolphin most frequently encountered during surveys at both the proposed Neart na Gaoithe (NnG) and Inch Cape Development Areas. These animals are quite vocal and are picked up reliably on the towed hydrophones. Dolphins are normally identified acoustically from their whistles (Rendell *et al*. 1999). However, it seems that, in this area at least, white-beaked dolphins whistle infrequently; Marine Ecological Research Ltd (MER Ltd) has found that many acoustic encounters contain no whistles at all, and this makes it difficult to rely on whistle detection and classification for acoustic species identification. Clicks from white-beaked dolphins have been recorded during every acoustic encounter. However, unlike the vocalisations of harbour porpoise, white-beaked dolphin clicks are highly variable, raising concerns about the extent to which they can be reliably identified acoustically. To date no automated click classifier has been devised which would allow reliable species identification. During earlier analysis however, MER Ltd noticed that white-beaked dolphin clicks often had multiple peaks in their spectra. American researchers have also recently reported similar multi-pulsed spectra in the clicks of another species in the Lagenorhynchus genus, the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) (Roch *et al*. 2011; Soldevilla *et al*., 2011). In order to explore this further, and to determine whether the characteristic of these frequency peaks could be used as a basis for species identification, two new PAMGUARD (www.PamGuard.org) modules were created: one produced a concatenated spectrogram from the spectra of multiple click detections, the second calculated mean spectra from large numbers of clicks and stored these as templates for comparison with spectra from other clicks. These tools make it possible to review the click trains and to extract the necessary data for further analysis. Preliminary data analyses of similar data sets from other locations suggest that the click characteristics of white-beaked dolphins can be used reliably for species identification (Wittich and Gordon 2012a, Wittich and Gordon 2012b).

### 14A.2.2 Methods

Data from December 2010 (first month of acoustic survey) until August 2012 at Inch Cape and NnG were analysed using PamGuard.

#### 14A.2.2.1 Detector Settings

The PamGuard click detector incorporates two types of frequency filter designed to remove noise and maximise the detector's performance. The pre-filter removes sound at frequencies that are not useful for either detecting or classifying the clicks of interest. Sound in these bands is simply removed and is then no longer available. A second filter, the trigger filter, is a narrower filter applied only to improve the efficiency of the triggering process. The broader band acoustic data output by the pre-filter is still kept available for classification post triggering. Because porpoise clicks have most of their energy in a narrow frequency band at around 130 kHz relatively narrow pre-filters and very narrow trigger filters are applied for porpoise analysis. Dolphin clicks are known to have energy over a greater frequency range than porpoises however, and the standard porpoise filter settings might result in less effective detectors and a much reduced capacity for classification. Thus, new detectors were devised for white-beaked dolphins and Risso's dolphins using filter settings based on published information on click characteristics for these species and our own measurements. These settings are shown in Table 14A.2.1.

All of the raw data files (.wav recordings) were batch reprocessed using the white-beaked dolphin click detector with its broader filter settings allowing the detector to be more sensitive to the lower frequencies found in dolphin clicks. Recordings made around the time of a Risso's dolphin sighting and around the time of an acoustic encounter with no visual data were also reprocessed using the Rissos's dolphin settings.

**Table 14A.2.1: Different Filter Settings for Processing Raw Data (for Comparison Harbour Porpoise Settings Shown)**

| Filter | Cut of Frequencies | HP settings | WBD settings | Risso's settings |
|---|---|---|---|---|
| Pre-Filter | High Pass | 40,000 Hz | 2,000 Hz | 2,000 Hz |
| | Low Pass | 180,000 Hz | 180,000 Hz | 180,000 Hz |
| Trigger Filter | High Pass | 100,000 Hz | 40,000 Hz | 5,000 Hz |
| | Low Pass | 150,000 Hz | 150,000 Hz | 150,000 Hz |

A single experienced operator (AW) reviewed all of the batch-processed data in a PamGuard Viewer configuration. Figure 14A.2.1 shows a typical acoustic encounter with a group of white-beaked dolphins. Every dolphin event was marked and stored to a database. Clicks with appropriate characteristics which occurred on distinct time/bearing "tracks" were marked as being "certain" dolphin tracks. Clicks that had appropriate acoustic characteristics but were not on distinct tracks were classified as "likely" and were not included in later analysis. Some of the clicks were "clipped", that is to say the signal exceeded the dynamic range of the digitiser. Clipped signals are likely to be distorted and the PamGuard amplitude/time display was used to identify and remove clipped signals before classification.

The remaining clicks were displayed as concatenated spectrograms (e.g. Figure 14A.2.2). These show the spectra for each identified click "stacked up" sequentially. Spectral banding in the lower frequency range (<80 kHz) was visible in such spectrograms from most of the events.

Note banding below 80 kHz, distinct bands are indicated by arrows.

An average spectrum was also made from all clicks from each event (e.g. Figure 14A.2.3). These were exported as.csv files and a simple routine was used to find the location of peaks and troughs: points of inflection in these amplitude frequency plots.

Target motion analysis was not applied to the bearing time plots to determine range from the trackline, (as it is typically carried out with porpoise detections) because it was evident that dolphin movement is quite high relative to vessel speed.

**Figure 14A.2.1: White-beaked Dolphin Certain Event**

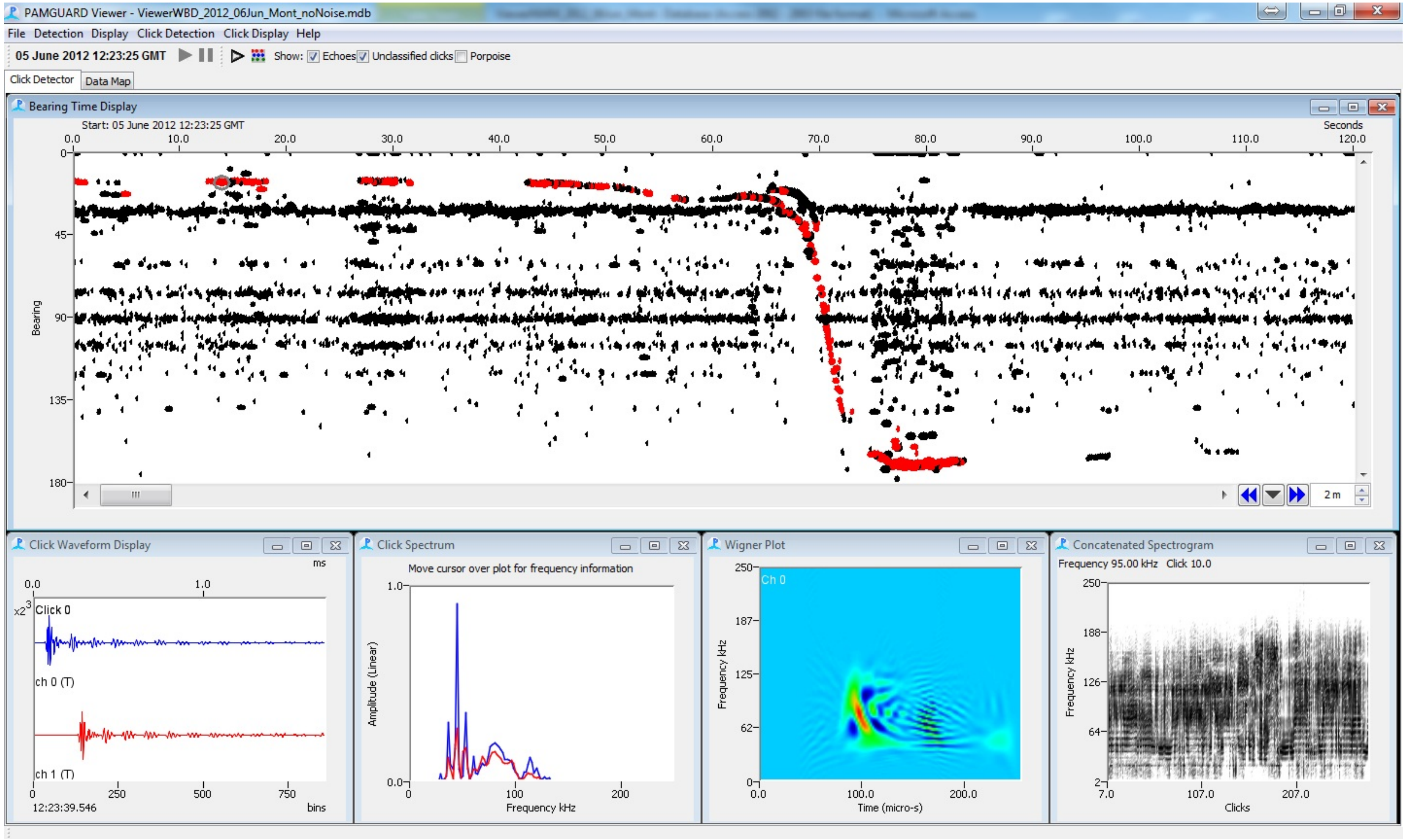


**Figure 14A.2.2: Concatenated Spectrum**

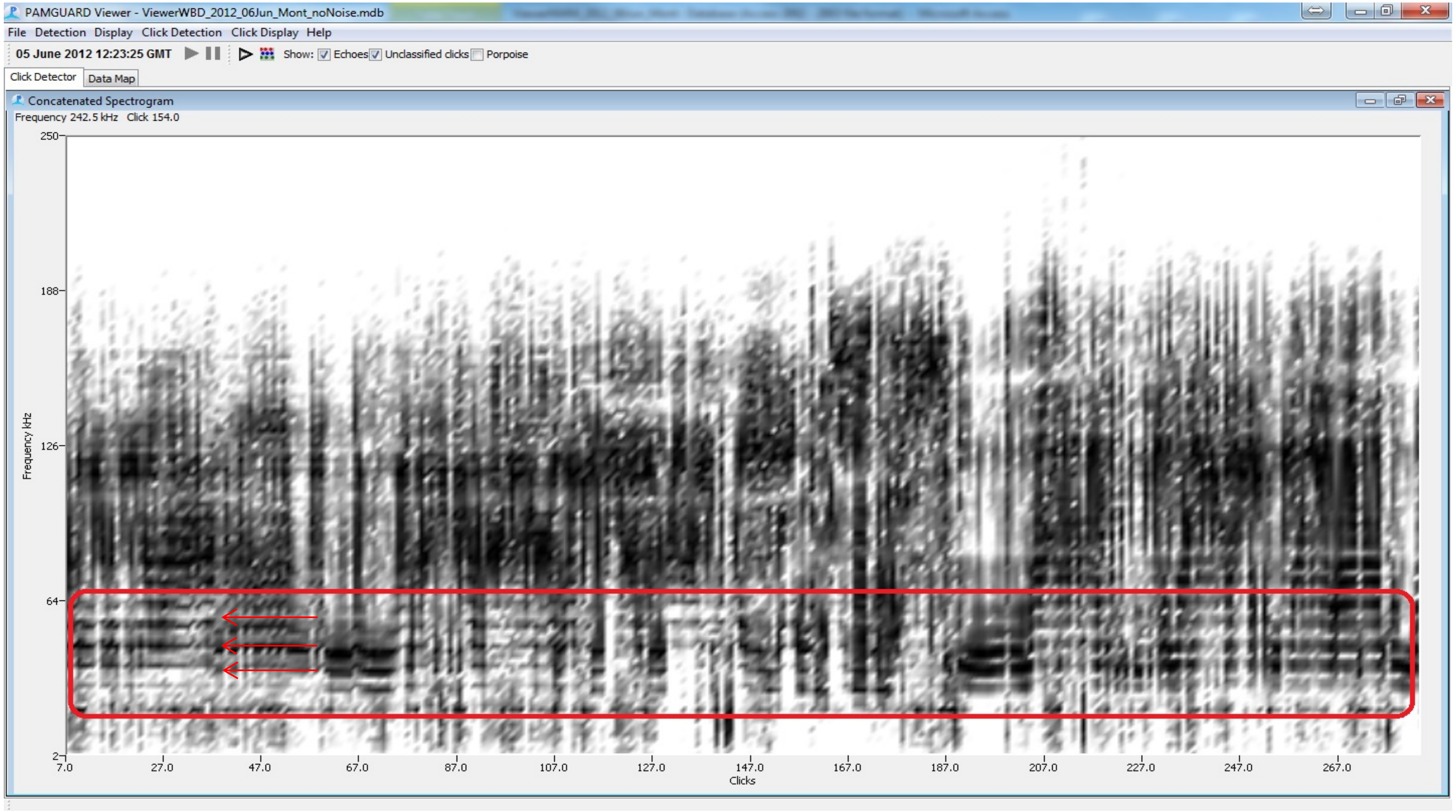
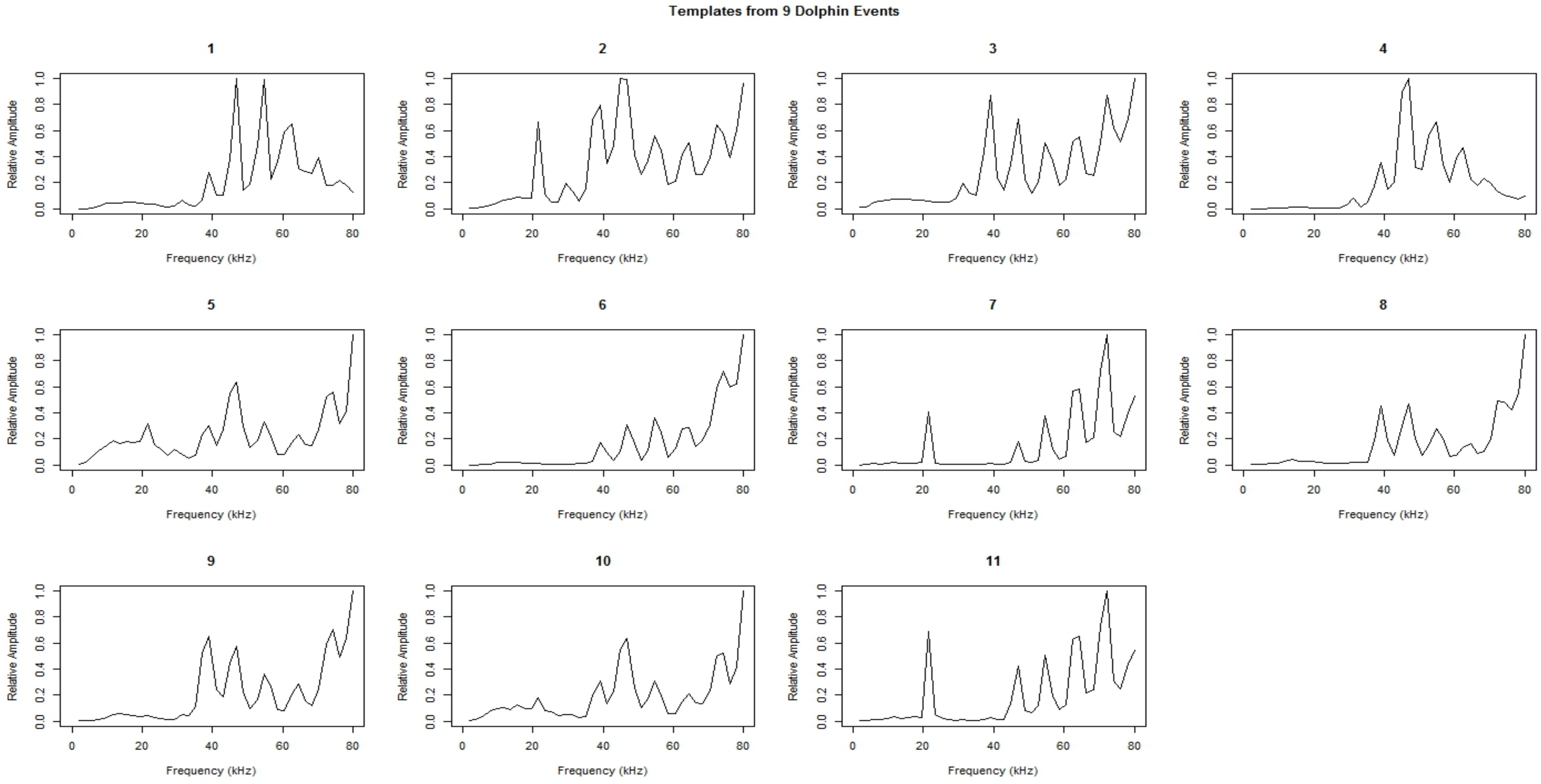


**Figure 14A.2.3: Spectral Templates (<80 kHz With Relative Amplitude). Note: Risso's Event 5 (WBD settings) and 10 (Risso's Settings) and Dolphin Event without Visual Event 7 (WBD Settings) and 11 (Risso's Settings)**



### 14A.2.3 Results

Visual and acoustic detections of dolphins between December 2010 and August 2012 are summarised in Table 14A.2.2. In total there were 24 visual sightings; most were noted as being white-beaked dolphins, one was recorded as a Risso's dolphin and there were three unidentified dolphin encounters. Locations of these sightings and acoustic detections are shown in Figure 14A.2.4. 13 of these 24 sightings occurred at a time when acoustic data were also being collected on the vessel and acoustic detections of dolphins were made on 11 of these occasions. Two of the sightings with no acoustic data were of distant groups (at 500 and 1000 m, which is probably beyond the acoustic range for this species). One visual encounter at a range of 300 m was not detected acoustically. There were also two acoustic detections that were not sighted.

As previously discussed, white-beaked dolphins rarely whistle. In fact whistles were recorded on only two occasions.

**Table 14A.2.2: Overview of Visual Sightings and Acoustic Detections of Dolphins**

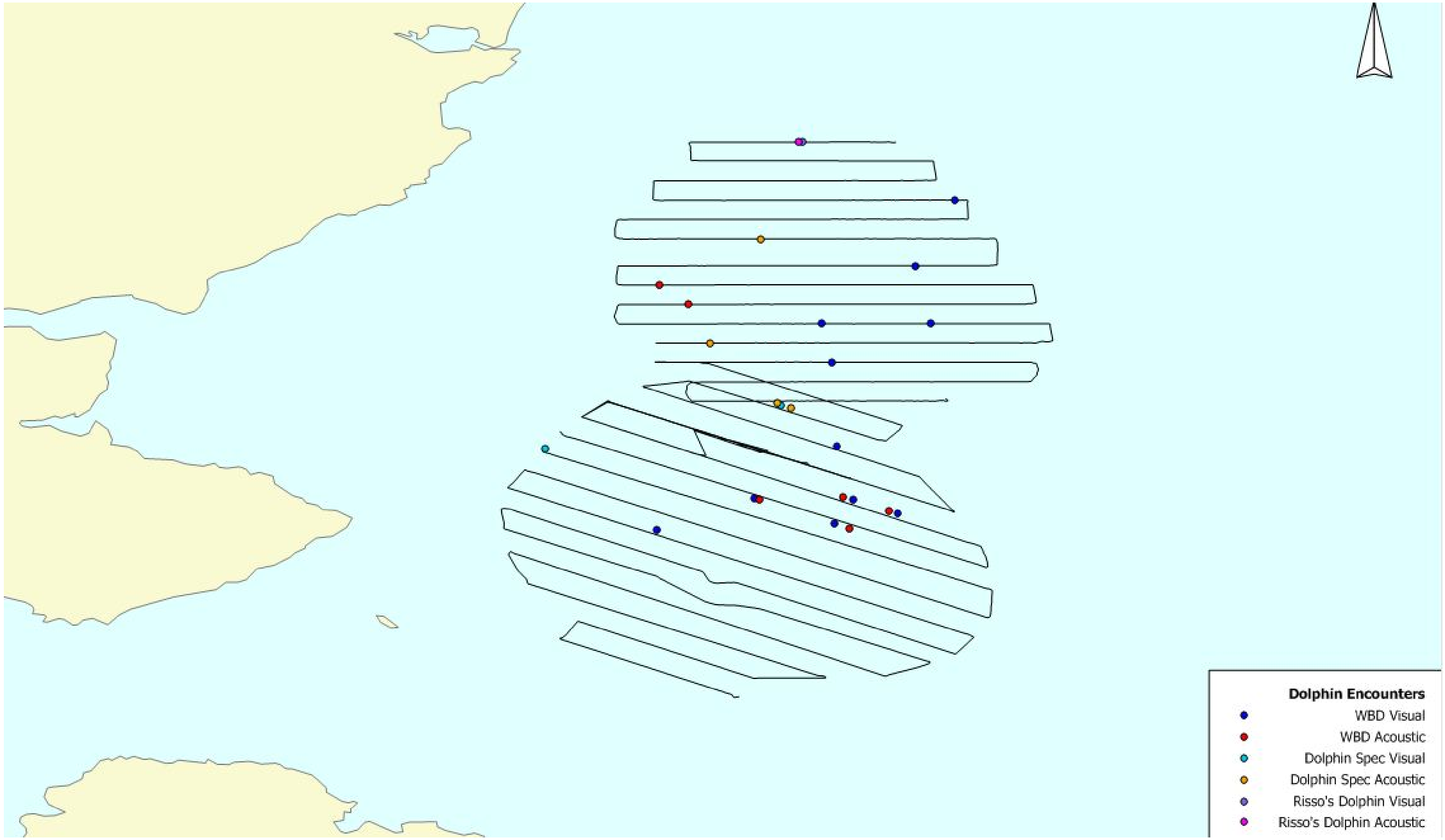
| Date and Time | Acoustic detection | Whistles | Click train | Acoustic classification | No. Clicks | Visually Recorded Species (Distance) | Site |
|---|---|---|---|---|---|---|---|
| 11/12/2009 13:03:00 | no acoustic effort | | | | | DOLPHIN SP. | NnG |
| 13/01/2011 09:30:00* | yes | 09:33:53 | 09:28:03 & 09:31:10 | 2 x certain | 49 & 57 | DOLPHIN SP. | Overlap |
| 13/01/2011 10:43:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | NnG |
| 26/05/2011 09:22:00* | yes | | 09:23:16 | certain | 218 | WHITE-BEAKED DOLPHIN | NnG |
| 26/05/2011 09:39:00* | yes | | 09:40:57 & 09:42:55 | 2 x certain | 34 & 88 | WHITE-BEAKED DOLPHIN | NnG |
| 26/05/2011 10:40:00* | yes | | 10:42:46 | certain | 93 | WHITE-BEAKED DOLPHIN | NnG |
| 26/05/2011 10:50:00 | yes | | 10:52:00 | likely | 9 | WHITE-BEAKED DOLPHIN | NnG |

| Date and Time | Acoustic detection | Whistles | Click train | Acoustic classification | No. Clicks | Visually Recorded Species (Distance) | Site |
|---|---|---|---|---|---|---|---|
| 05/06/2011 17:30:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | NnG |
| 19/06/2011 16:14:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 19/06/2011 00:00:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 19/06/2011 00:00:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 10/07/2011 15:26:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 10/07/2011 15:26:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 10/07/2011 15:26:00 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 05/06/2012 04:13:00* | yes | | 04:12:13 | certain | 130 | RISSO'S DOLPHIN | Inch Cape |
| 05/06/2012 09:28:00* | yes | | 09:28:00 | certain | 32 | NO VISUAL SIGHTING | Inch Cape |
| 05/06/2012 12:22:00* | yes | | 12:23:25 | certain | 289 | WHITE-BEAKED DOLPHIN | Inch Cape |
| 05/06/2012 12:45:00 | yes | 12:52:00 | 12:49:37 | likely | 7 | WHITE-BEAKED DOLPHIN | Inch Cape |
| 05/06/2012 13:45:01 | no | | | | | WHITE-BEAKED DOLPHIN (500 m) | Inch Cape |

| Date and Time | Acoustic detection | Whistles | Click train | Acoustic classification | No. Clicks | Visually Recorded Species (Distance) | Site |
|---|---|---|---|---|---|---|---|
| 05/06/2012 13:49:30 | no | | | | | WHITE-BEAKED DOLPHIN (1000 m) | Inch Cape |
| 05/06/2012 15:31:40 | yes | | 15:31:40 | likely | 25 | NO VISUAL SIGTHING | Inch Cape |
| 05/06/2012 18:46:00 | no acoustic effort | | | | | DOLPHIN SP. | Inch Cape |
| 07/08/2012 15:09:27 | no acoustic effort | | | | | WHITE-BEAKED DOLPHIN | Inch Cape |
| 08/08/2012 07:03:44 | no | | no | | | WHITE-BEAKED DOLPHIN (300 m) | Inch Cape |

** Indicates events used for analysis*

**Figure 14A.2.4: Locations of Dolphin Encounters**



#### 14A.2.3.1 Classification

Figure 14A.2.1 shows a white-beaked dolphin click train event in the PamGuard viewer while Figure 14A.2.2 shows the typical banding in a concatenated spectrogram for a white-beaked dolphin event. For comparison, Figure 14A.2.5 shows a common dolphin (*Delphinus delphis*) click train and Figure 14A.2.6 the concatenated spectrogram for this event. There is no indication of frequency banding for this species, indeed banding is thought to the exception rather than the rule amongst delphinid species.

Nine of the 11 acoustic encounters (five white-beaked dolphin, one Risso's and three Dolphin sp, plus two events reanalysed with different filter settings) had data of sufficient quality to produce average spectra (see Figure 14A.2.3) and allow further analysis.

Each template had between ten to seven peaks and notches. The frequencies of the peaks and notches in the mean spectra for each encounter (all species), and for the two Risso's acoustic only encounter which have been processed with the Risso's detector settings, are shown in Figure 14A.2.7. Symbol colours indicate the different classes of visual detection: blue are the animals identified as white-beaked dolphins in the field, dark grey indicates the unidentified dolphins, red are the Risso's dolphins while green indicates an occasion with a "certain" acoustic detection without a sighting. Consistent peaks occurred in all acoustic events at 39 kHz, 45-47 kHz, 55 kHz and at 62-64 kHz while consistent troughs were found at 33-36 kHz, 41-43 kHz, 49-53 kHz, 57-61 kHz and at 66-68 kHz (some patterns also seem to be evident below 30 kHz but are not as consistent). This suggests that the unidentified dolphins and the acoustic detection with no visual confirmation were in fact encounters with white-beaked dolphins. This suggestion would call into question whether the single Risso's dolphin sighting was correctly identified in the field.

To test this suggestion MER Ltd was able to obtain a single full bandwidth recording of a Risso's Dolphin from the Hebridean Whale and Dolphin Trust (HWDT) who kindly provided MER Ltd with a Risso's dolphin acoustic recording made with a confirmed visual sighting. Banding is evident for this species (Figure 14A.2.8) but at different frequencies. The HWDT templates are represented with rose squares in Figure 14A.2.7. Although there is some overlap with the white-beaked dolphin bandings the Risso's dolphin show consistent banding in the lower frequenices range (consistent peak at 23 kHz, 27 kHz and 37 kHz, notch at 25 kHz). Another difference between the two species is the waveform of the clicks (Figure 14A.2.9). The Risso's dolphin waveform does not show the pronounced multiplied structure seen in the white-beaked dolphin clicks.

**Figure 14A.2.5: Example of a Common Dolphin Click Train. Note: Lack of Peaks and Notches in Click Spectrum**

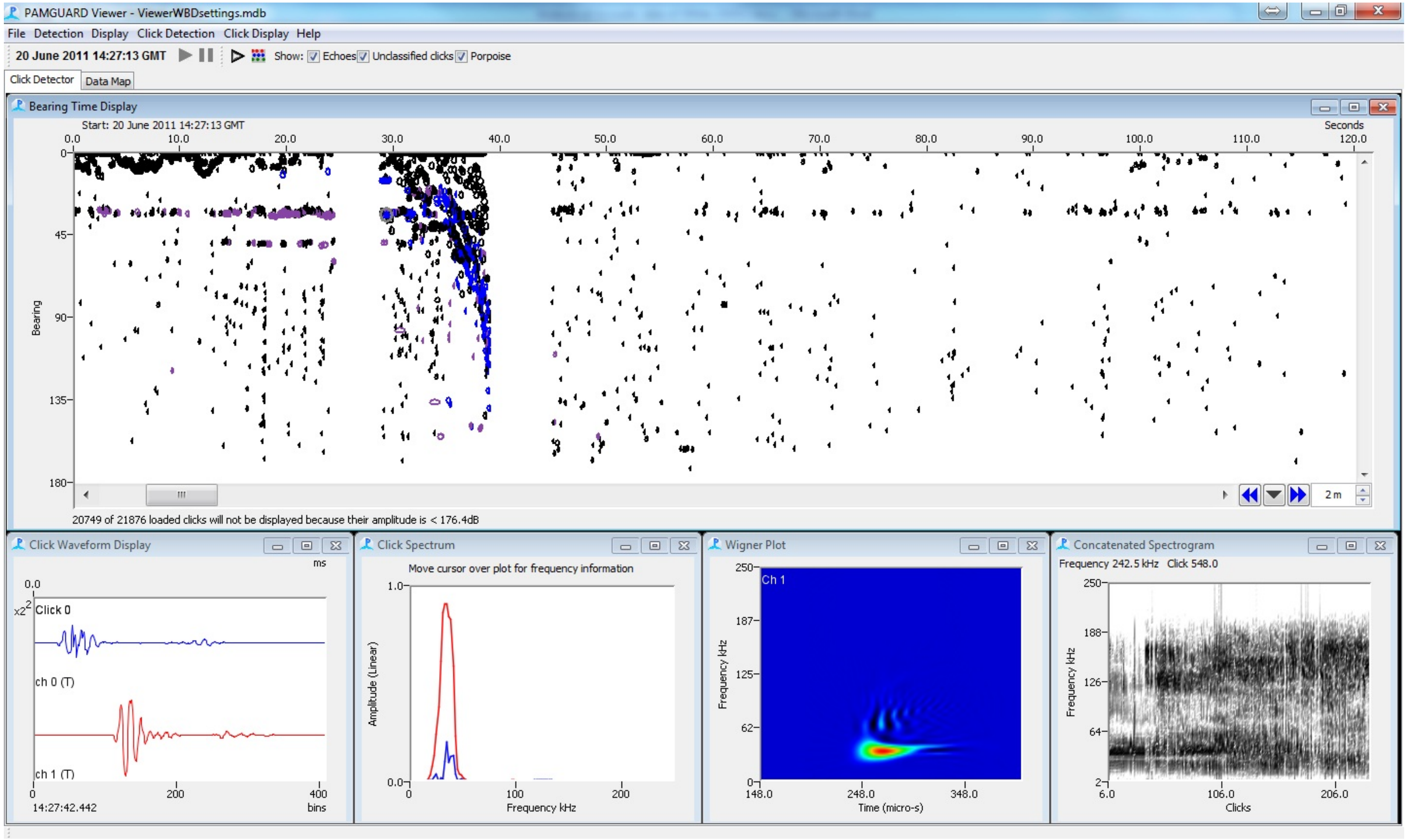


**Figure 14A.2.6: Concatenated Spectrum of Common Dolphin Click Train. Note: Lack of Banding in Lower Frequencies (<80 kHz)**

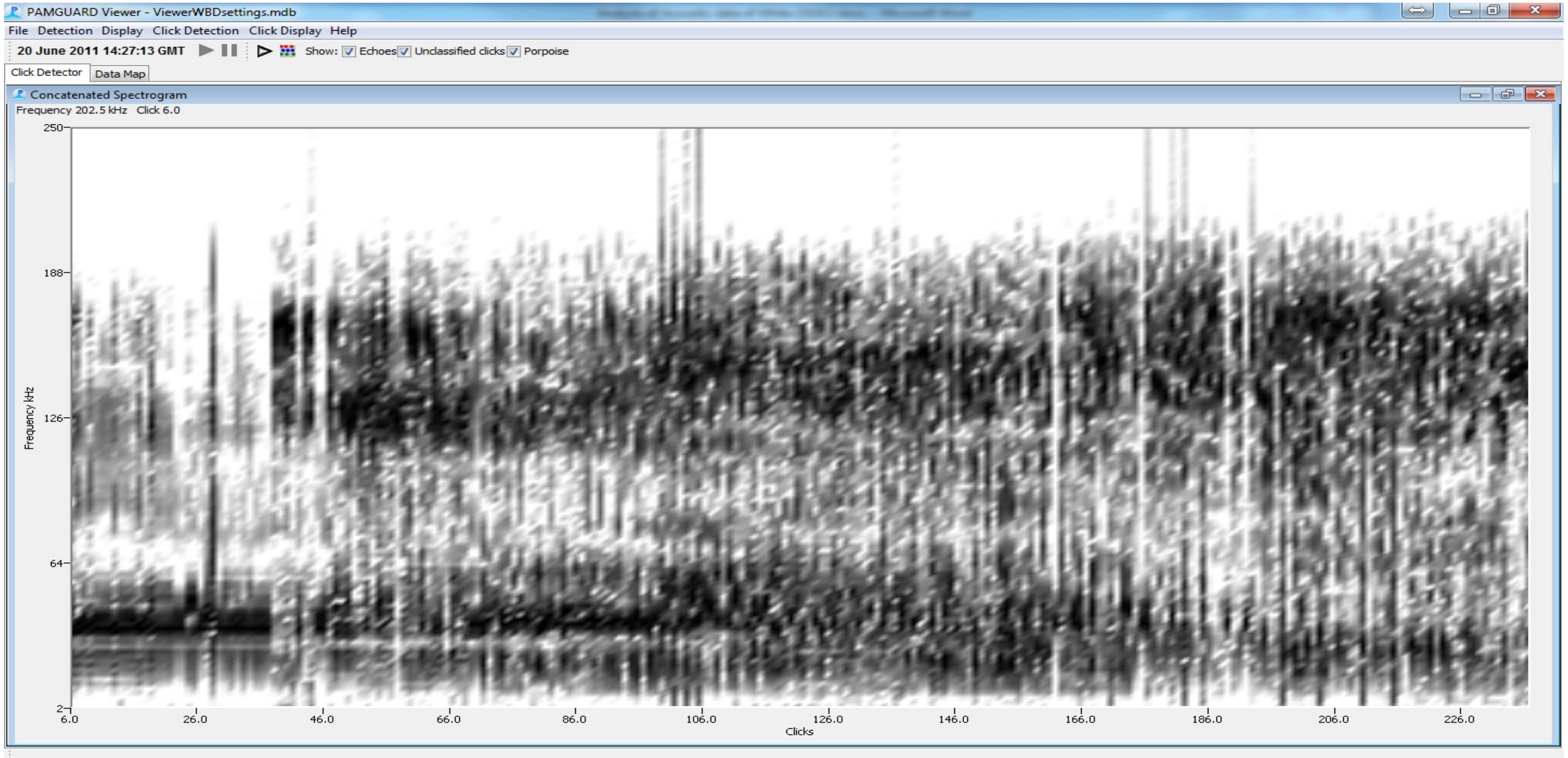


**Figure 14A.2.7: Representation of Peaks and Notches Found in White-beaked Dolphin Events. Red Squares Indicate Consistent Frequencies Throughout All Events (with in a 4 kHz range)**

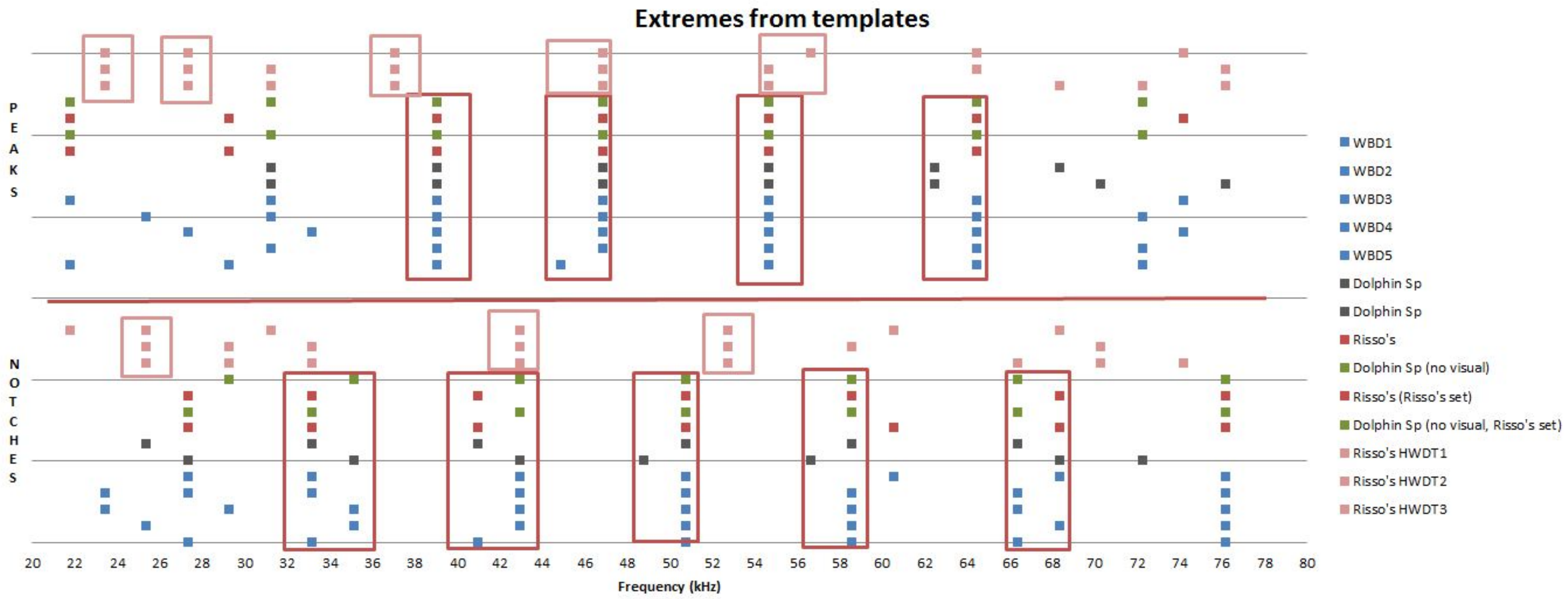
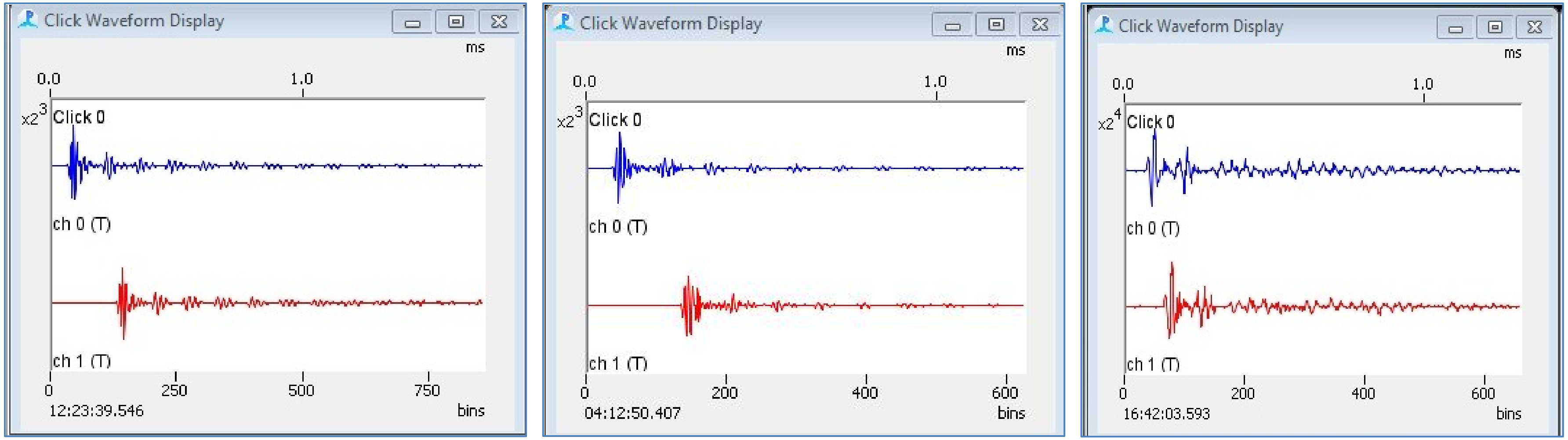


**Figure 14A.2.8: Waveforms of A: White-beaked Dolphin, B: Risso's Dolphin (but likely White-beaked Dolphin), C: Risso's Dolphin (Source: HWDT)**




**A** **B** **C**

## 14A.2.4 Discussion

Dolphins have typically been identified acoustically on the basis of the acoustic characteristics of their whistles. However, because white-beaked dolphins (and Risso's) whistle infrequently and usually only during specific behavioural states, a different approach based on the acoustic characteristics of their clicks is necessary (Rasmussen and Miller 2002, Neves *et al*. 2011). New PamGuard modules have been developed to facilitate this analysis. Previous work showed that the dominant banding that occurs in the clicks of these dolphins occurs in a characteristic pattern which can be measured and summarised by extracting the frequencies at which peaks and troughs occur in the mean spectra from all the dolphin clicks recorded during encounters (Wittich and Gordon 2012a, Wittich and Gordon 2012b). These characteristics appear to be sufficiently consistent to allow species identification. The work presented here demonstrates that it is possible to identify white-beaked dolphin clicks and MER Ltd was able to use this ability to determine the species for the one encounter which the visual team recorded as unidentified.

Risso's dolphins (*Grampus griseus*) have also been shown to produce banded clicks (Soldevilla *et al*. 2008, Roch *et al*. 2011, Soldvilla *et al*. 2011). MER Ltd analysed recordings made during one encounter with animals recorded as being Risso's dolphins by the visual team. The location of peaks and troughs during this encounter are the same as the banding from confirmed white-beaked dolphin encounters and were quite different from banding patterns reported for Risso's dolphins from the Pacific (Soldevilla *et al*. 2008, Roch *et al*. 2011, Soldvilla *et al*. 2011) and found in the recording of a Risso's dolphin in Scottish waters provided by HWDT. Based on this, MER Ltd questions whether the visual team might have misidentified these animals. Another option would be a mixed group of white-beaked and Risso's dolphins, as they have previously been reported as associating with each other (Reid *et al*. 2003). The distribution map suggests a sighting of Rissos's dolphins at this site is possible but unlikely (Reid *et al*. 2003).

Methods for reliable species identification based on dolphin clicks are still being developed. One useful next step should be to build an appropriate automated classifier as has been done for harbour porpoises (Gillespie and Chappell, 2002). However, although white-beaked dolphin click characteristics seem to be consistent, they are more complicated (multiple peaks and troughs need to be identified and measured) and less stereotyped than those of porpoise clicks. It is likely that a more sophisticated approach will be necessary to automate this process. A classifier would significantly reduce the time needed to analyse the data.

Being able to detect and identify dolphins acoustically has several advantages. Passive acoustic monitoring (PAM) is used increasingly for marine mammal surveys and as a mitigation tool during renewable energy developments. PAM is less affected by visibility and weather and can also be used effectively at night. Dolphins are usually encountered less frequently in European waters than are porpoises (Scans II, 2008) so important information is lost if groups go undetected, or if species identification cannot be confirmed. In this case, the acoustic system contributed only one detection which was not also made by the visual team (this probably reflects the fact that, unlike harbour porpoises, white-beaked dolphins are relatively easy to spot, and these surveys are generally conducted in good sighting conditions with large experienced visual teams). The greatest additional benefit came from the ability to provide species identification where this had not been confirmed in the field. It is also clear that it can be useful to have a second method of species ID to support visual observations.

Comparison of the findings from this study with preliminary results from similar recordings made off the east coast of England (Wittich and Gordon 2012a, Wittich and Gordon 2012b) reveal shared banding frequencies between the two areas. There were two shared peaks at 39 kHz and 45-47 kHz and three shared notches at 33-35 kHz, 41-43 kHz and at 49-51 kHz. By contrast, an on-going analysis of recordings made on the West Coast of Scotland suggests that banding is present at different frequencies from those in the East Coast population. This might point to the existence of different sub-populations in these two areas. If this is the case then the inclusion of PAM in surveys for this species should be seen as crucial.

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