Agenda Item 6.1 Project Funding through ASCOBANS

Progress of Supported Projects

Information Document 6.1.b

Interim Project Report: Examine habitat exclusion and long term effect of pingers

Action Requested

- Take note

Submitted by Secretariat / Aarhus University

UNEP ASCOBANS

NOTE:
DELEGATES ARE KINDLY REMINDED
TO BRING THEIR OWN COPIES OF DOCUMENTS TO THE MEETING

Status report –
Porpoise monitoring in Pinger fishery
(Marsvinemonitering i Pingerfiskeri (MIP))

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Contents

1 Introduction

Harbour porpoises are part of the assignment in 16 Natura 2000 areas in Danish waters. From 2011 porpoises became part of the national monitoring program of species and nature, NOVANA. In the inner Danish waters the Natura 2000 areas are monitored by static acoustic monitoring using C-PODs. C-PODs detect and record porpoise echolocation sounds in a radius of up to 500 meter and thereby provides a relative estimate of abundance (Kyhn *et al.* 2012).

Bycatch in set net fishery are considered the biggest threat to porpoises. The exact reason for bycatch is not well known, but using acoustic alarms, so-called "pingers" placed on the set nets are reducing bycatch of porpoises (e.g. Kraus *et al.* 1997). The temporal and spatial effect of pingers on porpoises is not fully understood, but experiments have shown, that e.g. the PICE pinger may scare porpoise away from the net in a radius of ca. 500 m (Culik *et al.* 2001, Carlstrøm *et al.* 2009). This present the risk, that the porpoises are scared out of, or change behaviour, in important habitats like Natura 2000 areas, when pingers are used. It is therefore important to investigate the effect of pingers, not only around individual stationary pingers, but also in larger areas with real life fishery where gear and number of pingers may change spatially from day to day. Before pingers are fully implemented as the solution to mitigate bycatch in areas designated to protect porpoises, the large scale and long term effects must be known.

Using a BACI design, this project aim to examine if porpoise density will changed in a larger area of the Great Belt, when mandatory use of pingers in all set net fisheries are enforced a limited time period from mid-2014. By comparing the presence of porpoises in the Great Belt with a control area in Kalundborg Fjord both before, during and after pingers have been introduced, we will be able to estimate the effect of pingers on porpoises in relation to density and acoustic behaviour. To increase the statistical certainty the presence of pingers in the vicinity of the recording stations will be monitored using noise loggers that are able to record pinger sounds out to about 700 meters. Furthermore, noise loggers will be used to make sure that pingers are not used in the control area in Kalundborg Fjord.

Simultaneously with the project described in this report, a project managed by DTU Aqua, will use video surveillance on-board 9 commercial set net fishing vessels to document the byctach before and during the use of pingers in the Great Belt.

DTU Aqua is also gathering information on the gillnet fishing effort in the Great Belt across the year by counting all set nets from boat along the coast several times a year 2013-2014.

This report is the first status report covering the baseline period from July 2011 to June 2013 for the 14 C-POD stations that have listened for porpoises more or less continuously during this period.

1.1 Description of the area

The Great Belt is one of three narrow straits between the Baltic Sea and the Kattegat/North Sea. This results in strong currents especially during and after storms. Kalundborg Fjord is more protected by two peninsulas stretching out in the northern Great Belt. The water depth varies a lot down to about 60 m. The Great Belt Bridge crosses east-west in the middle of the belt and one of the busiest ship routes (t-route) connecting the Baltic and the North Sea crosses the Belt from north to south. As seen in figure 2.1.1 a large part of the Great Belt and Kalundborg Fjord is designated as Natura 2000 areas for harbour porpoises.

1.2 Harbour porpoise biology

Harbour porpoises reach a maximum length of about 1.8 m and maximum weight about 90 kg. They are relatively short-lived compared to other odontocetes, with an expected lifetime of about 15-20 years (Figure 1.2.1., Lockyer and Kinze 2003).

Figure 1.2.1. Harbour porpoises. Photo: Jonas Teilmann.

The breeding period of harbour porpoises begins in late June and ends in late August. Ovulation and conception typically take place in late July and early August (Sørensen and Kinze 1994). The pregnancy period is about 11 months and the females thus give birth to the single calf in early summer. The calves begin suckling immediately after birth and feed by their mother until the following year possibly until the next calf is born (Teilmann *et al.* 2007). The females can conceive when they are 3 or 4 years old (Kinze *et al.* 2003). Changes in food resources may influence the reproduction of porpoises. Calves seem to be sighted throughout their range and there may not be any particular breeding/nursing areas (Hammond *et al.* 1995; Kinze *et al.* 2003). However, satellite tracking of adult females show that they may have individual preference for particular areas (Teilmann *et al.* 2004; Teilmann *et al.* 2008).

Between 1985 and 2006, the stomach contents of 392 harbour porpoises from the Kattegat, Danish Straits and the western part of the Baltic Sea were studied. The preferred food sources of harbour porpoises in Danish waters comprise 24 fish species. The percent of occurrence in the 392 stomachs was 45% with gobies (*Gobiidae*), 40% with herring (*Clupea harengus*), 33% with cod (*Gadus morhua*), 18% with saithe (*Pollacius virens*), 12% with sprat (*Sprattus sprattus*) and 11% with sandeel (*Ammodytes spp.*) as the six most important groups (Sveegaard 2011).

Like other toothed whales (odontocetes) harbour porpoises have good underwater hearing and use sound actively for navigation and prey capture (echolocation). They produce short ultrasonic clicks (130 kHz peak frequency, 50-100 µs duration; Møhl and Andersen 1973; Teilmann *et al.* 2002) and are able to orient and find prey even in complete darkness. Porpoises tagged with acoustic data loggers indicate that they use their echolocation almost continuously (Akamatsu *et al*. 2007; Linnenschmidt *et al.* 2012).

1.3 Density and distribution

The two SCANS surveys, conducted in 1994 and 2005 represents the largest coordinated effort to map the distribution and abundance of cetaceans, including harbour porpoises in European waters. They were conducted in July both years and thus represent summer distribution of animals. In July 2012, the SCANS method was used in a smaller scale survey covering the inner Danish waters (Kattegat, Belt Seas and Western Baltic). In all three surveys, porpoises were observed within the Inner Danish waters, but such large scale surveys cannot subsequently be utilised for calculating abundance for much smaller area such as the Great Belt or Kalundborg Fjord. Furthermore, visual surveys have a short temporal scale, and would have to be repeated continuously thoughout the year to detect any effect of pinger-implementation. Thus, when examining the effect of pingers, it is preferable to use a sampling method with long temporal scale such as static acoustic monitoring.

In the years 1997-2013, 99 harbour porpoises incidentally live caught in Danish pound nets were equipped with satellite transmitters. Individual animals were tracked for up to 500 days. From the data it is evident that animals cover extensive areas and tagged animals moved between areas in Kattegat, the Belt Seas and the western Baltic (Figure 1.3.3.1. Sveegaard *et al.* 2011). Furthermore, the porpoises do not distribute evenly but spend more time in certain high density areas such as the central Great Belt, the southern Samsø Belt and the northern Little Belt.

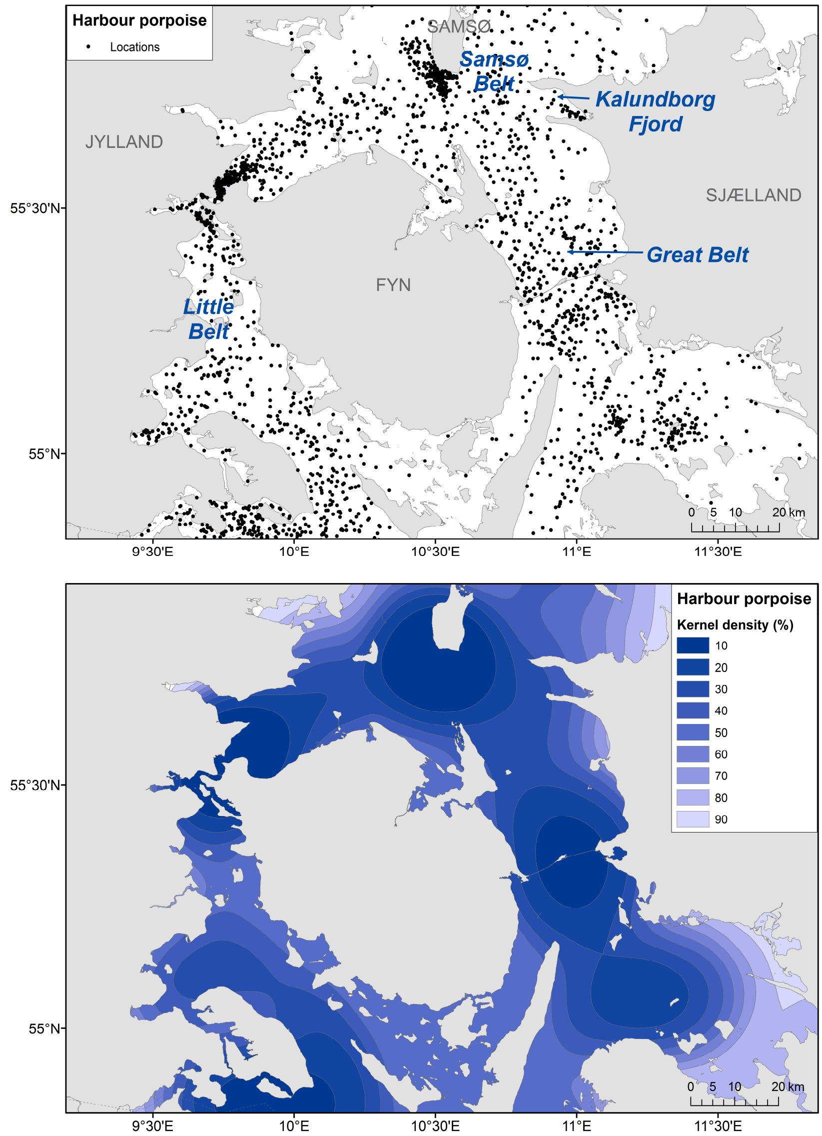


Figure 1.3.3.1. Locations from the harbour porpoises equipped with satellite transmitters in part of their range in the Danish Belt Seas from 1997 to 2013. Black dots in upper map indicate one daily position from each satellite tagged porpoise. Coloured areas in bottom map indicate kernel density home ranges with darker blue indicating higher concentration and lighter blue lower concentration of animals (Methodology from Sveegaard *et al.* 2011).

1.4 Protection

The harbour porpoise is listed in Annex II and IV of the Habitats Directive (92/43/EEC), Annex II of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention) and Annex II of the Convention on International Trade in Endangered Species (CITES), and it is covered by the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), and by the Convention on the Protection of the Marine environment of the Baltic Sea (HELCOM).

The annex IV of the Habitats Directive, among other implies that "*Member States shall take the requisite measures to establish a system of strict protec-*

tion for the animal species listed in Annex IV (a) in their natural range, prohibiting: ... (b) Deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration ..." (article 12).

The ASCOBANS agreement states among other that member states are obligated to "*Work towards ...(c) the effective regulation, to reduce the impact on the animals, of activities which seriously affect their food resources, and (d) the prevention of other significant disturbance, especially of an acoustic nature*" (Annex to Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (New York, 1992)).

2 Materials and methods

2.1 Stations and deployment period

In total 14 C-POD stations have been deployed in the study area, 5 of which act as control stations (no impact) in the Kalundborg Fjord and 9 as impact stations in the Great Belt (Fig. 2.1.1., Table 2.1.1.).

Battery capacity and memory in the C-PODs is under normal conditions sufficient for continuous operation for 6 months and therefore all stations have been visited within this timeframe for service. The time series obtained from the C-POD signals contained some gaps where they were not deployed or lost from the position mainly due to trawling. 13 of the 14 C-POD stations was, however, successfully recorded on 58-99% of deployment days, whereas the last C-POD (KF1) only recorded for 31% of deployment days (Figure 2.1.2.).

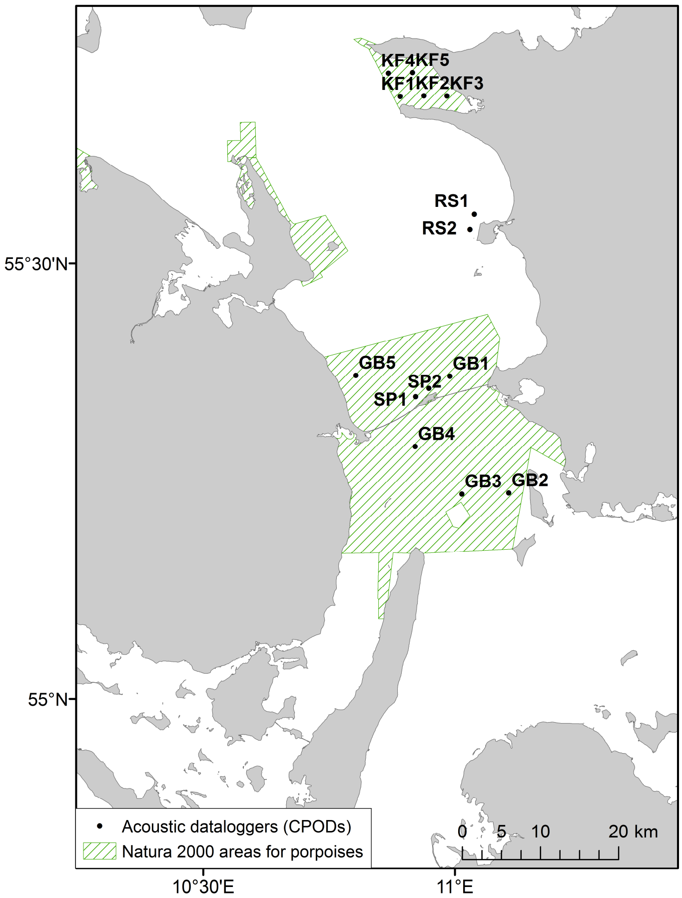


Figure 2.1.1. Map of the study area with black dots indicating the C-POD stations in the Great Belt (GB) including two stations near Sprogø (SP) and two stations near Reersø (RS) and Kalundborg Fjord (KF) under the NOVANA program. Blue dots indicate C-POD stations deployed under this project as a supplement to the NOVANA monitoring design.

Table 2.1.1. List of the 14 C-POD stations, their coordinates and water depth as well as location. KF= Kalundborg Fjord, GB=Great Belt, RS= Reersø, SP=Sprogø.

Area	Station	Position (WGS84)		Depth (m)
Control 1	KF1	10° 56,034'E	55° 40,956'N	6.2
Control 2	KF2	10° 58,922'E	55° 40,956'N	13.4
Control 3	KF3	11° 01,718'E	55° 40,900'N	13.1
Control 4	KF4	10° 54,659'E	55° 42,575'N	16
Control 5	KF5	10° 57,608'E	55° 42,574'N	15.2
Impact 1	GB1	11° 01,096'E	55° 21,600'N	18
Impact 2	GB2	11° 07,763'E	55° 13,477'N	10
Impact 3	GB3	11° 02,125'E	55° 13,492'N	27
Impact 4	GB4	10° 56,658'E	55° 16,842'N	26.5
Impact 5	GB5	10° 49,738'E	55° 21,837'N	21
Impact 6	RS1	11° 04,620'E	55° 32,700'N	8
Impact 7	RS2	11° 04,050'E	55° 31,680'N	8
Impact 8	SP1	10° 56,880'E	55° 20,280'N	7.6
Impact 9	SP2	10° 58,500'E	55° 20,820'N	8

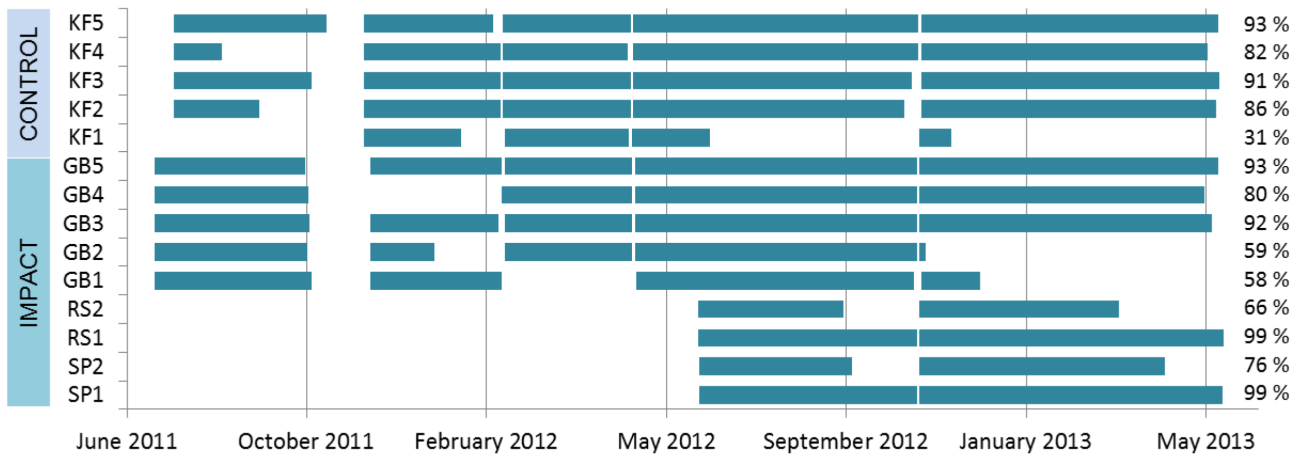


Figure 2.1.2. Overview of CPOD recording periods by station during the 2 year baseline deployment period (June 2011-May2013). % shows percent days with CPOD recordings out of the total number of deployment days. KF= Kalundborg Fjord, GB=Great Belt, RS= Reersøe, SP=Sprogø.

2.2 C-PODs – principle of operation and characteristics

The C-POD or POrpoise Detector is a small self-contained data-logger that logs echolocation clicks from harbour porpoises and other cetaceans. It is developed by Nick Tregenza (Chelonia, UK). It is programmable and can be set to specifically detect and record the echolocation signals from harbour porpoises.

The C-POD consists of a hydrophone, an amplifier, a number of band-pass filters and a data-logger that logs echolocation clicks.

The C-POD relies on the highly stereotypical nature of porpoise sonar signals. These are unique in being very short (50-150 µs) and containing virtually no energy below 100 kHz (Fig. 2.2.1). The main part of the energy is in a narrow band (120-150 kHz), which makes the signals ideal for automatic detection. Most other sounds in the sea, with the important exception of boat echosounders, are characterised by being either more broadband (energy distributed over a wider frequency range), longer in duration, with peak energy at lower frequencies or combinations of the three. In addition echosounders has a more regular pattern than porpoise echolocation. No other cetacean regularly found in the Great Belt area has sonar signals that can be confused with porpoise signals.

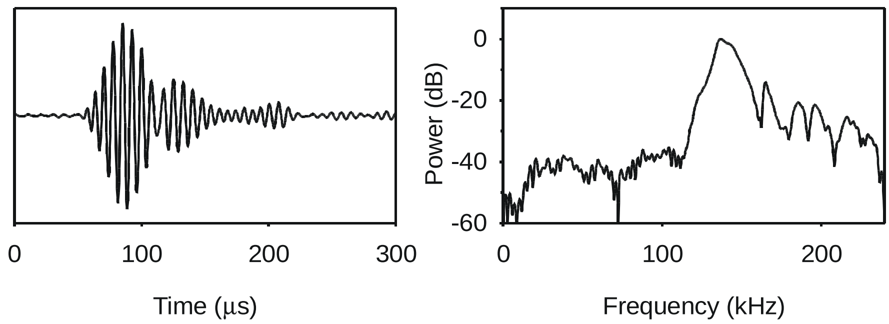


Figure 2.2.1. Porpoise click time signal (left) and power spectrum (right). There is virtually no energy present below 100 kHz (the curve below 100 kHz represents background noise of the recording).

Prior to the first deployment, the C-PODs were calibrated in a circular cedar wood tank, 2.8 m deep, 3 m diameter located at University of Southern Denmark's research facility in Kerteminde. C-PODs were fixed in a holder with the hydrophone pointing downwards and placed 0.5 m below the water surface. A projecting hydrophone (Reson TC4033) was placed in the same depth, 1 m from the C-POD. Calibration signals were 100 µs pulses of 130 kHz pure tones, shaped with a raised cosine envelope. Signals were generated by an Agilent 33250A arbitrary waveform generator. Projector sensitivity was measured prior to calibration by placing a reference hydrophone (Reson TC4034) at the position of the C-POD hydrophone.

The data recorded by the C-PODs are processed using the software C-POD.exe v2.042 (Fig. 2.2.2.) using the "Hel1" classifier, which is an algorithm especially designed for the Baltic conditions, and the train filter (the encounter classifier) "Harbour Porpoise". Data from each station were exported as "detection positive minutes" (=Porpoise Positive Minutes, PPM).

Figure 2.2.2. Screen snapshot from the C-POD.exe software showing a harbour porpoise encounter with time (seconds) on the X-axis and frequency on the Y-axis.

C-POD deployment system

Two deployment systems were used in the study area: Acoustic release and surface buoy. The acoustic release system consisted of two 25 kg sand bags as anchor, an acoustic release (Sonardyne, type 7986 Light-weight Release Transponder), the C-POD and 3 orange floats at the top. The releaser and the C-POD were placed in a black tube for protection against trawlers (Fig. 2.3.1).

Figur 2.3.1 Acoustic equipment with and without protective tube with hydrophone at the top and acoustic release mecanish between tube and sand bag. Orange buoys keeps the equipment vertical in the water column.

The deployment system using acoustic releasers were used on larger depths (10-27m) while the surface buoy system were used on the positions with shallow water (6-8 m). The surface buoy system consisted of a surface buoy with a yellow cross and radar reflector on the top. This was connected to an anchor at the bottom by a metal chain. This anchor were connected to a seconds anchor with typhoon wire, which again connects to an orange float at the surface. The C-POD was attached to the wire at the bottom (Fig. 2.3.2., Fig. 2.3.3.).

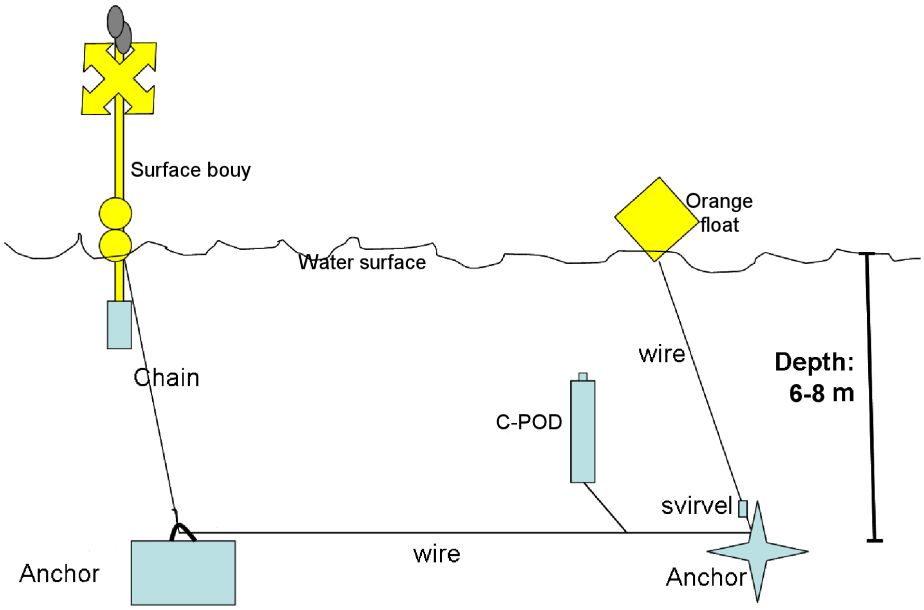


Figure 2.3.2. The deployment system used for mooring C-PODs. The set-up has been designed so that the instruments can be lifted to the surface by hand by pulling in the orange float (displayed as yellow square).

Figure 2.3.3. The buoy system seen from the surface. The red float is used to retrieve the instruments without pulling the heavy anchor up.

2.2.1 Porpoise activity indicators from T-POD signals

Four indicators were calculated from the C-POD signals extracted from the C-POD software with a 1 minute resolution. This signal, denoted x_t, describes the recorded number of porpoise clicks per minute and consisted of many zero observations (no clicks) and relatively few observations with click recordings. This signal, denoted x_t, described the recorded number of clicks per minute and consisted of many zero observations (no clicks) and relatively few observations with click recordings. The click activity per minute was aggregated into daily observations of:

$$\text{PPM = Porpoise Positive Minutes} = \frac{\text{Number of minutes with clicks}}{\text{Total number of minutes}} = \frac{N\{x_t > 0\}}{N_{total}}$$

$$\text{Click/PPM = Click intensity} = \frac{1}{N\{x_t > 0\}} \sum_{x_t > 0} x_t$$

Another approach was to consider the recorded click as a point process, i.e. separate events occurring within the monitored time span. Therefore, we considered x_t as a sequence of porpoise encounters within the C-POD range of detection separated by silent periods without any clicks recorded. Porpoise clicks were often recorded in short-term sequences consisting of both 1-minute observations with and without clicks. Such short-term sequences were considered to belong to the same encounter although there were also silent periods (no minute clicks) within the sequence. We decided to use a silent period of 10 minutes to separate two different encounters from each other. This threshold value was determined from graphical investigation of different time series of x_t. Thus, two click recordings separated by a 9 minute silent period would still be part of the same encounter. Converting the constant frequency time series into a point process resulted in two new indicators for porpoise echolocation activity.

Encounter duration = Number of minutes between two silent periods

Waiting time = Number of minutes in a silent period >10 minutes

This implied that waiting times had a natural lower bound of 10 minutes, and that encounters potentially included zero minute recordings. Encounter duration and waiting times were computed from data from each C-POD deployment individually identifying the first and last encounters and the waiting times in-between. Consequently, each deployment resulted in one more observation of encounter duration, since the silent periods at beginning and end of deployment were truncated (interrupted) observations of waiting times. Encounter duration and waiting time observations were temporally associated with the time of the midpoint observation, i.e. a silent period starting 30 September at 12:14 and ending 1 October at 1:43 was associated with the mean time of 30 September 18:59 and categorised as a September observation.

2.2.2 Statistical analyses

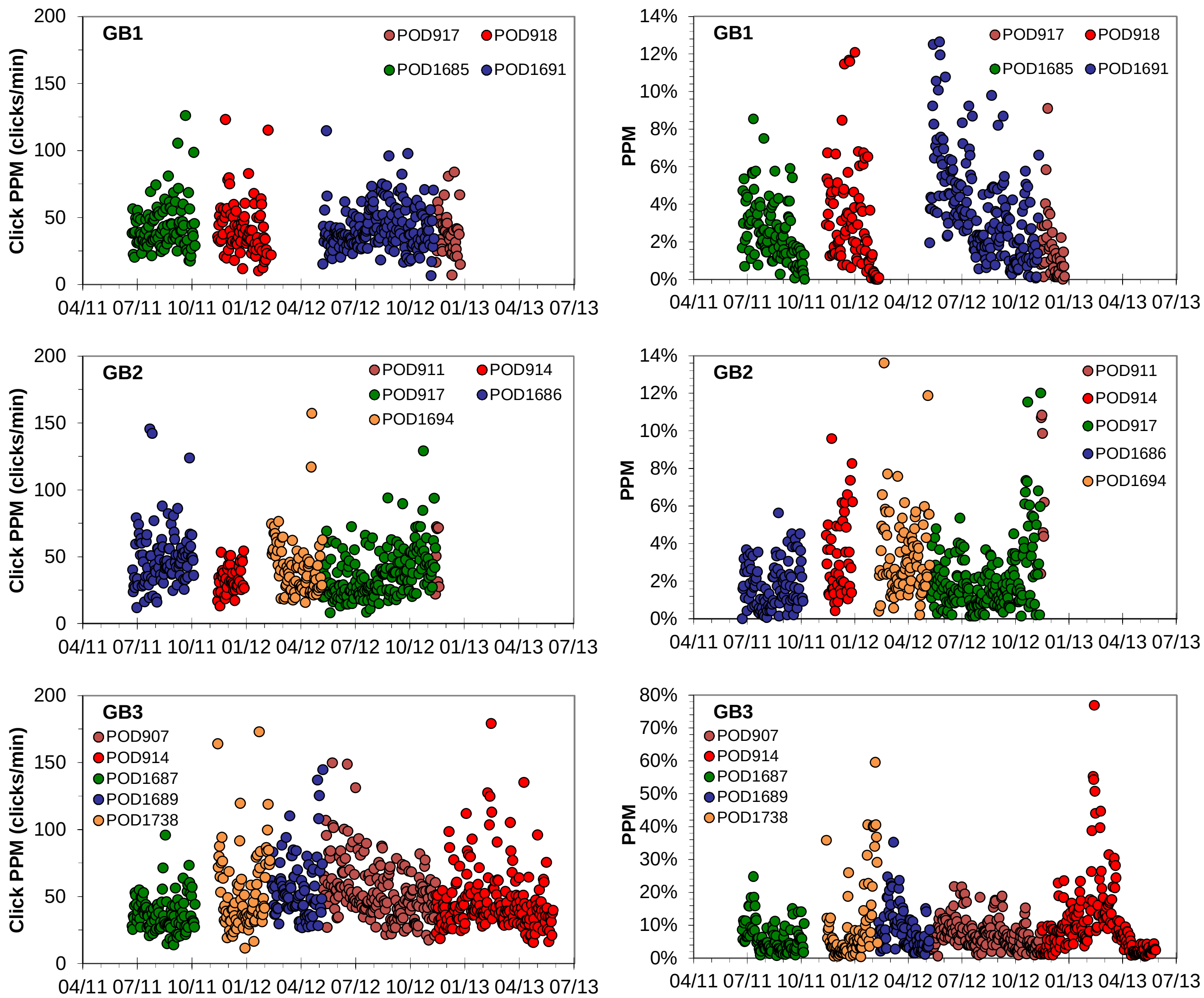
The main objective of the statistical analysis of the baseline data was to evaluate the suitability of the current monitoring design for assessing a potential effect on harbour porpoise echolocation activity of employing pingers on all deployed set net fishing gear. This objective will be investigated with a BACI design, where the implicit assumption is that the porpoise detection activity in the control and the impact area are comparable such that a potential effect of using pingers can be traced in the impact area. A correlation analysis between daily observations of PPM was carried out during the baseline period to determine if temporal variations between stations were similar, or if some stations had a differing temporal pattern that would exclude that station from the BACI analysis. The correlation analysis could not be carried out for the encounter statistics since these are not paired the same way as the daily statistics.

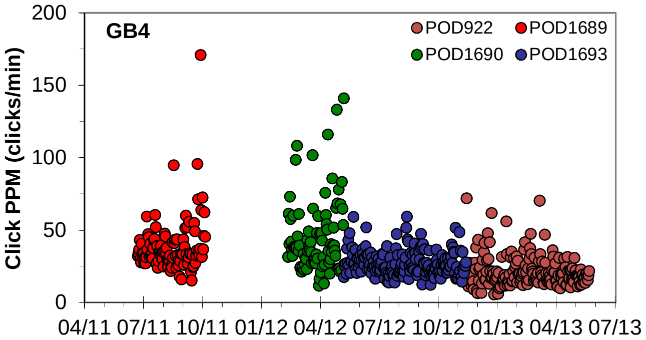
3 Results and discussion

During the baseline period C-PODs were deployed in the study area between 23 June 2011 and 8 June 2013 at the 14 stations. The echolocation activity of harbour porpoises was assessed by means of the indicators described applied to click recordings obtained from the porpoise detectors (C-PODs).

3.1 Daily statistics

Click PPM and PPM were calculated from the C-POD recordings (Fig. 3.1.1). There was a total of 6861 days with C-POD monitoring data from the 14 positions with number of deployment days ranging from 236 at RS2 to 678 at GB5 during the baseline period (Table 3.1.1). Clicks were recorded on most days (6245 out of 6861 days, ~91%). However, there were generally more silent days in January, February and March.

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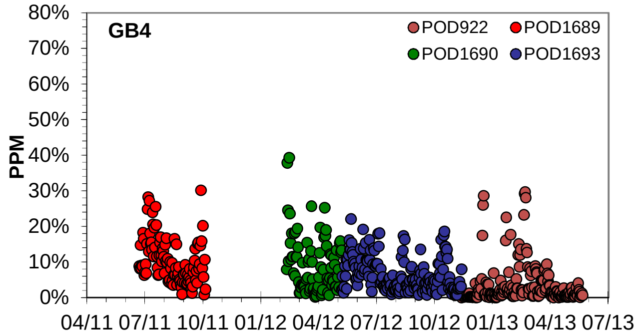
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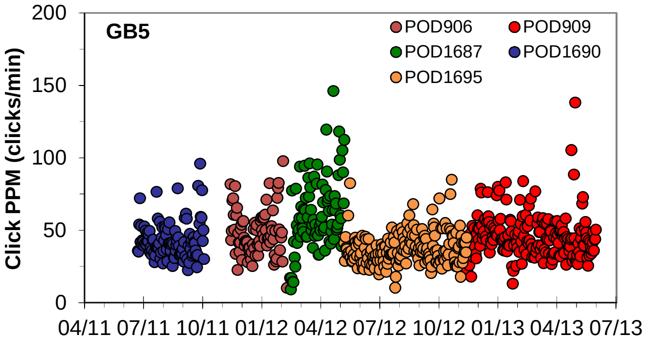
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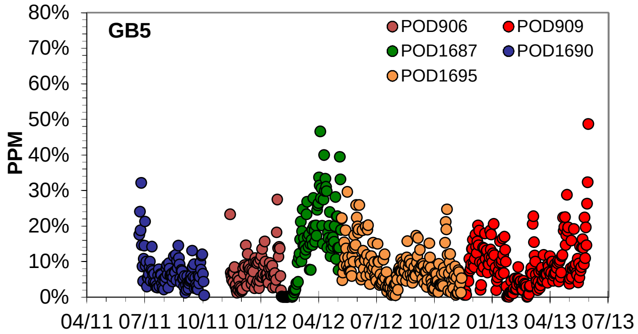
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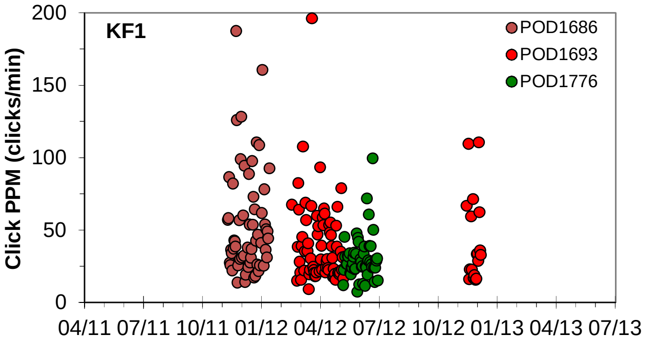
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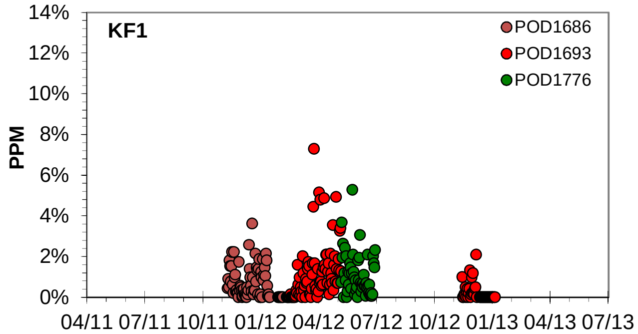
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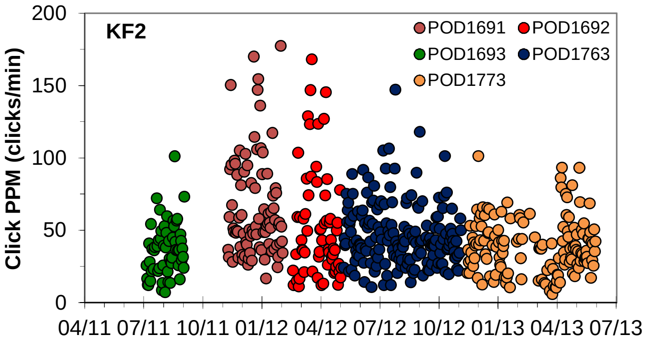
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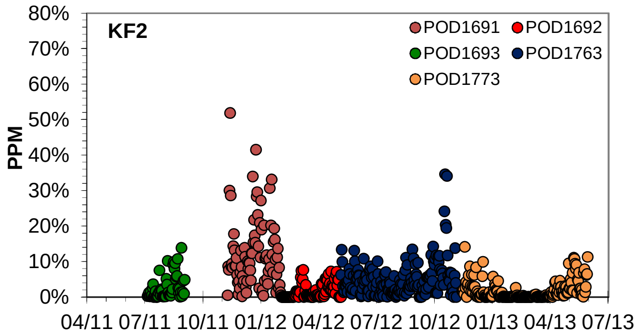
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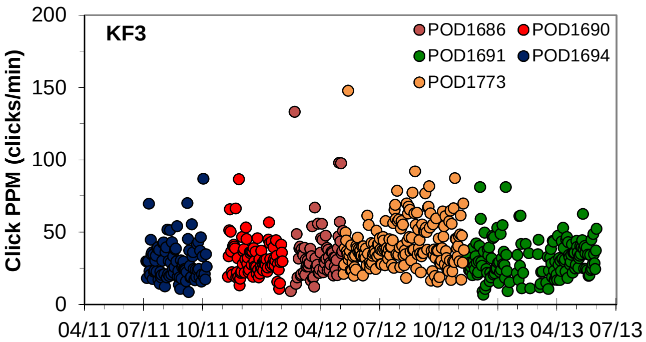
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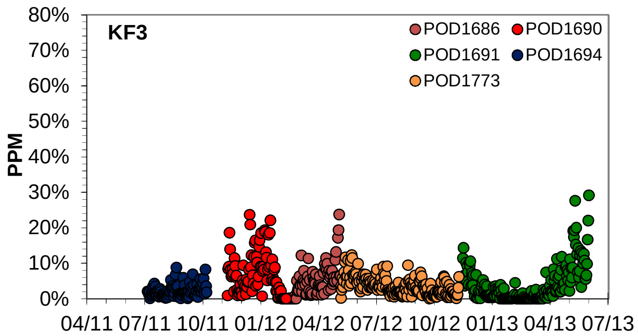
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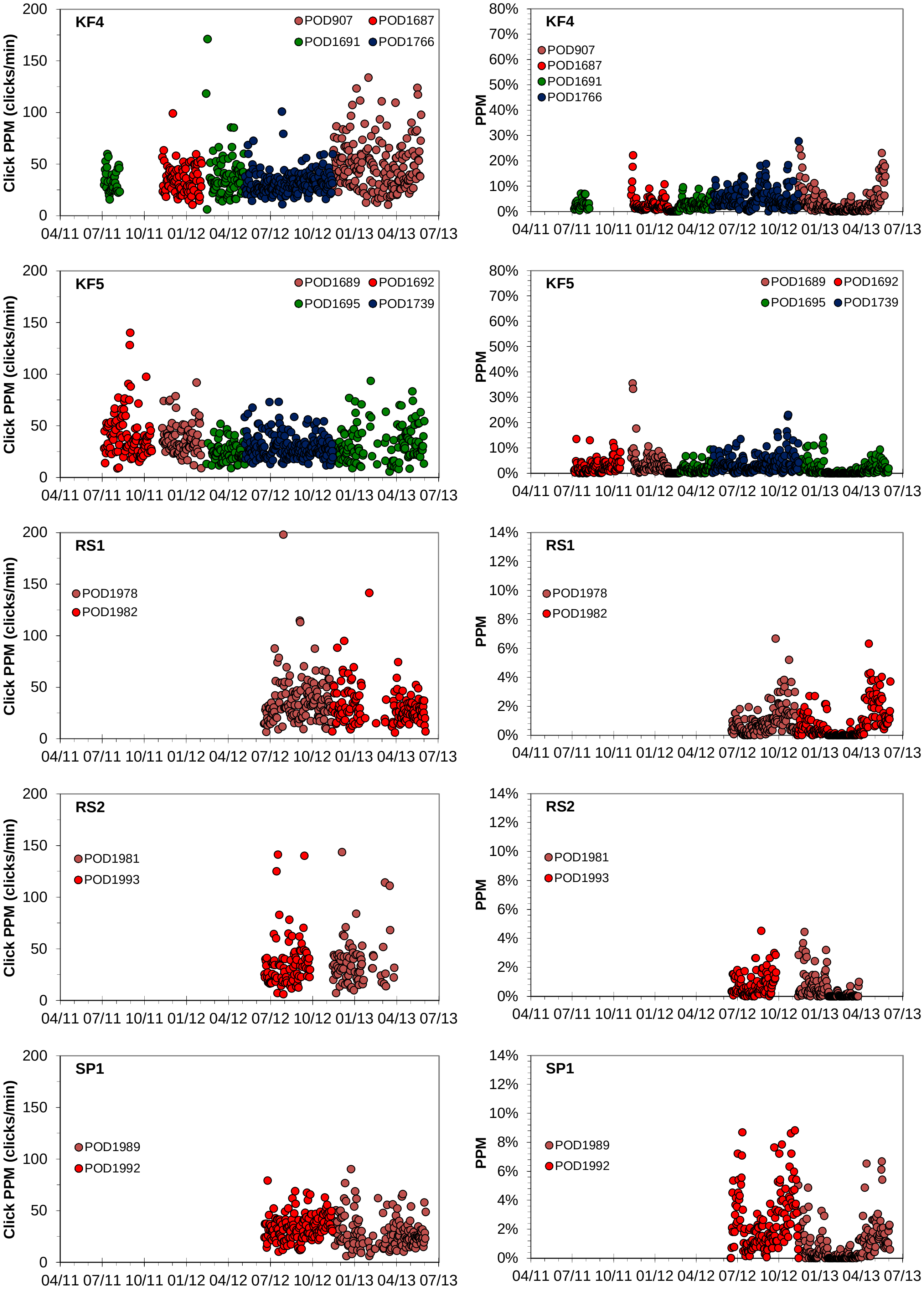
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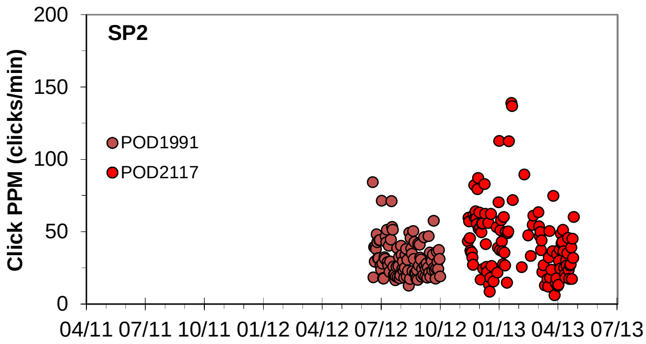
PPM
POD1689
POD1692
POD1695
POD1739
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13
RS1
Click PPM (clicks/min)
POD1978
POD1982
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13
RS1
PPM
0%
2%
4%
6%
8%
10%
12%
14%
POD1978
POD1982
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13
RS2
Click PPM (clicks/min)
POD1981
POD1993
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13
RS2
PPM
POD1981
POD1993
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13
SP1
Click PPM (clicks/min)
POD1989
POD1992
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13
SP1
PPM
POD1989
POD1992
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13



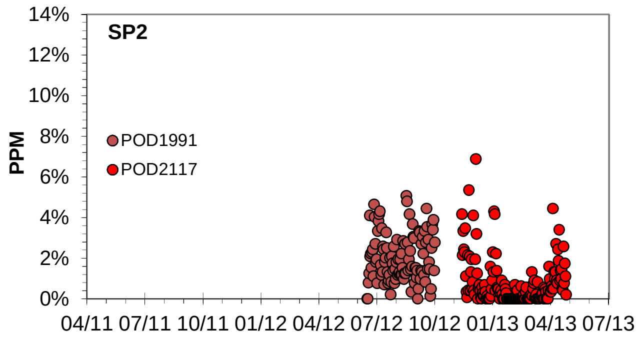


Figure 3.1.1 Click PPM (left panel) and PPM (right panel) extracted from C-POD data collected during the baseline (June 23rd 2011 to June 8th 2013). Observations are shown in different colours identifying the different C-PODs from which the indicators were obtained.

Temporal variations and variation between positions and PODs were relatively smaller for intensities (click PPM) compared to frequencies (PPM) (Table 3.1.1). For the 14 positions the coefficients of variation varied between 38% and 76% for click PPM and between 79% and 146% for PPM.

Table 3.1.1 Statistics of the two daily indicators monitored during the baseline periods in the Great Belt, Kalundborg Fjord, Reersø and Sprogø. Number of days with PPM is equal to the number of deployment days, whereas number of days with click PPM can be less due to days without any click recordings (missing value of click PPM).

Area	Posi-	Click PPM (clicks/minute)					PPM (%)				
	tion	N	Min	Median	Mean	Max	N	Min	Median	Mean	Max
Great	GB1	432	6.5	38.3	41.7	126	429	0	2.4	3.0	12.6
Belt	GB2	436	8.0	37.4	41.2	298	437	0	1.9	2.5	13.6
	GB3	673	11.4	43.2	49.5	236	673	0.3	6.3	8.5	76.9
	GB4	572	5.5	26.4	30.1	171	578	0	4.4	6.5	39.2
	GB5	664	9.0	42.2	45.2	146	676	0	7.2	9.1	48.7
Kalund-	KF1	200	7.3	31.8	43.0	227	268	0	0.5	0.8	7.3
borg	KF2	528	5.7	41.6	47.6	418	626	0	1.9	4.1	51.8
Fjord	KF3	605	6.5	32.4	34.7	148	667	0	2.8	4.2	29.2
	KF4	577	6.0	34.5	39.6	218	604	0	2.6	3.9	27.7
	KF5	595	5.5	29.0	32.7	140	681	0	1.7	2.7	35.5
Reersø	RS1	281	6.0	30.1	34.3	198	355	0	0.6	0.9	6.7
	RS2	172	6.0	31.3	36.1	144	236	0	0.3	0.6	4.3
Sprogø	SP1	303	6.0	29.7	31.3	90	357	0	1.1	1.6	8.8
	SP2	217	6.0	32.2	37.5	139	274	0	0.9	1.3	6.9

There were large differences in PPM between months during the baseline period (Fig. 3.1.2), and these were most pronounced in Kalundborg Fjord, Reersø and Sprogø having low PPM during February and to some degree also January and March. It should be stressed that for Reersø and Sprogø these months were measured only from summer 2012-2013. The almost opposite pattern was observed at stations GB3 and GB4 where PPM was highest in February, suggesting that porpoises may have shifted from the shallower coastal stations to the deeper and more open parts of the Great Belt. It is possible that this shift could have coincided with formation of thin surface ice in the more sheltered and near-shore stations. Click PPM did not reflect similar patterns.

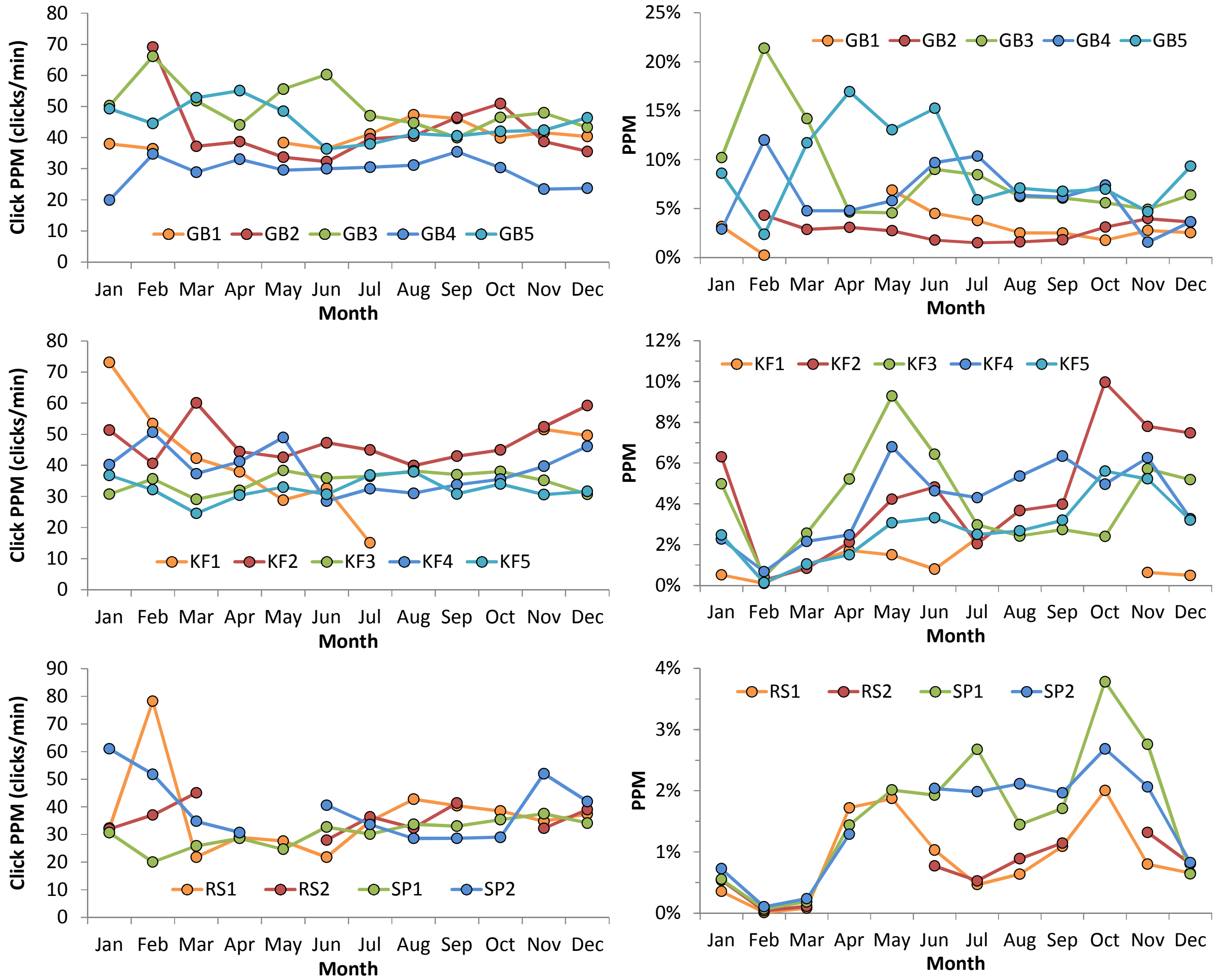


Figure 3.1.2 Monthly averages of Click PPM (left panel) and PPM (right panel) extracted from C-POD data collected during the baseline (June 23rd 2011 to June 8th 2013). Differences in sensitivity among C-PODs were not taken into account.

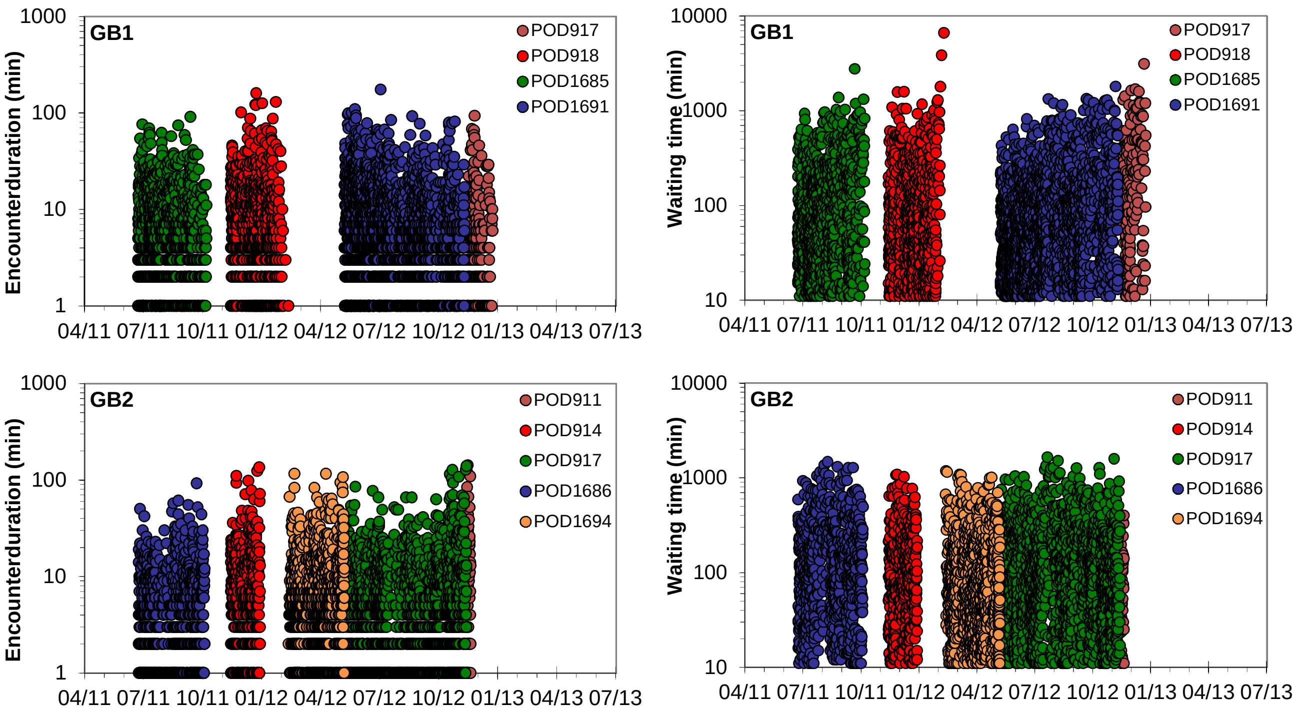
In fact, the opposing pattern between stations GB3 and GB4 versus the other stations was also apparent in the correlation analysis of daily observations of PPM (Table 3.1.2). In particular, station GB3 had several negative and significant correlations with the stations at Sprogø, Reersø and Kalundborg Fjord. Station GB4 also had negative correlations with most of the other stations, although not as significant as for GB3. On the other hand, all stations north of the Great Belt Bridge were strongly intercorrelated, suggesting that porpoise echolocation activity at these stations could be governed by the same mechanisms. A recommendation based on this correlation analysis would be to use stations north of the bridge only in the BACI analysis and therefore concentrate monitoring efforts during the pinger assessment period in this area.

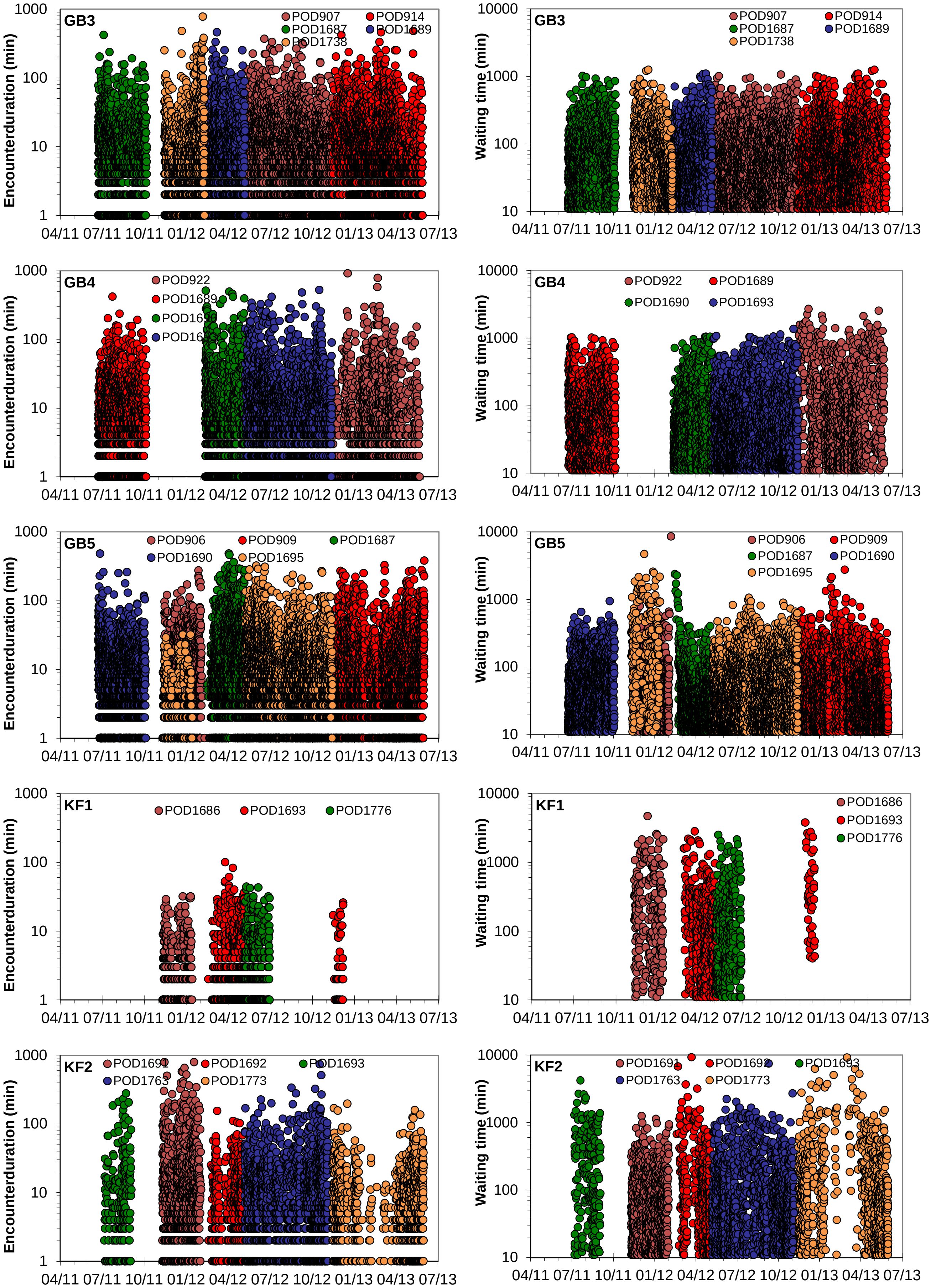
Table 3.1.2 Correlation between daily observations of PPM. Positive and significant (P<0.01) correlations are highlighted in green and negative and significant (P<0.01) correlations are highlighted in red. Stations are ordered from south to north.

	GB2	GB3	GB4	SP2	SP1	GB1	GB5	RS2	RS1	KF1	KF2	KF3	KF4	KF5
GB2	1.00	0.01	0.08	0.29	0.26	0.05	0.08	0.04	0.22	0.03	0.15	0.16	0.06	0.14
GB3	0.01	1.00	0.22	-0.32	-0.38	0.01	-0.08	-0.28	-0.48	-0.14	-0.22	-0.27	-0.20	-0.23
GB4	0.08	0.22	1.00	-0.03	0.04	0.28	-0.03	-0.08	-0.12	0.20	-0.03	-0.12	-0.11	-0.03
SP2	0.29	-0.32	-0.03	1.00	0.71	0.22	0.16	0.37	0.45	0.35	0.53	0.49	0.44	0.54
SP1	0.26	-0.38	0.04	0.71	1.00	0.12	0.10	0.40	0.51	0.41	0.50	0.36	0.35	0.49
GB1	0.05	0.01	0.28	0.22	0.12	1.00	0.27	-0.14	-0.16	0.47	0.21	0.48	0.23	0.17
GB5	0.08	-0.08	-0.03	0.16	0.10	0.27	1.00	0.31	0.27	0.43	0.13	0.36	0.27	0.17
RS2	0.04	-0.28	-0.08	0.37	0.40	-0.14	0.31	1.00	0.65	0.12	0.43	0.46	0.36	0.38
RS1	0.22	-0.48	-0.12	0.45	0.51	-0.16	0.27	0.65	1.00	0.34	0.50	0.45	0.29	0.42
KF1	0.03	-0.14	0.20	0.35	0.41	0.47	0.43	0.12	0.34	1.00	0.20	0.44	0.22	0.30
KF2	0.15	-0.22	-0.03	0.53	0.50	0.21	0.13	0.43	0.50	0.20	1.00	0.48	0.33	0.51
KF3	0.16	-0.27	-0.12	0.49	0.36	0.48	0.36	0.46	0.45	0.44	0.48	1.00	0.42	0.40
KF4	0.06	-0.20	-0.11	0.44	0.35	0.23	0.27	0.36	0.29	0.22	0.33	0.42	1.00	0.51
KF5	0.14	-0.23	-0.03	0.54	0.49	0.17	0.17	0.38	0.42	0.30	0.51	0.40	0.51	1.00

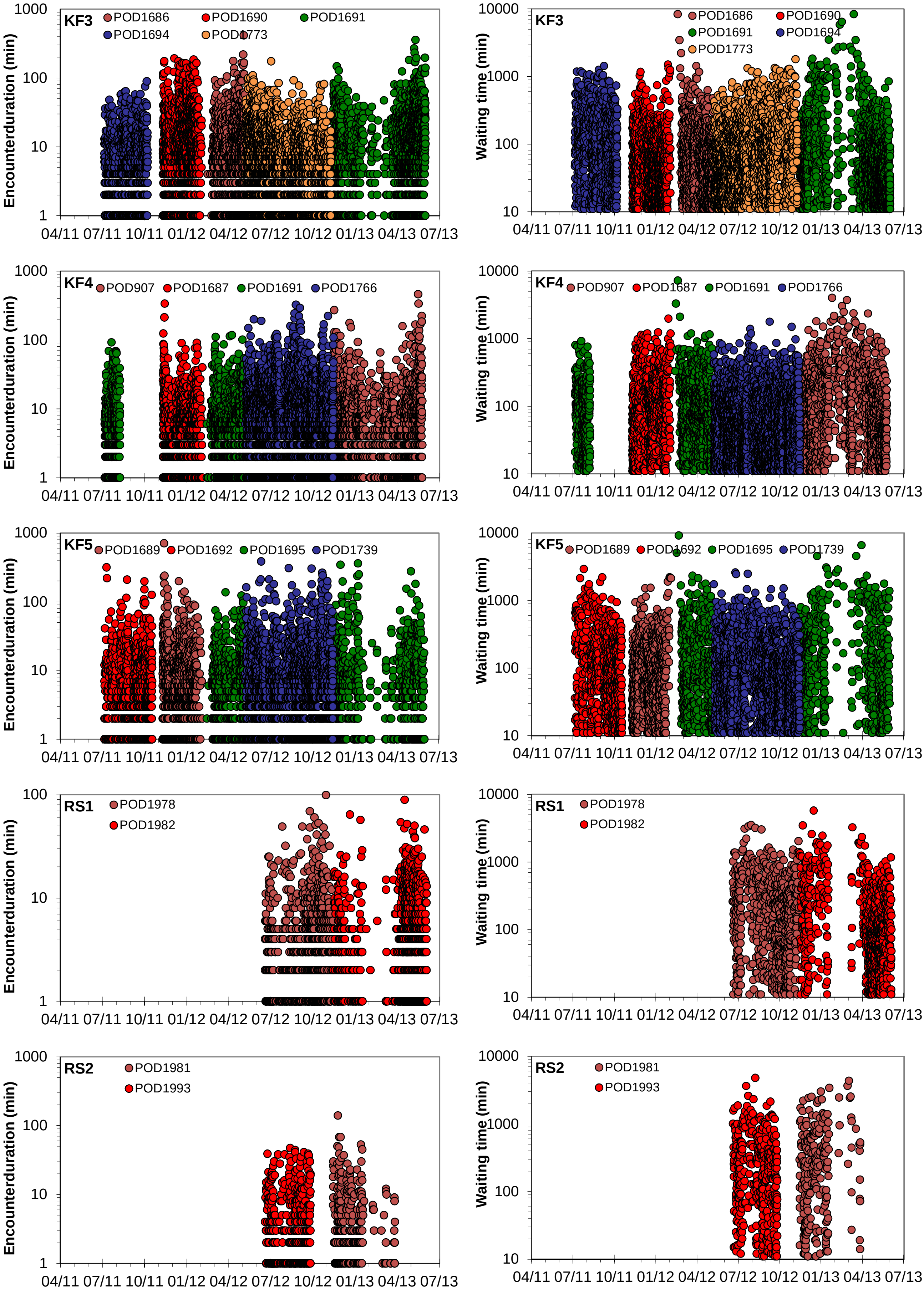
3.2 Encounter statistics

Encounter duration (n=60205) and waiting time between encounters (n=60151) were calculated from the C-POD data (Figure 3.2.1). The number of encounters and waiting times were lowest in Reersø and Sprogø, because the C-PODs were not deployed as long at these stations (Table 3.2.1). For the other stations only KF1 had a substantially lower number of encounters, whereas GB5 had more than 10000 encounters. Encounters were typically between 3 and 9 minutes, but could last almost a day. Waiting times were typically between 1 and 2 hours, but could be up to 20 days. The lowest waiting times were observed at the Great Belt stations, particularly the three stations south of the bridge.





GB3
POD907
POD914
POD1687
POD1689
POD1738
Encounterduration (min)
Waiting time (min)
GB4
POD922
POD1689
POD1690
POD1693
GB5
POD906
POD909
POD1687
POD1690
POD1695
KF1
POD1686
POD1693
POD1776
KF2
POD1692
POD1763
POD1773
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13


KF3
POD1686
POD1690
POD1691
POD1694
POD1773
KF4
POD907
POD1687
POD1691
POD1766
KF5
POD1689
POD1692
POD1695
POD1739
RS1
POD1978
POD1982
RS2
POD1981
POD1993
Encounterduration (min)
Waiting time (min)
04/11 07/11 10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13

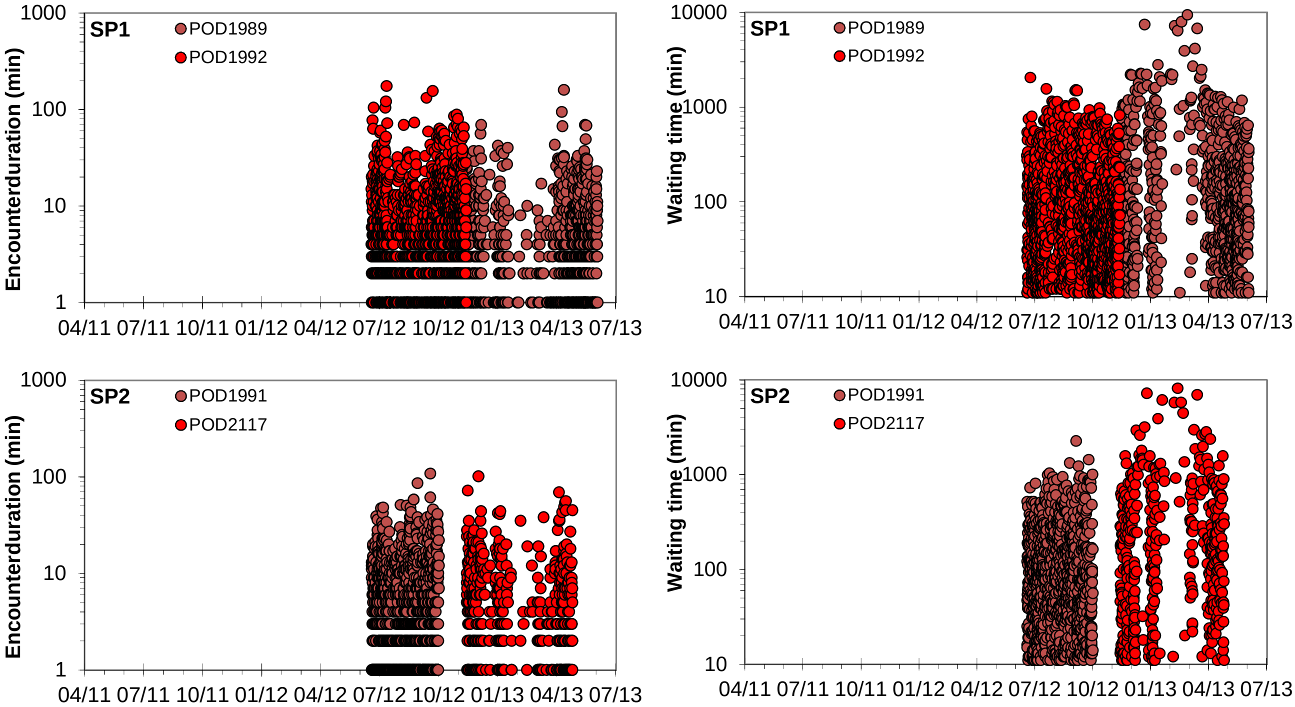


Figure 3.2.1 Encounter duration (left panel) and waiting time (right panel) extracted from C-POD data collected during the baseline (June 23rd 2011 to June 8th 2013). Observations are shown in different colours identifying the different C-PODs from which the indicators were obtained.

The relative variation in encounter duration had a CV=126-216% and for waiting time it ranged from 128-354% for the 14 positions. Both duration and waiting time distributions were strongly skewed to the right with many observations exceeding 1 hour for encounter duration and 1 day for waiting time (Figure 3.2.1).

Table 3.2.1 Statistics of encounter duration and waiting time monitored during the baseline periods in the Great Belt, Kalundborg Fjord, Reersø and Sprogø.

Area	Posi-tion	Encounter duration (minutes)					Waiting time (minutes)				
		N	Min	Median	Mean	Max	N	Min	Median	Mean	Max
Great Belt	GB1	3984	1	6.0	10.5	174	3980	11	61.0	142.5	6631
	GB2	3799	1	5.0	9.1	142	3794	11	80.5	154.3	1652
	GB3	8678	1	9.0	19.3	965	8673	11	48.0	91.4	1252
	GB4	5895	1	8.0	22.2	913	5891	11	44.0	117.5	2706
	GB5	10517	1	9.0	19.1	482	10512	11	36.0	72.0	8544
Kalund-borg Fjord	KF1	1126	1	3.0	6.6	100	1122	11	103.0	275.9	11598
	KF2	3796	1	9.0	21.3	792	3792	11	65.0	206.3	15467
	KF3	6477	1	8.0	14.6	415	6472	11	52.0	129.5	18146
	KF4	5627	1	7.0	13.7	460	5622	11	62.0	136.6	7189
	KF5	4425	1	7.0	14.8	709	4420	11	79.0	201.8	23802
Reersø	RS1	1557	1	4.0	6.6	99	1555	11	105.0	319.0	27151
	RS2	666	1	3.0	7.4	140	664	11	190.0	499.9	27529
Sprogø	SP1	2208	1	5.0	8.8	174	2206	11	71.0	220.7	18147
	SP2	1450	1	5.0	8.0	108	1448	11	85.0	259.4	19193

At the Great Belt stations encounter duration and waiting times appeared relatively constant over the year with the exception of long waiting times at GB1 in February (Fig. 3.2.2). The low click activity in February was more pronounced in Kalundborg Fjord, Reersø and Sprogø. Moreover, waiting times were longer during January and March as well at Reersø and Sprogø stations. The relatively lower echolocation activity at Reersø and Sprogø was also clearly visible with substantially lower encounter durations and substantially longer waiting times.

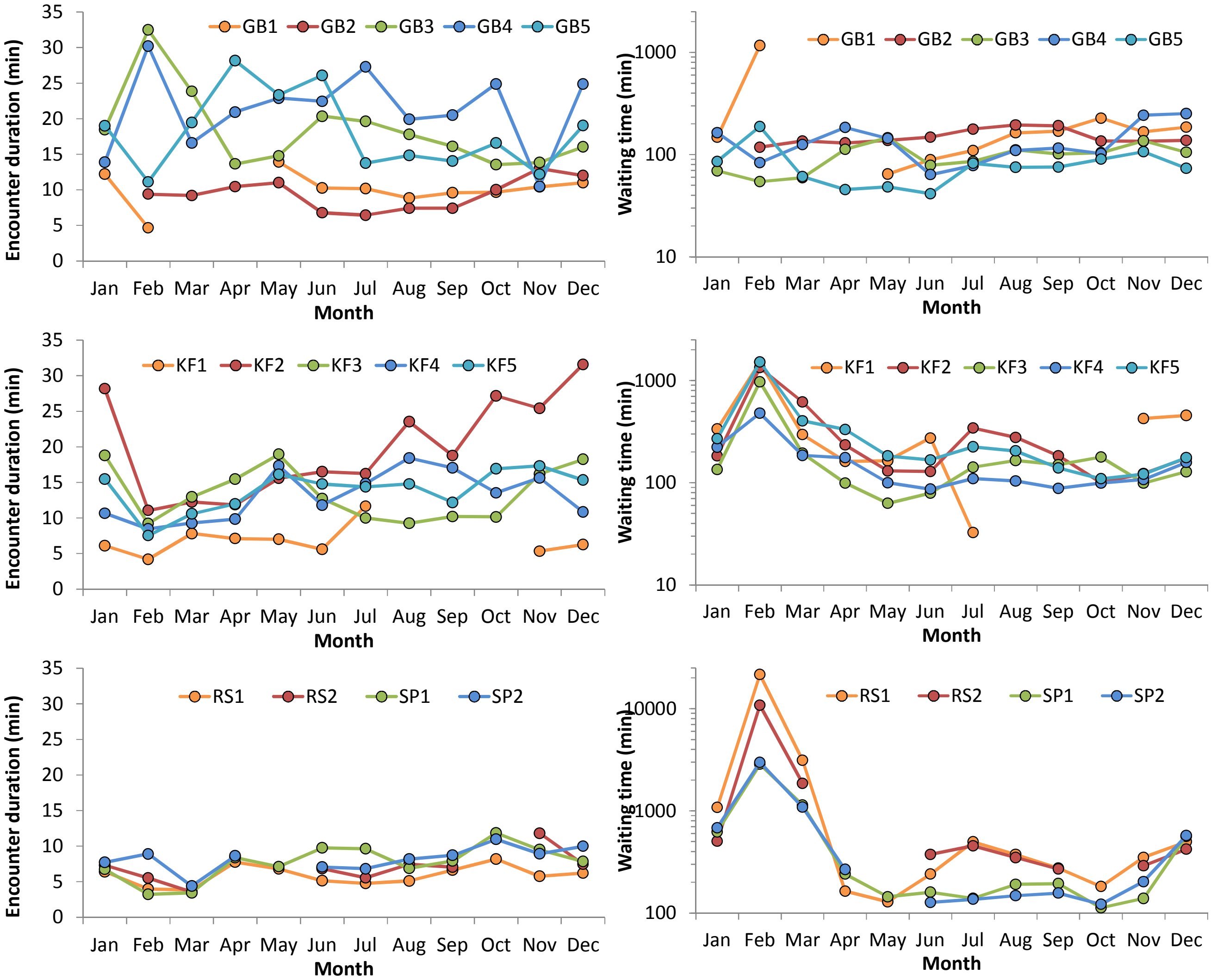


Figure 3.2.2 Monthly averages of encounter duration (left panel) and waiting time (right panel) extracted from C-POD data collected during the baseline (June 23rd 2011 to June 8th 2013). Differences in sensitivity among C-PODs were not taken into account. Note that the scale for waiting times at Reersø and Sprogø is 10 times larger than the scale for Great Belt and Kalundborg Fjord.

4 Conclusion

The baseline monitoring of the 14 C-POD stations have provided a strong dataset for the evaluation of the pinger introduction to the Great Belt scheduled for 2014-2015. 10 stations (Great Belt and Kalundborg Fjord) have provided data since summer 2011, while 4 stations (Reersø and Sprogø) were deployed a year later in summer 2012. The baseline monitoring is continuing until the pinger program is introduced. Therefore, this report should be seen as a status report only reporting on a part of the baseline period.

As shown above the stations south of the Great Belt Bridge seem to show a different seasonal pattern in porpoise activity than the rest of the stations, indicating that porpoises here may utilize other food resources or be part of a different group of animals. Based on these differences it is recommended only to use stations north of the bridge for the statistical BACI analysis after data on the effect of pingers have been collected. It should be discussed whether the stations south of the bridge is still useful for evaluating the general distribution of porpoises in relations to where nets and pinger have been set.

5 Acknowledgements

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