ABERDEEN HARBOUR
EXPANSION PROJECT
November 2015

Volume 3:
Technical
Appendices

APPENDIX 15-A BASELINE DISTRIBUTION OF MARINE MAMMALS USING INTEGRATED PASSIVE ACOUSTIC AND VISUAL DATA FOR NIGG BAY

EcoFish
CONSULTANTS

Nigg Bay (Aberdeen)
Baseline Distribution of Marine Mammals using Integrated Passive Acoustic and Visual Survey Data

September 2015

Prepared By:

Eco-Fish Consultants Ltd

Ecology, Hydrology, Fisheries, Marine
Suite 5, Waverley House
Caird Park,
Hamilton,
South Lanarkshire,
ML3 0QA.

Tel: 01698 324758
Skype: ecofish.consultants
Email: info@ecofishconsultants.co.uk
Web: www.ecofishconsultants.co.uk

Registered in Scotland Number SC402213

This Project has received funding from the European Union: The content of the document does not necessarily reflect the views or opinions of the EU Commission, and the Commission is not responsible for any use made by any party of the information contained within it.

QUALITY CONTROL

RECORD:

Status	Author	Date	Review	Date	Authorised	Date
FINAL	EC	10/15	RM	09/15	RM	09/15

ISSUE:

Organisation	Contact	Copies
Fugro EMU Limited	Alastair Mackay / Ian Stewart	1A

QUALITY ASSURANCE:

Eco-Fish Consultants Ltd employs high level scientists that are full members of an appropriate professional institution and adhere to that institution's code of conduct.

DISCLAIMER:

This report is presented to Fugro EMU Limited in respect of the Nigg Bay (Aberdeen) marine mammal survey 2014/15, and may not be used or relied on by any other person or by the client in relation to any other matters not covered specifically by the scope of this Report.

Notwithstanding anything to the contrary contained in the report, Eco-Fish Consultants Ltd is obliged to exercise reasonable skill, care and diligence in the performance of the services required by Fugro EMU Limited, and Eco-Fish Consultants Ltd shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This Report has been prepared by Eco-Fish Consultants Ltd. No individual is personally liable in connection with the preparation of this Report. By receiving this Report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

COPYRIGHT ©:

RECOMMENDED CITATION:

Clarkin, E. and McMullan, R. (2015). Baseline distribution of marine mammals using integrated passive acoustic and visual survey data for Nigg Bay, Aberdeen (Final Report). A report for Fugro EMU Limited provided by Eco-Fish Consultants Ltd., Hamilton, South Lanarkshire.

CONTENTS

Tables

1 INTRODUCTION

1.1 Background

Eco-Fish Consultants Ltd was commissioned by Fugro EMU Limited to undertake integrated passive acoustic and visual data analyses to characterise/value the baseline distribution of marine mammals within the vicinity of Nigg Bay, Aberdeen. As part of this temporal and spatial distribution of marine mammal species was assessed and in relation to the proposed Aberdeen Harbour Expansion Project.

The Aberdeen Harbour Board (AHB) have proposed a design and to construct a new harbour facility at Nigg Bay, immediately South of the existing harbour. The purpose of this new facility is to complement and expand the capabilities of the existing harbour, accommodate larger vessels, retain existing custom, and attract increased numbers of vessels and vessel types to Aberdeen.

1.2 Development Activities

The new harbour development shall include but is not limited to:-

- Dredging the existing bay to accommodate vessels up to 9m draft with additional dredge depth of 10.5m to the east quay and entrance channel;
- Construction of new north and south breakwaters to form the harbour;
- Provision of approximately 1500m of new quays and associated support infrastructure. The quay will be constructed with solid quay wall construction and suspended decks over open revetment;
- Construction of areas for development by others to facilitate the provision of fuel, bulk commodities and potable water;
- Land reclamation principally through using materials recovered from dredging operations and local sources, where possible;
- Provision of ancillary accommodation for the facility;
- Off-site highway works to the extent necessary to access the facility and to satisfy statutory obligations; and
- Diversions and enabling works necessary to permit the development.

1.3 Aims and Objectives

The main aims and objectives of this report are:-

1. To provide analysis of C-POD deployments 1-4 (~12 months duration) and vantage point data (~12 months duration);
2. To process all data and provide interpretation on temporal and spatial distribution of marine mammal species;
3. To combine/incorporate data and provide overall characterisation/value (including comparisons with other related studies); and
4. To provide a final report (including recommendations and with reference to ongoing studies).

1.4 Setting the Scene for Conservation

1.4.1 Cetaceans

Whales, dolphins and porpoises are collectively known as cetaceans. There are many different cetacean species which can be found in UK waters, from the relatively small harbour porpoise *Phocoena phocoena*, to killer whales *Orcinus orca* and even larger species such as the humpback *Megaptera novaeangliae* and fin whales *Balaenoptera physalus*.

1.4.2 Protection

Whales, dolphins and porpoises are classed as European Protected Species (EPS) and are fully protected under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended).

1.4.3 Offences

The following provides a summary of the offences in the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) in relation to whales, dolphins and porpoises in Scottish inshore waters (within 12 nautical miles of land).
It is an offence to intentionally or recklessly:

- kill, injure or capture whales, dolphins or porpoises; and
- disturb or harass them.

In offshore waters (greater than 12 nautical miles from land) cetaceans are protected by the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007, with similar offences to those of the inshore regulations.

1.4.4 Licensing and Cetaceans

Licences are available to allow specified people to carry out actions that could otherwise constitute an offence. As with any EPS, licences can only be issued for specific purposes that are set out in the legislation.

1.4.5 Seals

There are two species of seal found around the Scottish coast - the harbour seal *Phoca vitulina* and the grey seal *Halichoerus grypus*. Harbour seals occur in the north Atlantic and north Pacific. There are about 83,000 harbour seals in Europe; 35 % of these are found in the UK, with 83% of the UK population found in Scotland.

Grey seals are found only in the north Atlantic, the Baltic Sea and the Barents Sea. They are one of the rarer seal species with a world population of only 350,000- 400,000. About 40 % of the world population live in the UK, and about 90 % of the UK population live in Scotland.

1.4.6 Protection

On the 1st February 2011 it became an offence to kill, injure or take a seal at any time of year except to alleviate suffering or where a licence has been issued to do so by Marine Scotland under the Marine (Scotland) Act 2010. The method of killing or taking seals is detailed in licences issued and regular reporting is required. Under the Marine (Scotland) Act 2010 it will

also be an offence to intentionally or recklessly harass seals at significant haul-out sites when these have been designated. The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) also prohibits certain methods of catching or killing seals.

1.4.7 Licensing and Seals

Marine Scotland are the licensing authority for seals under the Marine (Scotland) Act 2010 and licences are issued annually authorising the killing or taking of seals for a number of activities including research, to protect the health and welfare of farmed fish and to prevent serious damage to fisheries or fish farms. Before granting a seal licence Marine Scotland must have regard to any information they have about damage which seals have already done to the fishery or fish farm concerned and the effectiveness of non-lethal alternative methods of preventing seal damage to the fishery or fish farm concerned.

1.4.8 Seal Conservation Areas

The Marine (Scotland) Act 2010 also provides for Scottish Ministers to designate "seal conservation areas". The areas previously covered by the Conservation of Seal (Scotland) Orders namely Shetland, Orkney, the Moray Firth and the East Coast of Scotland have been transcribed into seal conservation areas and in addition the Outer Hebrides has also been scheduled as a seal conservation area under the Marine (Scotland) Act 2010. Marine Scotland must not grant a seal licence authorising the killing or taking of seals in a seal conservation area unless they are satisfied that there is no satisfactory alternative way of achieving the purpose for which the licence is granted, and that the killing or taking authorised by the licence will not be detrimental to the maintenance of the population of any species of seal at a favourable conservation status in their natural range (within the meaning of Article 1(e) of the Habitats Directive).

2 SITE DESCRIPTION

2.1 General Site Description

Nigg Bay (Aberdeen) is a shallow sandy / muddy bay that faces east into the North Sea, located on the east coast of Aberdeenshire, Scotland. The total area of Nigg Bay, below mean high water springs (MHWS) is approximately 530,134 square metres.

Immediate to the North of the Bay lays the busy sea port of Aberdeen, which is the principal marine support centre for the energy sector in the North Sea, and the main commercial shipping port serving the North-East of Scotland.

A map illustrating the proposed development footprint is provided in the Environmental Statement, Chapter 1: Introduction to the Proposed Development.

2.2 Site Usage (Marine Mammal Species)

From the initial sightings data it is clear that the Nigg Bay area is frequented by several species of marine mammal, including populations/records of harbour porpoise, bottlenose dolphin *Tursiops truncatus*, grey seal and white beaked dolphin *Lagenorhynchus albirostris*.

2.2.1 Harbour Porpoise

Harbour porpoise are the most common species of cetacean living in the North Sea and are found in both coastal and offshore areas. This species is regularly observed throughout the year in the inshore waters off Aberdeen, with peak activity in August and September. This has been attributed to the inshore movements of lactating females with their calves and associated movements by males (Weir 2007, Genesis 2012). May to July are the peak calving periods for harbour porpoise in Scottish seas, with calves often observed off the Aberdeenshire coast between May and September. In Scottish waters the principal prey species for harbour porpoise are sandeels, but they are also known to feed on a wide range of marine fish (Genesis, 2012; Robinson, et al. 2008).

2.2.2 Bottlenose Dolphin

Bottlenose dolphin are frequently encountered along the east coast of Scotland between Montrose and Aberdeen in waters less than 20m depth and within 2 km of the coastline, but they have also been observed in offshore areas off north-east Scotland (Quick, et al. 2014). Research has shown that there is significant movement of highly mobile individuals along the east coast of Scotland with the same identified individuals seen in the Moray Firth as well as off the Grampian / Fife coast (Cheney et al. 2013). It is thought that nearly 200 dolphins make up the east coast population between the Moray Firth and Fife, with known differences in site fidelity and ranging behaviour within this population (Thompson et al. 2011; Cheney et al. 2012; Quick et al. 2014).

Bottlenose dolphin are well known to frequent the entrance to Aberdeen Harbour and surrounding waters throughout the year. The high presence of bottlenose dolphin at the entrance to Aberdeen Harbour has been attributed to the migration of salmon up river in the summer and autumn months (Genesis 2012). Studies show that the presence of this species in shallow inshore waters is directly related to the distribution of their near shore target species,

and that migrating salmonids are important in determining the seasonal movements and diets of dolphin populations (Robinson et al. 2008).

It is thought that approximately 25% of the total Scottish east coast population regularly uses the coastal stretch between Aberdeen and Stonehaven further south, and some 60% of the total Scottish population is using the coastal seas between Aberdeen and the Firth of Forth (Quick, et al. 2014). The bottlenose dolphin found off Aberdeen are thought to be part of the Moray Firth Special Area of Conservation (SAC) resident population that range as far south as the Firth of Forth. Research has indicated that some sub-groups of this population spend the majority of time within the Inner Moray Firth SAC, whilst others exploit a wider range along the Scottish east coast (Cheney et al. 2012). During the spring and early summer months calves are known to be present in Aberdeen's coastal waters (Genesis 2012, Quick, et al. 2014).

2.2.1 White-Beaked Dolphin

White-beaked dolphin are predominantly an offshore dolphin species and are more commonly found in the central and northern North Sea; they are known to come closer to the Aberdeenshire coast in the summer months between June and August. It is thought that this seasonal presence in coastal waters relates to calving, with sightings in the summer months. Their presence may also be due to the increased availability of prey species such as mackerel and herring. Evidence suggests that white beaked dolphin prefer deep water coastal stretches when compared to shallower coastal areas (Weir 2007), seen in the increased observations between Aberdeen and Stonehaven a known deeper stretch off the Aberdeenshire coastline (Genesis 2012). The regularity of sightings observed within this coastal stretch area is comparatively higher than reported from other North Seas regions, highlighting the potential importance of this area for this dolphin species (Weir 2007).

2.2.2 Minke Whale

Minke whale *Balaenoptera acutorostrata* also occur within North Sea coastal waters, and have been shown to occur within the deeper water coastal stretches between Aberdeen and Stonehaven during the month of August. Along this stretch of coastline, such deeper water (50m plus) is observed a minimum of 3.5km offshore (Weir 2007).

2.2.1 Other Cetaceans

Other cetacean species recorded in low numbers or even just as a single reported individual within the North Sea include whales (e.g. sei *Balaenoptera borealis*, fin, sperm *Physeter macrocephalus*, Curviers beaked *Ziphius cavirostris*, and humpbacked) and dolphin (e.g. common *Delphinus delphis*, striped *Stenella coeruleoalba* and Risso's *Grampus griseus*). Killer whale and long finned pilot whale *Globicephala melas* have been recorded in relatively higher numbers in the Northern North Sea (Reid et al. 2003).

2.2.2 Grey Seal

The closest dedicated grey seal SAC is found on the Isle of May at the entrance of the Firth of Forth. Grey seal are present at a low density along the East coast of Scotland, but are present at a high density in the Firth of Tay and Eden Estuary. Several important grey seal haul out sites are located along the east coast of Aberdeenshire at the mouths of the river Don and Ythan, Peterhead harbour, Catterline, Boddam and in Cruden Bay. Grey seal are often

observed throughout the year in Aberdeen Bay with known aggregations at the mouth of the rivers Don and Dee. They are known to feed primarily on sandeels, gadoid fish species, and on salmon and marine fish in the Don and Dee estuaries (Carter 2001, Genesis 2012).

Grey seal have been shown to travel large distances connecting populations along the length of the Scottish North Sea coast (McConnell, et al.1999), and it is expected that individuals from colonies further north and south along the east coast will pass through or close to the proposed development area at Nigg Bay, Aberdeen.

The grey seal annual moult takes place between February and April, and the pupping season takes place from October to November. It is during these important seasons that grey seals will spend more time in coastal waters and ashore in local haul-out sites (Genesis 2012).

2.2.3 Harbour Seal

Seasonal aggregations of harbour seal are known to occur within the estuaries of the river Dee and Don, with maximum numbers observed in the winter and early spring months and absent from these areas in the summer months of June and July. The river Don is known to be used as a haul-out site, whilst the river Dee being used as a foraging location, feeding on mostly salmonids, flounder and other marine fish species (Carter 2001, Genesis 2012).

Other haul-out sites used by harbour seal along the Aberdeenshire east coast include the Donmouth, the mouth of the river Ythan and at Catterline (Genesis 2012).

The harbour seal annual moult takes place between June and September, and the pupping season takes place from June to July. It is during these important seasons that harbour seals will spend more time in coastal waters and ashore in local haul-out sites (Genesis 2012).

2.3 Designated Sites

Part of the southern region of Nigg Bay has been designated as a Site of Special Scientific Interest (SSSI) for Quaternary geology and geomorphology.

The proposed Nigg Bay development area is located in close proximity to the River Dee Special Area of Conservation (SAC). Qualifying features for this SAC are Atlantic Salmon *Salmo salar*, Otter *Lutra lutra* and the Freshwater Pearl Mussel *Margaritifera margaritifera* and all are listed as Annex II species under the EU Habitats Directive.

Further North from Nigg Bay along the eastern coast of Scotland is the Moray Firth SAC. This SAC was designated primarily due the presence of bottlenose dolphin. The bottlenose dolphin found in the Moray Firth SAC are part of the Scottish east coast population that ranges south past Aberdeen to the Firths of Tay and Forth.

Further South along the eastern coast of Scotland is the Firth of Tay and Eden Estuary SAC. Harbour seals are a primary qualifying feature for this site. Other SACs for grey and harbour seal to the North and South include the Dornoch Firth and Morrich More SAC and the Isle of May SAC (Firth of Forth).

3 METHODOLOGY & EFFORT

3.1 Integrated Passive Acoustic and Visual Data

3.1.1 Passive Acoustic Monitoring (C-PODs)

Acoustic data were collected using two passive acoustic monitoring (PAM) devices (C-POD, Chelonia Ltd., www.chelonia.co.uk). These were deployed by FugroEMU Ltd and were situated directly offshore from Nigg Bay (immediately adjacent to the proposed Aberdeen Harbour Expansion Project). See Table 3.1 for an overview of the C-POD deployment dates from August 2014 to August 2015, which covers all 5 deployment periods.

Table 3-1: C-POD Deployment dates

Deployment	C-POD	Start Date /Time	End Date / Time
1	**North C-POD2464**	21/08/2014 10:00	14/10/2014 08:46
	South C-POD2460	21/08/2014 10:40	06/10/2014 16:17
2	**North C-POD2459**	25/11/2014 14:41	01/02/2015 04:49
	South C-POD2464	26/11/2014 13:06	21/01/2015 06:43
3	**North C-POD2460**	06/02/2015 13:15	07/03/2015 08:22
	South C-POD2459	06/02/2015 13:56	07/04/2015 10:13
4	**North C-POD2460**	07/04/2015 13:03	11/06/2015 12:54
	South C-POD2459	07/04/2015 11:32	08/04/2015 17:36
5	**North C-POD2464**	11/06/2015 12:31	31/08/2015 10:15
	South C-POD2459	11/06/2015 11:44	31/08/2015 10:18

C-PODs have been designed to detect and continuously monitor the 20-160 kHz frequency range of odontocete (toothed whales) echolocation clicks, thus allowing for the detection of visits within the vicinity of Nigg Bay and the collection of presence-absence data over several months. These devices are able to distinguish between the high-frequency clicks from harbour porpoise and the mid frequency clicks from dolphin, but are unable to distinguish between the clicks from different dolphin species.

C-PODs use digital waveform characterisation to select all clicks similar to cetacean clicks and logs the time, centre frequency, sound pressure level, duration and bandwidth of each click. The desktop software 'cpod.exe' then processes the click data using the KERNO classifier to identify click trains and their likely sources.

The identification of source works very well for porpoise trains, but is less precise for dolphin click trains, and a secondary encounter classifier called GENENC, which uses a longer

classification time window to improve the detection performance, is usually to improve the classification of these. The classified click trains are recorded in a 'CP3' file.

The detection range of static loggers is generally expressed as the 'EDR' or Effective Detection Radius, that being a radius having as many detections made outside it, as are missed inside it. This corresponds to the 'effective strip width' used in line transect methods. The EDR of C-PODs for porpoise detections in a minute is generally in the range of 100-150m radius, this is much shorter than the maximum detection range of approximately 500m which is a rare and atypical event and of limited significance in analysis. The EDR for dolphin detections is less well known but will be several times longer, with maximum detection ranges reaching over 2km. Due to the limited ability for C-PODs to provide a detection range (SMRU 2010), the EDR for porpoise in this study is 150m and for dolphin the EDR is 700m i.e. approximately one third of the known maximum detection ranges for each species (Figure 3-1).

3.1.2 C-POD and Vantage Point Locations

C-PODs (Figure 3-1) were deployed at two different offshore locations adjacent to Nigg Bay, to provide passive acoustic monitoring and allow a more detailed assessment of cetacean presence / absence in the area.

Four vantage point locations (Figure 3-1) allowed for full visual coverage of Nigg Bay, whilst also monitoring viewshed distances of up to 2km offshore from the coast in all directions (Figures 3-2 to 3-5).

3.1.3 Vantage Point Survey

Shore-based vantage point bird and marine mammal surveys were conducted by Mark Lewis on behalf of Fugro EMU Ltd between June 2014 and May 2015 for 11 hours monthly (Table 4-4). Four different vantage point (VP) locations to the North and South of Nigg Bay (Figure 3-1), provided full coverage of the proposed Nigg Bay development area as well as viewshed distances of up to 2km offshore (Figures 3-2 to 3-5).

These surveys combined marine mammal and bird observations for VPs 1 and 2, with dedicated marine mammal surveys undertaken from VPs 3 and 4. In total over the 12 month period, 36 hours of surveys were carried out for VP 1, 72 hours for VP 2, 12 hours for VP 3 and 12 hours for VP 4 (Table 4-4).

NB: Data presented for the month of June is based upon observation distances calculated using an inclinometer only, and not based upon estimated distance, which was found to provide higher accuracy and was therefore used by the recorder in the subsequent survey months (recorder: Mark Lewis on behalf of Fugro EMU Ltd).

See Lewis, M (2015) for further results and survey methodologies.

4 RESULTS & DATA ANALYSIS

4.1 C-PODs Summary of Deployment

Table 4-1-1: C-POD Summary of Deployment DPH and Days

Site/Deployment No./File name	Start time	End time	Total Porpoise DPH	% Days porpoise detections	% DPH porpoise detections	Total Dolphin DPH	% Days dolphin detections	% DPH dolphin detections	% DPH boat sonar detections	Days on	Hours on	% Time Lost
North/1/North 2014 08 18 POD2464 file01.CP3	21/08/14 10:00:	14/10/14 08:46	681	100%	50%	50	47%	3.6%	10.7%	54	1362	3
South/1/South 2014 11 26 POD2460 file01.CP3	21/08/14 10:40	06/10/14 16:17	737	100%	62.6%	28	38%	2.4%	8.7%	46.3	1178	1
North/2/North Site 2015 02 06 POD2459 file01.CP3	25/11/14 14:41	01/02/15 04:49	964	100%	59.4%	60	48%	3.6%	5.7%	67.6	1622	2.8
South/2/South Site 2015 02 06 POD2464 file01.CP3	26/11/14 13:06	21/01/15 06:43	872	100%	65.2%	67	58%	4.8%	6.2%	55.7	1337	3.2
North/3/NORTH 2015 04 07 POD2460 file01.CP3	06/02/15 13:15	07/03/15 08:22	449	100%	65%	38	67%	5.4%	4.8%	28.8	691	1.4
South/3/South Site 2015 04 07 POD2459 file01.CP3	06/02/15 13:56	07/04/15 10:13	913	100%	64%	102	77%	7%	4.5%	59.9	1437	2.2
North/4/NORTH 2015 06 15 POD2460 file01.CP3	07/04/15 13:03	11/06/15 12:54	197	68%	12.7%	154	89%	9.9%	5.3%	65	1559	1
South/4/SOUTH 2459 2015 06 15 POD2459 file01.CP3	07/04/15 11:32	08/04/15 17:36:00	5	100%	16.7%	4	100%	13.3%	3.3%	1.3	30	0.5
North/5/2015 0831_NORTH RECOVERY_2464.CP3	11/06/15 12:31	31/08/15 10:15	894	99%	46.1%	92	38%	4.4%	19.6%	80.9	1941	1.1
South/5/2015 0831_SOUTH RECOVERY_2459.CP3	11/06/15 11:44	31/08/15 10:18	1281	100%	66%	95	41%	4.8%	10.8%	80.9	1942	0.1
North Total				**93%**	**44.4%**		56%	**5.4%**	**10.2%**	**296**	**7174**	
South Total				**100%**	**64.3%**		54%	**4.9%**	**7.8%**	**244**	**5923**	
TOTAL				**97%**	**53.4%**		56%	**5.2%**	**9.1%**	**540**	**13097**	

% Detection positive hours (DPH) is the percentage of total hours that were detection positive for that classification e.g. porpoise. A detection positive hour is where one or more click trains have been classified in that hour.

Days/Hours On is the time the C-POD was operating and recording clicks.

Table 4-2-2: C-POD Summary of Deployment DPM

Site/Deployment No./File name	Start time	End time	Total Porpoise DPM	% DPM porpoise detections	Total Dolphin DPM	% DPM dolphin detections	Mins on
North/1/North 2014 08 18 POD2464 file01.CP3	21/08/14 10:00:	14/10/14 08:46	6753	8.69%	243	0.31%	77695
South/1/South 2014 11 26 POD2460 file01.CP3	21/08/14 10:40	06/10/14 16:17	7163	10.75%	135	0.20%	66623
North/2/North Site 2015 02 06 POD2459 file01.CP3	25/11/14 14:41	01/02/15 04:49	11529	11.85%	229	0.24%	97327
South/2/South Site 2015 02 06 POD2464 file01.CP3	26/11/14 13:06	21/01/15 06:43	11536	14.37%	314	0.39%	80257
North/3/NORTH 2015 04 07 POD2460 file01.CP3	06/02/15 13:15	07/03/15 08:22	7494	18.11%	145	0.35%	41389
South/3/South Site 2015 04 07 POD2459 file01.CP3	06/02/15 13:56	07/04/15 10:13	14521	16.90%	434	0.51%	85901
North/4/NORTH 2015 06 15 POD2460 file01.CP3	07/04/15 13:03	11/06/15 12:54	824	0.88%	609	0.65%	93545
South/4/SOUTH 2459 2015 06 15 POD2459 file01.CP3	07/04/15 11:32	08/04/15 17:36:00	16	0.89%	19	1.05%	1804
North/5/20150831_NORTH RECOVERY_2464.CP3	11/06/15 12:31	31/08/15 10:15	4164	3.58%	364	0.31%	116320
South/5/20150831_SOUTH RECOVERY_2459.CP3	11/06/15 11:44	31/08/15 10:18	9949	8.55%	523	0.45%	116324
North Total				**7.22%**		**0.37%**	**426276**
South Total				**12.31%**		**0.41%**	**350909**
TOTAL				**9.51%**		**0.38%**	**777185**

% Detection positive minutes (DPM) is the percentage of total minutes that were detection positive for that classification e.g. porpoise. A detection positive minute is where one or more click trains have been classified in that minute.

Mins On is the time the C-POD was operating and recording clicks.

4.2 Overview of C-POD Data

The summary data in Table 4.1 shows that data at the North site was recorded for 296 days and during that time logged 3185 porpoise detection positive hours (44.4% of all hours) and 384 dolphin detection positive hours (5.4% of all hours).

At the South site data was recorded for 244 days and during that time logged 3808 porpoise detection positive hours (64.3% of all hours) and 290 dolphin detection positive hours (4.9% of all hours). Please note that due to equipment failure the South C-POD only recorded for 30 hours during deployment 4.

A total of 526 days out of 540 across both sites had porpoise detections, over 97% of all days. Out of the

A total of 305 days out of 540 across both sites had dolphin detections, over 56% of all days.

Figures 4.1 and 4.2 show the seasonal variation of porpoise detection positive hours per day at the North and South sites respectively for all 5 deployments.

Figures 4.3 and 4.4 show the seasonal variation of dolphin detection positive hours per day at the North and South sites respectively for all 5 deployments.

The red dashed line indicates that no data was recorded for this period.

4.3 Detections over Full Time Period

The charts in Figure 4.5 to Figure 4.14 show the frequency distribution of clicks logged over the full time period with *porpoise detections* in the top portion of each chart and *all clicks* in the lower half.

The charts in Figure 4.15 to Figure 4.24 show the frequency distribution of clicks logged over the full time period with *dolphin detections* in the top portion of each chart and *all clicks* in the lower half.

The charts show relative numbers of clicks detected at different sound frequencies across the whole time period. Sound frequencies logged range from 20kHz (red) to 160kHz (purple). Porpoise clicks are around 130kHz. The thin black line shows the mean number of clicks logged per minute. This may be limited to 4096 clicks per minute (to avoid memory overload). It shows that some of the peaks in click incidence correspond to high levels of clicks at porpoise frequencies, showing that at these times they are major contributors to the ambient noise profile.

The thin white line shows fluctuations in temperature, scale for this has been omitted to simplify the charts.

The series of tilted lines running through the centre of each chart show the angle of the C-POD. Vertical lines indicate no water movement, horizontal lines indicate that the C-POD is lying flat probably either in very shallow water or on the deck of a boat. The C-POD's default setting is to not record data if tilted more than 80 degrees off vertical.

In Figures 4.5 and 4.15 a stormy period of 2 days is seen just before day 50, with many clicks logged, but reduced porpoise and dolphin detections.

4.4 Evaluation of Detection Errors

4.4.1 Results

Each data file was subject to systematic sampling for false positive porpoise detections, and the overall rate of false positive porpoise detections across all files was 0.4%, comprised of 0.7% from the North site and 0% from South site.

Each data file was subject to systematic sampling for false positive dolphin detections, if the Detection Positive Minutes (DPM) found were higher than 100, otherwise all DPM were examined. The overall rate of false positive dolphin detections found was 6.6%, comprised of 7.5% from the North site and 5.6% from South site.

In the context of DPH isolated false DPM will only render an hour false if it has no other true DPM.

For porpoise detections 0 DPH were found to be false in either the North of South site files.

For dolphin detections 3% of DPH were found to be false (10 DPH out of 394) for the North site and 2% for the South site (6 DPH out of 296).

Tables 4.2-1 and 4-2-2 show breakdowns of all false DPM and DPH for each file for porpoise and dolphin detections respectively.

Table 4-3-1 *False positive DPM and DPH for porpoise in all deployments*

Site/ Deployment	Days Logged	Total Porpoise DPM	Total Porpoise DPH	False positive Porpoise DPM	False positive Porpoise DPH
North/1	54	6753	681	1.00%	0.00%
South/1	46.3	7163	737	0.00%	0.00%
North/2	67.6	11529	964	0.00%	0.00%
South/2	55.7	11536	872	0.00%	0.00%
North/3	28.8	7494	449	2.00%	0.00%
South/3	59.9	14521	913	0.00%	0.00%
North/4	65	824	197	0.00%	0.00%
South/4	1.3	16	5	0.00%	0.00%
North/5	80.9	4164	894	1.00%	0.00%
South/5	80.9	9949	1281	0.00%	0.00%

Table 4-4-2 *False positive DPM and DPH for dolphins in all deployments*

Site/ Deployment	Days Logged	Total Dolphin DPM	Total Dolphin DPH	False positive Dolphin DPM	False positive Dolphin DPH
North/1	54	243	50	6.6%	2.00%
South/1	46.3	135	28	3.7%	0.00%
North/2	67.6	229	60	3.1%	3.33%
South/2	55.7	314	67	6.7%	4.48%
North/3	28.8	145	38	8.3%	2.63%
South/3	59.9	434	102	3%	0.98%
North/4	65	609	154	3%	0.00%
South/4	1.3	19	4	0%	0.00%
North/5	80.9	364	92	15%	6.52%
South/5	80.9	523	95	8%	2.11%

4.4.2 Method

For porpoise and dolphin detections the files (where DPM counts were greater than 100) were sampled using stratified temporal sampling, to give 10 samples with start times spaced at approximately even time intervals through the file. The 10 detection positive minutes following the start of each sampling period were visually validated.

The visual validation method was based on the information provided by Chelonia in the document 'Validating cetacean detections.pdf' available on www.chelonia.co.uk. This sets out the relevant features in terms of the characteristics of clicks, multipath clusters, and trains. Additional criteria based on the characteristics of the ambient noise regime were also used, particularly in relation to sediment transport noise, which generates a large number of ultrasound 'clicks' also the presence of boat sonars.

The level of false positives is not some consistent fraction of true positives, but is determined by the prevalence of the sources that are liable to be misclassified, e.g. other cetaceans, boat sonars, and sediment transport noise.

It should be recognised that the cause of a substantial proportion of the 'false positive porpoises' is actually true porpoises, but they are rejected because they are not distinctive enough to meet these stringent criteria.

For dolphin detections every train was examined as far fewer were recorded with the exception of files that had more than 100 dolphin DPM.

4.4.3 Assessment

Porpoises
The error rates found for porpoises are far below the natural variability seen in the data files in the true detection rates, so they will not have a significant effect on any qualitative or statistical analysis based on these data sets. On inspection the porpoise false positives are most likely to be low quality porpoise detections. As the false positive rate is so small there is no need to, or value in, removing the false positive found.

Dolphins
The error rate for dolphin detections are mostly due to incorrect classification of porpoise trains with some misclassification of distant and distorted boat sonar. These have been removed from the dataset because they are at a higher level.

False negatives
False negatives have not been evaluated, because they are considered to be part of the vastly larger set of animals that are outside the detection range of the instrument and the instruments will have been calibrated when manufactured so the detection range can be expected to be reasonably uniform. No evidence was seen of any instrument malfunction in these data files.

4.4.4 Loss of Click Detections Due to Noise

In very noisy environments the minute click limit can be exceeded meaning that no further clicks will be detected until the start of the next minute.

This can be for a number of reasons but the most common is sediment transport noise i.e. the broadband ultrasound noise resulting from sediment moving around in suspension and the small particles colliding with one another. Boat sonar can also sometimes result in the click limit being reached.

Table 4.3 lists significant noise events in all deployments, these can be seen as peaks in the lower charts in Figures 4.5 to 4.24. These are lost likely due to storms or at least significantly rougher seas and account for much of the time lost in each file. It is possible that porpoises temporarily leave very noisy areas as this would make navigation and hunting more difficult, but this has not been proved.

Table 4-5. *Significant noise events*

Deployment	Start of noise event	Duration of noise event
1	06/10/2014	2 days
2	27/11/2014	3 days
2	14/01/2015	2 days
3	15/02/2015	1.5 days
3	28/02/2015	1 day
3	09/03/2015	4 days (intermittent)
4	03/05/2015	1.5 days
4	01/06/2015	0.5 days
5	19/08/2015	1 day
5	23/08/2015	1 day

4.4.5 Boat Sonar

Boat sonar was detected throughout most of the deployments with a total of 175 DPH recorded; this was almost entirely 50kHz sonar with some 38kHz and 25kHz sonar and did not result in false positive porpoise detections and only a very few false positive dolphin detections. It does appear from the frequency graphs (example in Figure 4.25) that a few porpoise trains were misclassified as boat sonar (the purple lines in the upper graphs).

4.4.6 Temporal Distribution of Detections

This was investigated using autocorrelation.

Auto-correlation is the correlation between a time series and itself, initially the correlation is always 1, a perfect correlation. Successive values are obtained by making bigger time offsets. If an animal typically makes brief visits, spread evenly across the day, to the logger site then the autocorrelation will fall below significance when the offset is bigger than the duration of most visits, so this is a neat way of characterising encounter durations and showing any regularly repeated patterns.

Auto-correlations indicate, that starting at any given peak in activity, how long you are likely to have to wait until the next encounter or activity peak occurs and how significant this next encounter is, there may be several more after the first one. As you look along the x-axis you see peaks which usually decrease with increased time offset.

4.4.7 Auto-Correlation Results

Figures 4.26 - 4.34 show the auto-correlations for porpoise detections for up to a 5 day offset for the whole file.

Figures 4.35 - 4.43 show the auto-correlations for dolphin detections for up to a 5 day offset for the whole file.

There is no auto-correlation for deployment 4 at the South site as there was insufficient data to produce a significant offset.

The encounter duration is the length of time the initial encounter is likely to last, the point at which the plotted line crosses below the horizontal line of significance (upper line of the 3 central horizontal lines). The bin size in is the bin size used to display the auto-correlation at the given resolution e.g. to show a 5 day offset a 30 min bin is calculated to be the appropriate size.

Figure 30 showing porpoise detections from deployment 3 at the North site there is a correlation for repeated activity of just over 12 hours from the time of the first activity, indicating that activity is closely linked to tidal cycles with the correlation dropping below significance after 4 days offset. Comparing Figure 30 with the appropriate frequency distribution chart in Figure 9, it can be seen that in the upper chart (porpoise only clicks) there are roughly evenly spaced peaks in click rate (black line) showing a regular repeated activity occurring approximately every day. The auto-correlation in Figure 30 confirms this pattern and shows in detail the reoccurrence of activity.

4.5 Diel Patterns

The charts in Figures 4.44 and 4.45 plot total porpoise and dolphin detection positive minutes (DPM) respectively for each hour of the day across all deployments for the North and South sites.

For porpoise activity Figure 4.44 shows there is a general trend towards higher activity between 6am and 6pm with activity falling off significantly at night.

There are far fewer dolphin DPM than porpoise DPM, however, there are enough to show a daily pattern at both sites. Figure 4.45 shows a general trend towards increased activity in the early hours of the morning, a dip in activity late morning to midday then an increase again early afternoon to early evening.

4.5.1 Seasonal Porpoise Patterns

The pattern of daily peaks in porpoise activity vary across the seasons as can be seen in Figures 4.46.1 – 4.46.4.

The winter (Figure 4.46.1) and spring (Figure 4.46.2) months indicate higher activity towards the middle of the day and mid-morning respectively.

The summer (Figure 4.46.3) and autumn (Figure 4.46.4) months indicate higher activity early in the morning and late afternoon with a reduction in activity mid-morning and midday respectively. These patterns are true for both North and South sites although the South site generally shows this more strongly.

4.5.2 Seasonal Dolphin Patterns

The pattern of daily peaks in dolphin activity vary across the seasons as can be seen in Figures 4.47.1 – 4.47.4, these patterns are less significant than those shown for porpoises as there is far less activity and therefore individual days of high activity will have a greater influence on the overall seasonal pattern.

The winter months (Figure 4.47.1) indicate higher activity at night, there is no clear pattern for the spring (Figure 4.47.2) months which may be associated with lower total activity. The summer (Figure 4.47.3) months indicate higher activity early in the morning, afternoon and evening with a reduction in activity late morning, midday and middle of the night. Very little activity has been recorded for the autumn (Figure 4.47.4) months so the pattern of relatively high activity in the evening and towards the middle of the night is not highly significant as is due to relatively few encounters.

These patterns are true for both North and South sites although the South site generally shows this more strongly.

4.5.3 Monthly Porpoise Patterns

The pattern of daily peaks in porpoise activity for each month can be seen in Figures 4.48.1 - 4.48.12.

Some months have considerably more activity than others but those with high total activity in the winter months show peaks in the evening and some with peaks in the morning. The summer months generally have higher activity during the day.

As the dataset only spans a 13 month period it is not possible to say if these monthly activity patterns are a typical year cycle.

4.5.4 Monthly Dolphin Patterns

The pattern of daily peaks in dolphin activity for each month can be seen in Figures 4.49.1 – 4.49.12.

Some months have considerably more activity than others, most notably October and November have very little, mostly due to the few days of deployment during this time.

Those with higher total activity in the winter months show peaks in early in the morning and in the evening. The summer months generally have higher activity during the day.

As the dataset only spans a 13 month period it is not possible to say if these monthly activity patterns are a typical year cycle.

4.6 Click Trains in Detail

Porpoises

Porpoise click trains are characterised by narrow band high frequency (NBHF) clicks that contain many cycles per click but are comparatively quiet compared with dolphins or boat sonar. Any static hydrophone does not record the whole train produced by the animal but records a fragment of the train as the narrow sound beam produced by the animal sweeps across the sensor. These detected trains typically show a smooth sound pressure envelope.

Figure 4.50 shows the sound pressure level (SPL) of a porpoise click train. The y-axis from 0 to 255 is a relative scale where one unit is calibrated to be 0.06Pa peak-peak at 130kHz. In this example the x-axis time covers just over 1 second.

Figure 4.51 shows the click duration profile for the same porpoise train shown in Figure 4.50. The duration number on the y-axis is the number of cycles in that click. Typically porpoises have many more cycles per click than dolphins.

Figure 4.52 shows the frequency spectrum of a typical porpoise click train, the height of each bar is proportional to the number of clicks recorded at that frequency.

Dolphins
Dolphins are harder to detect as they produce shorter clicks (less cycles per click) and are broadband across the detection range unlike porpoises which are very narrow band. Dolphins are also much louder than porpoises and multi-path detections are more likely. Multi-path is when a single click bounces off the water surface or other reflecting object, or is refracted by variations in temperature or salinity, and each path is detected shortly after the main path.

Figure 4.53 shows the sound pressure level (SPL) of a dolphin click train. The y-axis from 0 to 255 is a relative scale where one unit is calibrated to be 0.06Pa peak-peak at 130kHz. In this example the x-axis time covers just over 1 second.

Figure 4.54 shows the click duration profile for the same dolphin train shown in Figure 4.53. The duration number on the y-axis is the number of cycles in that click. Typically dolphins have less than 10 cycles per click whereas porpoises are mostly over 10 cycles.

Figure 4.55 shows the frequency spectrum of a typical dolphin click train, the height of each bar is proportional to the number of clicks recorded at that frequency.

4.7 Vantage Point Summary of Effort

Table 4-2 summarises the visual survey effort across all four vantage points between the months of June 2014 and May 2015. 132 hours of vantage point survey data (11 hours each month) were collected across the 12 month period.

Table 4-6: Vantage Point Monthly Survey Effort 2014/15

Monthly Survey Effort (Minutes) 2014/15													
Vantage point (VP)	**Jun 14**	**Jul 14**	**Aug 14**	**Sept 14**	**Oct 14**	**Nov 14**	**Dec 14**	**Jan 15**	**Feb 15**	**Mar 15**	**Apr 15**	**May 15**	**Total Mins / Hours**
VP1 (Birds / Marine Mammals)	180	180	180	180	180	180	180	180	180	180	180	180	2160 / 36
VP2 (Birds / Marine Mammals)	360	360	360	360	360	360	360	360	360	360	360	360	4320 / 72
VP3 (Marine Mammals)	60	60	60	60	60	60	60	60	60	60	60	60	720 / 12
VP4 (Vessel Traffic / Marine Mammals)	60	60	60	60	60	60	60	60	60	60	60	60	720 / 12

4.8 Vantage Point Sightings

4.8.1 Harbour Porpoise

Table 4-7: Total number of harbour porpoise individuals sighted at various distances across each vantage point. NB: June data not based on estimated distance (Only data with distance measures included).

		Estimated Distance (m)							
Month	VP	<100	101-200	201-300	301-400	401-500	501-1000	1001-1500	1501-2000
June 2014	1								
	2	2	3	2					
	3			2		4			
	4					1			
July 2014	1								2
	2						6		
	3						2		
	4								
Aug 2014	1							2	2
	2								
	3								
	4						1	2	
Sept 2014	1						1		
	2								
	3								
	4								
Oct 2014	1								
	2								
	3						1		
	4								
Nov 2014	1								
	2								
	3								
	4								
Dec 2014	1								
	2								
	3								
	4								
Jan 2015	1								
	2						1		
	3								
	4								
Feb 2015	1								
	2					1			
	3								
	4								
Mar 2015	1								
	2								
	3								
	4								
Apr 2015	1						1	2	
	2						2	1	
	3						2		
	4						3	1	
May 2015	1						2		
	2						2	1	
	3								
	4						1	1	

4.8.2 *Bottlenose Dolphin*

Table 4-8: Total number of bottlenose dolphin individuals sighted at various distances across each vantage point. NB: June data not based on estimated distance (Only data with distance measures included).

		Estimated Distance (m)							
Month	VP	<100	101-200	201-300	301-400	401-500	501-1000	1001-1500	1501-2000
June 2014	1								
	2	29	5						
	3		10						
	4					8			
July 2014	1								
	2								
	3								
	4								
Aug 2014	1								
	2								
	3								
	4								
Sept 2014	1								
	2								
	3						9		
	4						3		
Oct 2014	1								
	2								
	3					4			
	4								
Nov 2014	1								
	2								
	3								
	4								
Dec 2014	1								
	2								
	3						7		
	4								
Jan 2015	1		3	4					
	2								
	3			6					
	4								
Feb 2015	1		5						
	2								
	3				10				
	4								
Mar 2015	1						8		
	2						17		
	3								
	4						8		
Apr 2015	1						10		
	2						11		
	3								
	4						10		
May 2015	1				8		2		
	2						9		
	3								
	4						4		

4.8.1 White Beaked Dolphin

Table 4-9: Total number of white beaked dolphin individuals sighted at various distances across each vantage point. NB: Sightings for this species only took place in July 2014.

		Estimated Distance (m)							
Month	VP	<100	101-200	201-300	301-400	401-500	501-1000	1001-1500	1501-2000
July	1								
	2						3		
	3								
	4								

4.8.2 Grey Seal

Table 4-10 Total number of grey seal individuals sighted at various distances across each vantage point. NB: June data not based on estimated distance. (Only data with distance measures included).

		Estimated Distance (m)							
Month	VP	<100	101-200	201-300	301-400	401-500	501-1000	1001-1500	1501-2000
June 2014	1								
	2	3	2						
	3						1		
	4				1				
July 2014	1	2							
	2		7	3			2		
	3						1		
	4								
Aug 2014	1								
	2		3				6		
	3								
	4								
Sept 2014	1	3							
	2						8		
	3								
	4								
Oct 2014	1				1		3		
	2	3	2				5		
	3								
	4								
Nov 2014	1								
	2	7							
	3								
	4								
Dec 2014	1						4		
	2	8							
	3								
	4								
Jan 2015	1						10		
	2	3	6				3		
	3								
	4								
Feb 2015	1						5		
	2	5	9				4		
	3								
	4								
Mar 2015	1						3		
	2						8		
	3								

	4								
Apr 2015	1						4		
	2		13						
	3								
	4								
May 2015	1						7		
	2		10						
	3						1		
	4								

4.9 Comparison of C-POD and VP data

No comparisons are available for June and July 2014 as the C-POD deployments did not start until August 2014. VP surveys finished in May 2015 so no comparisons with C-POD data are available from this date.

Table 4-11: Comparison of C-POD and VP data for Harbour Porpoise. NB: Comparisons were not possible on VP data for the 20/08/14, 18/10/14, 19/10/14 and 24/11/14 as C-PODs were not active. 'X' indicates that there was no active C-POD present on that day.

Comparison of C-POD and VP data for Harbour Porpoise						
			North C-POD		South C-POD	
Date	Vantage Point	Number of individuals sighted	DPM	DPH	DPM	DPH
27-08-14	N/A	0	60	13	120	**13**
30-08-14	4	2	124	11	253	20
06-09-14	1	2	55	8	62	9
06-09-14	3	1	55	8	62	9
07-09-14	4	2	33	10	99	17
24-09-14	2	2	73	12	56	13
25-09-14	2	1	30	6	40	11
16-12-14	N/A	0	123	14	151	16
17-12-14	N/A	0	157	13	223	14
24-01-15	2	1	66	14	X	X
25-01-15	N/A	0	207	15	X	X
18-02-15	N/A	0	77	11	252	14

19-02-15	2	1	171	14	225	16
15-03-15	N/A	0	X	X	189	14
22-03-15	N/A	0	X	X	70	12
25-04-15	1	2	0	0	X	X
25-04-15	2	3	0	0	X	X
26-04-15	2	1	0	0	X	X
26-04-15	3	2	0	0	X	X
26-04-15	4	4	0	0	X	X
16-05-15	1	2	0	0	X	X
16-05-15	2	2	0	0	X	X
17-05-15	2	1	0	0	X	X
17-05-15	4	2	0	0	X	X

 # No porpoises were detected visually or acoustically on 25/11/14.

Table 4-12: Comparison of C-POD and VP data for Bottlenose Dolphin. NB: Comparisons were not possible on VP data for the 18/10/14, 19/10/14 and the 24/11/14 as C-PODs were not active. 'X' indicates that there was no active C-POD present on that day.

Comparison of C-POD and VP data for Bottlenose Dolphin						
			North C-POD		South C-POD	
Date	**Vantage Point**	**Number of individuals sighted**	**DPM**	**DPH**	**DPM**	**DPH**
27-08-14	N/A	0	6	2	6	2
06-09-14	1	6	8	1	5	1
06-09-14	3	9	8	1	5	1
07-09-14	4	3	0	0	0	0
24-09-14	N/A	0	18	2	10	2
25-09-14	N/A	0	11	3	16	3

25-11-14	N/A	0	6	1	X	X
17-12-14	3	7	0	0	0	0
24-01-15	1	7	0	0	X	X
25-01-15	3	6	0	0	X	X
18-02-15	1	7	0	0	1	1
19-02-15	3	10	0	0	0	0
15-03-15	2	13	X	X	14	5
15-03-15	4	8	X	X	14	5
22-03-15	2	4	X	X	2	1
22-03-15	4	8	X	X	2	1
25-04-15	1	10	3	1	X	X
25-04-15	2	6	3	1	X	X
26-04-15	2	5	9	5	X	X
26-04-15	4	10	9	5	X	X
16-05-15	1	10	23	3	X	X
16-05-15	2	3	23	3	X	X
17-05-15	2	6	8	3	X	X
17-05-15	4	4	8	3	X	X

 # No dolphins were detected visually or acoustically on 30/08/14 and the 16/12/14.

5 EVALUATION OF RESULTS

5.1 Porpoise Detections

Porpoises were detected throughout the detection period on both C-PODs with some peaks in activity.

At North site porpoises were detected on 93% of days with a total of 3185 DPH (30760 DPM), which equates to porpoise detections in 44.4% of all hours recorded (7.2% of all minutes).

At the South site porpoises were detected on 100% of days with a total of 3808 DPH (43185 DPM), which equates to porpoise detections in 64.3% of all hours recorded (12.3% of all minutes).

Overall porpoises were detected on 97% of all days, 53.4% of all hours and 9.5% of all minutes.

Referring to Figure 4.44; over the entire dataset of each C-POD there is a clear activity pattern which generally shows increased activity during daylight hours and much reduced activity at night.

Figures 4.46.1 – 4.46.4 indicate seasonal patterns, were the winter and spring months indicate higher activity towards the middle of the day and mid-morning respectively. The summer and autumn months indicate higher activity early in the morning and late afternoon with a reduction in activity mid-morning and midday respectively. These patterns are true for both North and South sites although the South site generally shows this more strongly.

When looking across the 12 months of C-POD deployments the South site has marginally higher porpoise DPH when compared to the North section, but error bars representing the standard of the mean in most cases are overlapping. Where these error bars do not overlap there is generally a low sample size or a difference in sample size between the North and South C-PODs (See Fig. 4.57).

5.2 Dolphin Detections

Dolphin activity was far less than porpoise activity and was detected for less days.

At the North site dolphins were detected on 56% of days with a total of 384 DPH (1537 DPM), which equates to dolphin detections in 5.4% of all hours recorded (0.4% of all minutes).

At the South site dolphins were detected on 54% of days with a total of 290 DPH (1378 DPM), which equates to dolphin detections in 4.9% of all hours recorded (0.4% of all minutes).

Overall dolphins were detected on 56.5% of all days, 5.15% of all hours and 0.4% of all minutes.

Referring to Figure 4.45; there are daily increases in dolphin activity in the early hours of the morning and again in the afternoon but these are less significant due the reduced dataset of dolphin DPM.

Figures 4.47.1 – 4.47.4 indicate seasonal patterns, where the winter months have higher activity at night, there is no clear pattern for the spring months which may be associated with lower total activity. The summer months indicate higher activity early in the morning, afternoon and evening with a reduction in activity late morning, midday and midnight. Very little activity has been recorded for the autumn months so the pattern of relatively high activity in the evening and towards the middle of the night is not highly significant as is due to relatively few encounters.

Due to the effective detection ranges (EDR) for dolphins (i.e. 700m) and the close proximity of the North and South C-PODs and subsequent EDR overlap, dolphin individuals can be detected simultaneously, therefore interpretation of this data should be treated with caution.

5.3 Comparative Assessment (Other Studies)

A study of bottlenose dolphin distribution in the Moray Firth during 2008 placed Timing Porpoise Detectors (T-PODs), static acoustic monitoring devices at various locations along the east coast of Scotland. At Stonehaven, the closest site to Aberdeen in the study, it was found that during the summer months (May to September) bottlenose dolphin were present 62% of the days monitored, dropping to just 28% during the winter months (October to April) (SNH Commissioned Report No. 354).

For the North C-POD in Nigg Bay, dolphins were detected on 56% of all days monitored across all 5 deployments (August 2014 - August 2015). For the South C-POD in Nigg Bay dolphins were detected on 54% of all days monitored across all 5 deployments. The percentage of days where dolphins were detected (Average between North and South C-PODs) between the end of August and October 2014 was 46%, between November and February this was 53%, between February and April detections increased to 67%, between April and June dolphins were detected on 89% (North C-POD only) of the days monitored, and between June and August 2015 dolphins were detected on 40% of the days monitored. These results clearly show an increase in dolphin activity into the early summer months, but then dropping off after June.

These results are comparable to the Scottish Natural Heritage (SNH) Commissioned Report No. 354, where dolphin positive days in the area of Stonehaven decreased markedly at the end of the summer months (i.e. in August) and peak dolphin positive days in this region were between April and July.

Based on this Stonehaven data it was expected that the percentage of dolphin positive days for bottlenose dolphin would remain low until April 2015 in the Aberdeen area. This study contradicts other observations, which found an increase in bottlenose dolphin

activity in the Aberdeen Bay area between the months of November and May (Genesis 2012), but local factors such as food availability e.g. seasonal salmon migrations up the rivers Dee and Don will no doubt be important when interpreting bottlenose dolphin activity. The results of the Nigg Bay survey show that between February and April 2015 dolphin detections started to increase from winter detection rates, and it found that dolphins were detected nearly every day between April and June 2015 as the summer months progressed.

Marine Scotland provided C-POD data from various locations along the Scottish east coast in 2013/14. Results from this monitoring data that include locations in Fraserburgh, Stonehaven, Cruden Bay and Arbroath which are found along the Scottish east coast, indicate that during the summer months (approximately May to August) porpoise were detected between 98% and 100% of the days monitored (See Marine Scotland 2013-14 C-POD summary data). These results strongly compare with the detection rates seen in the vicinity of Nigg Bay where porpoise were detected on 100% of the days monitored between August 2014 and April 2015, although it was shown that porpoise detection days decreased to 68% (North C-POD only) between April and June, coinciding with a large increase in dolphin activity. Porpoise activity then increased to 100% of the days monitored between the months of June and August 2015.

The Marine Scotland C-POD data also indicate that dolphins were detected between 6% and 17% of the days monitored in Fraserburgh, Stonehaven, Cruden Bay and Arbroath between May and August 2014 (See Marine Scotland 2013-14 C-POD summary data), which are comparatively low with the detection rates found at Nigg Bay. In Nigg Bay dolphin detection rates ranged from a peak of 89% of all days monitored between April and June 2015 to a low of 40% of all days monitored between June and August 2015 and similarly from August to October 2014. These results indicate that Nigg Bay and its local vicinity may be an important area or hotspot for dolphin activity along the Scottish east coast.

Other data using acoustic monitoring should be used conservatively when comparing with Nigg Bay, Aberdeen due to the potential difference in local environments. For example a lot of work has been carried out in the Moray Firth to monitor the distribution of cetaceans over protracted periods, with results indicating that dolphin presence within and between sites in this region vary markedly both temporally and spatially.

5.4 Visual Survey

Harbour porpoise were recorded across all four vantage points, with the distance from shore ranging between 500m and 2km, based upon estimated distances (Table 4-5, see also Figures 3-2 to 3-5 for viewshed distance measures). They were observed from June to October 2014 with the majority of sightings in the summer months between June and August 2014, there were no sightings in November or December. In 2015 there were only single sightings during the months of January and February with no sightings in March, but then in April and May porpoise sightings greatly increased covering all 4 vantage points. Sightings took place and at various times of the day and covered all tidal states.

Bottlenose dolphin have been recorded across all four vantage points, with the distance from shore ranging between 100m and 1km from shore, based upon estimated distances

(Table 4-6). In 2014 they were observed in June, September, October and December with no sightings recorded in July, August or November. In 2015 they were observed across all months from January to May. Sightings took place at various times of the day and covered all tidal states.

White-beaked dolphin were recorded from vantage point 2 at a distance of between 500m and 1km from the shore (Table 4-7). Three individuals were recorded during this single sighting event on evening of the 21st July during a mid and rising tide.

Grey seals were recorded across all four vantage points and in all months, with the distance from shore ranging from less than 100m to up to 1km from the shore (Table 4-8). Sightings took place at various times of the day and covered all tidal states but were most commonly sighted between mid and high tides, with few sightings at low tide.

5.5 Combination Assessment (C-PODs & Vantage Point Surveys)

Porpoises

When comparing C-POD data alongside the visual survey data it is clear that on the majority of days porpoise were detected in the Nigg Bay area. During the visual survey porpoise were detected on 20 out of the 30 days monitored. In total over the course of the 5 C-POD deployments the North C-POD detected porpoise on 277 out of 296 days monitored, and the South C-POD detected porpoise on 244 out of 244 days monitored.

When comparing the specific days where both the visual surveys and C-POD surveys coincided (19 comparative days), visual surveys sighted porpoises on 11 out of the 19 days, and C-PODs detected porpoises on 14 out of the 19 days. There were 7 days were no porpoises were sighted visually but the C-PODs detected them acoustically. There were 10 days where porpoises were not detected by the C-PODs but were sighted during the visual survey.

When comparing specific days where harbour porpoise were visually observed alongside C-POD acoustic detections, it can be seen that although individuals may only be sighted infrequently or on a single occasion, the C-PODs indicate that they are spending a lot of time in the local vicinity of Nigg Bay. C-PODs on the days where visual sightings took place indicate between 6 DPH and 20 DPH within a single 24 hour period. When taking into consideration DPM which ranges between 30 DPM and 253 DPM, this may indicate that porpoise are visiting the area during multiple periods throughout the day (See Table 4-9: for further specific daily comparisons of C-POD and VP data for porpoise).

Dolphins

When comparing C-POD data alongside the visual survey data it is clear that on the majority of days dolphins were detected in the Nigg Bay area. Dolphins were detected in the Nigg Bay area on 18 out of the 30 visual survey days. In total over the course of the 5 C-POD deployments the North C-POD detected dolphin on 170 out of 296 days monitored, and the South C-POD detected dolphin on 135 out of 244 days monitored.

When comparing days where both the visual surveys and C-POD surveys coincided (19 comparative days), visual surveys sighted dolphins on 13 out of the 19 days, and C-PODs detected porpoises on 12 out of the 19 days. There were 4 days were no dolphins were sighted visually but the C-PODs detected them acoustically. There were 5 days where dolphins were not detected by the C-PODs but were sighted during the visual survey.

When comparing specific days where bottlenose dolphin were visually observed alongside C-POD acoustic detections, it can be seen that these single visual sightings were also backed up by C-POD detections. C-PODs on the days where visual sightings took place indicate between 1 DPH and 5 DPH within a single 24 hour period. When taking into consideration DPM which ranges between 2 DPM and 23 DPM, which is considerably lower than that of porpoise, this may indicate only single visits or very short repeat visits to the area on detection days (See Table 4-10: for further specific daily comparisons of C-POD and VP data for dolphin).

There were 5 visual sighting events of bottlenose dolphins that were not picked up acoustically by the active C-PODs (See Table 4-10: Comparison of C-POD and VP data for Bottlenose Dolphin). One potential explanation for the lack of acoustic detections could be that the dolphins may not have been echo locating on these occasions as they travelled through the area. These visual data point to a likely underestimation of the level of dolphin presence / activity detected by the C-PODs in vicinity of Nigg Bay.

There were 4 occasions where the C-PODs detected dolphins but were not seen during the visual survey on those days. This may simply be because the C-PODs detections occurred outside the visual survey window within the specific 24 hour period on those days, or that environmental conditions were not optimal on those particular days.

It is clear from comparing the visual survey and C-POD data that a combined approach is valuable for determining porpoise and dolphin presence / absence in the Nigg Bay.

5.6 Access Database and Excel Spreadsheet

The train data has been cleaned of false positives. Access databases are provided containing all the click and train data and includes some useful queries. The exported DPH and DPM daily totals are contained in the DPH and DPM named in the spreadsheet.

5.7 Other Data Features

Landmark Sequences

These are sequences showing the approach of a porpoise as it reduces it's inter click interval to allow for the shorter distances and associated shorter return times as it echo locates off the C-POD.

Landmark sequences are useful in enabling swimming speeds and source levels to be calculated.

108 landmark sequences were found across all files, Figure 4.56 shows an example of a landmark sequence recorded at the North Site in deployment 1 with time in seconds along

the x-axis and the inter-click interval along the y-axis, the upper portion of the chart shows porpoise only classified clicks, the lower shows all clicks.

5.8 Overall Characterisation and Value

The site has been characterised in detail for detections of porpoise and dolphin and the results have been summarised as percentage of all hours recorded. It has also been characterised in detail for visual sightings over the sampling period and species within the study area including harbour porpoise, bottlenose dolphin, white-beaked dolphin and grey seal.

From the available data collected during the 12 month visual survey, it is clear that porpoise activity is highest in the months of April, May and June. The C-POD deployments indicate porpoise presence in the Nigg Bay area on every day that was monitored between August 2014 and April 2015, but between April and June there was a large decrease in porpoise activity. This decrease in porpoise activity coincides with a large increase in dolphin activity shown by the C-PODs between April and June 2015, with corresponds strongly with the visual survey showing the highest level of dolphin activity between the months of March and June. Porpoise activity then continued to increase from June to August 2015 (See Figs. 4.1 and 4.2).

There are currently limitations to allow for a determination of overall value (geographical scale) versus the data collected. The limitations are primarily related to the nature of the data collected, technology used, total number of animals using the site, sampling periods, sampling effort, volume of data available and interrelationships with known populations on a geographical scale.

Based on comparisons with other areas along the east coast of Scotland (See Section 5.3) we conclude that the vicinity of Nigg Bay is of ***Regional*** importance for bottlenose dolphin due to their high presence in this area when compared to others. We consider harbour porpoise to be of ***Local*** importance even though they were recorded nearly every day in the vicinity of Nigg Bay, this is because in other comparative sites along the east coast of Scotland the same presence patterns can be found.

With a full year of visual and acoustic assessments complete it is clear that there is a seasonal trend in bottlenose dolphin activity in the vicinity of Nigg Bay. It has also become apparent that harbour porpoise are present all year round occurring within the vicinity of the site on most days, but this presence may also be affected by higher bottlenose dolphin activity, with lower numbers seen during these periods. When looking at diel patterns (see Section 4.5) it can be seen that porpoise show peak activity between 6am and 6pm (Fig. 4.44), and bottlenose dolphin peak activity occurs in the early hours of the morning and late afternoon / evening (Fig. 4.45). Finally the data indicates that there is potentially a higher level dolphin activity in the northern vicinity of Nigg Bay and a slightly higher level of porpoise activity in the southern vicinity of Nigg Bay, although robust interpretation of this is difficult due to the limited data available.

6 REFERENCES

Baulch, S. (2008). "Fine-scale spatio-temporal variation and habitat partitioning in bottlenose dolphins and harbour porpoises." CCW Marine Monitoring Report No. 61.

Carter, T.J., Pierce, G.J., Hislop, J.R.G., Houseman, J.A., and Boyle, P.R. (2001). Predation by seals on Salmonids in two Scottish estuaries. Fisheries Management and Ecology 8: 207-225.

Cheney, B., Thompson, P.M., Ingram, S.N., Hammond, P.S., Stevick, P.T., Durban, J.W., Culloch, R.M., Elwen, S.H., Mandleberg, L., Janik, V.M., Quick, N.J., Islas-Villaneuva, V., Robinson, K.P., Costa, M., Eisfeld, S.M., Walters, A., Phillips, C., Weir, C.R., Evans, P.G.H., Anderwald, P., Reid, R.J., Reid, J.B. and Wilson, B. (2013). Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins *Tursiops truncatus* in Scottish waters. Mammal Review 43(1): 71-78.

Gallus, A., Dähne, M., Verfuß, U.K., Bräger, S., Adler, S., Siebert, U., Benke, H. (2012). "Use of static passive acoustic monitoring to assess the status of the "Critically Endangered" Baltic harbour porpoise in German waters." Endangered Species Research 18: 265-278.

Genesis (2012). Aberdeen offshore wind farm marine mammals baseline addendum. J90008A-Y-TN-24001 G1.

Jefferson TA, Hung SK, Law L, Torey M and Tregenza N (2002). "Distribution and abundance of finless porpoises in Hong Kong and adjacent waters of China." Raffles Bulletin of Zoology (SUPPL. 10): 43-55.

Koschinski, S., Culik, B, M., Trippel, E. A., Ginzkey, L. (2006). "Behavioral reactions of free-ranging harbor porpoises *Phocoena phocoena* encountering standard nylon and BaSO4 mesh gillnets and warning sound." Mar Ecol Prog Ser 313: 285–294.

Koschinski, S., Culik, B. M., Henriksen, O. D., Tregenza, N., Ellis, G., Jansen, C., and Kathe, G. (2003). "Behavioural reactions of free-ranging porpoises and seals to the noise of a simulated 2 MW windpower generator," Mar. Ecol.: Prog. Ser. 265: 263–273.

Leeney, R.H., Berrow, S., McGrath, D., O"Brien, J., Cosgrove, R. and Godley, B.J. (2007). "Effects of pingers on the behaviour of bottlenose dolphins." Journal of the Marine Biological Association of the United Kingdom, 87: 129-133.

Leeney, R.H., Carslake, D., Elwen, S.H. (2011). "Using Static Acoustic Monitoring to Describe Echolocation Behaviour of Heaviside"s Dolphins (*Cephalorhynchus heavisidii*) in Namibia." Aquatic Mammals, 37(2): 151-160, DOI 10.1578/AM.37.2.2011.151.

Lewis, M (2015) Nigg Bay Vantage Point Survey Report – Marine Mammals and Birds (June to November 2014) Report to Fugro Emu Ltd.

Meding, A, Verfuß, U. K., Honnef, C. G., Benke, H. (2005). "Interpreting the echolocation behaviour of wild harbour porpoises (*Phocoena phocoena*) around the island of Fehmarn, Germany." In *European Research on Cetaceans*. Vol. 19. La Rochelle, France, 2005.

Merchant, N.D., Enricio, P., Barton, T.R. and Thompson, P.M. (2014). Monitoring ship noise to assess the impact of coastal developments on marine mammals. Marine Pollution Bulletin 78(1-2): 85-95. doi: 10.1016/j.marpolbul.2013.10.058.

McConnell, B.J. Fedak, M.A. Lovell, P. and Hammond, P.S. (1999). Movements and foraging areas of grey seals in the North Sea. Journal of Applied Ecology 36: 573-590.

Nuuttila, Thomas, L., Hiddink, J.G., Meier, R., Turner, J.R., Bennell, J.D., Tregenza, H. J. C., Evans, P.G.H., (2013). "Acoustic detection probability of bottlenose dolphins, *Tursiops truncatus*, with static acoustic dataloggers in Cardigan Bay, Wales." J. Acoust. Soc. Am. 134(3): 2596–2609.

Nuuttila, H.K., Meier,R., Evans, P.G.H., Turner, J.R., Bennell, J.D., Hiddink, J.G. (2013). "Identifying Foraging Behaviour of Wild Bottlenose Dolphins (*Tursiops truncatus*) and Harbour Porpoises (*Phocoena phocoena*) with Static Acoustic Dataloggers." Aquatic Mammals, 39(2): 147-161.

Pirotta, E., Brookes, K. L., Graham, I. M. and Thompson, P. M. (2014). "Variation in harbour porpoise activity in response to seismic survey noise." Biol. Lett. 10: 20131090. http://dx.doi.org/10.1098/rsbl.2013.1090.

Quick, N., Arso, M., Cheney, B., Islas, V., Janik, V., Thompson, P.M., and Hammond, P.S. (2014). The east coast of Scotland bottlenose dolphin population: Improving understanding of ecology outside the Moray Firth SAC. Sea Mammal Research Unit (SMRU), University of Aberdeen. Document identifier URN: 14D/086.

Rayment, W., Dawson, S., Scali, S. and Slooten, E. (2011). "Listening for a needle in a haystack: passive acoustic detection of dolphins at very low densities." Endangered Species Research 14: 149-156.

Reid, J.B., Evans, P.G.H, and Northbridge, S.P. (2003). Atlas of Cetacean distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough.

Robinson, K.P., Baumgartner, N., Eisfeld, S.J., Clark, N.M., Culloch, R.M., Haskins, G.N., Zapponi, L., Whaley, A.R., Weare, J.S. and Tetley, M.J.P (2008). The summer distribution and occurrence of cetaceans in the coastal waters of the outer southern Moray Firth in northeast Scotland (UK). Lutra. Marine Biodiversity Records 3: 1-4.

Scheidat, S., Tougaard, J., Brasseur, S., Carstensen, J., van Polanen Petel, T., Teilmann, J., Reijnders, P. (2011). "Harbour porpoises (*Phocoena phocoena*) and wind farms: a case study in the Dutch North Sea." Environ. Res. Lett. 6 025102 (10pp).

Simon, M., Nuuttila, H., Reyes-Zamudio, M. M., Ugarte, F., Verfuss, U., and Evans, P. G. H. (2010). "Passive acoustic monitoring of bottlenose dolphin and harbour porpoise, in

Cardigan Bay, Wales, with implications for habitat use and partitioning." Journal of the Marine Biological Association of the UK. Vol 90 / Special Issue 08: 1539 – 1545.

SMRU (2010). Approaches to marine mammal monitoring at marine renewable energy developments. Ref: MERA 0309 TCE.

Thomsen, Frank, N. van Elk, V. Brock, and Werner Piper. (2005). "On the performance of automated porpoise-click-detectors in experiments with captive harbour porpoises (*Phocoena phocoena*) (L.)." J. Acoust. Soc. Am. 118: 37-40.

Thompson, PM, Cheney, B, Ingram, S, Stevick, P Wilson, B & Hammond, PS (Eds) (2011). Distribution, abundance and population structure of bottlenose dolphins in Scottish waters. SNH Commissioned Report No. 354.

Thompson, P.M., Brookes, K.L., Graham, I.M., Barton, T.R., Needham, K., Bradbury, G., Merchant, N.D. (2013). "Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises." Proc.R. Soc. B. 280: 2001.

Thompson, P.M., Brookes, K.L., and Cordes, L.S. (2014). Integrating passive acoustic and visual data to model spatial patterns of occurrence in coastal dolphins. ICES Journal of Marine Sciences, doi:10.1093/icesjms/fsu110.

Tougaard J., Carstensen, J., J Teilmann, J., Skov, H., Rasmussen, P. (2009). "Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (*Phocoena phocoena* (L.))." J. Acoust. Soc. Am. 126: 11.

Verfuß, U.K., Dähne, M., Gallus, A., Jabbusch, M., Benke, H. (2013). "Determining the detection thresholds for harbor porpoise clicks of autonomous data loggers, the Timing Porpoise Detectors." J. Acoust. Soc. Am. 134: 2462.

Weir, C.R., Stockin, K.A. and Pierce, G.J. (2007). Spatial and temporal trends in the distribution of harbour porpoises, white-beaked dolphins and minke whales off Aberdeenshire (UK), north-western North Sea. Journal of the Marine Biological Association of the UK 87: 327-338.

Wilson B, Benjamins S, Elliott J (2013). "Using drifting passive echolocation loggers to study harbour porpoises in tidal-stream habitats." Endangered Species Research 22: 125–143.

Websites

jncc.defra.gov.uk/
www.chelonia.co.uk
www.sepa.org.uk

SNH Commissioned Report No. 354.
http://www.snh.org.uk/pdfs/publications/commissioned_reports/354.pdf.

Nigg Bay (Aberdeen)
Baseline Distribution of Marine Mammals using Integrated Passive Acoustic and Visual Data

FIGURES DOCUMENT

Figures: 3-1 – 4-57

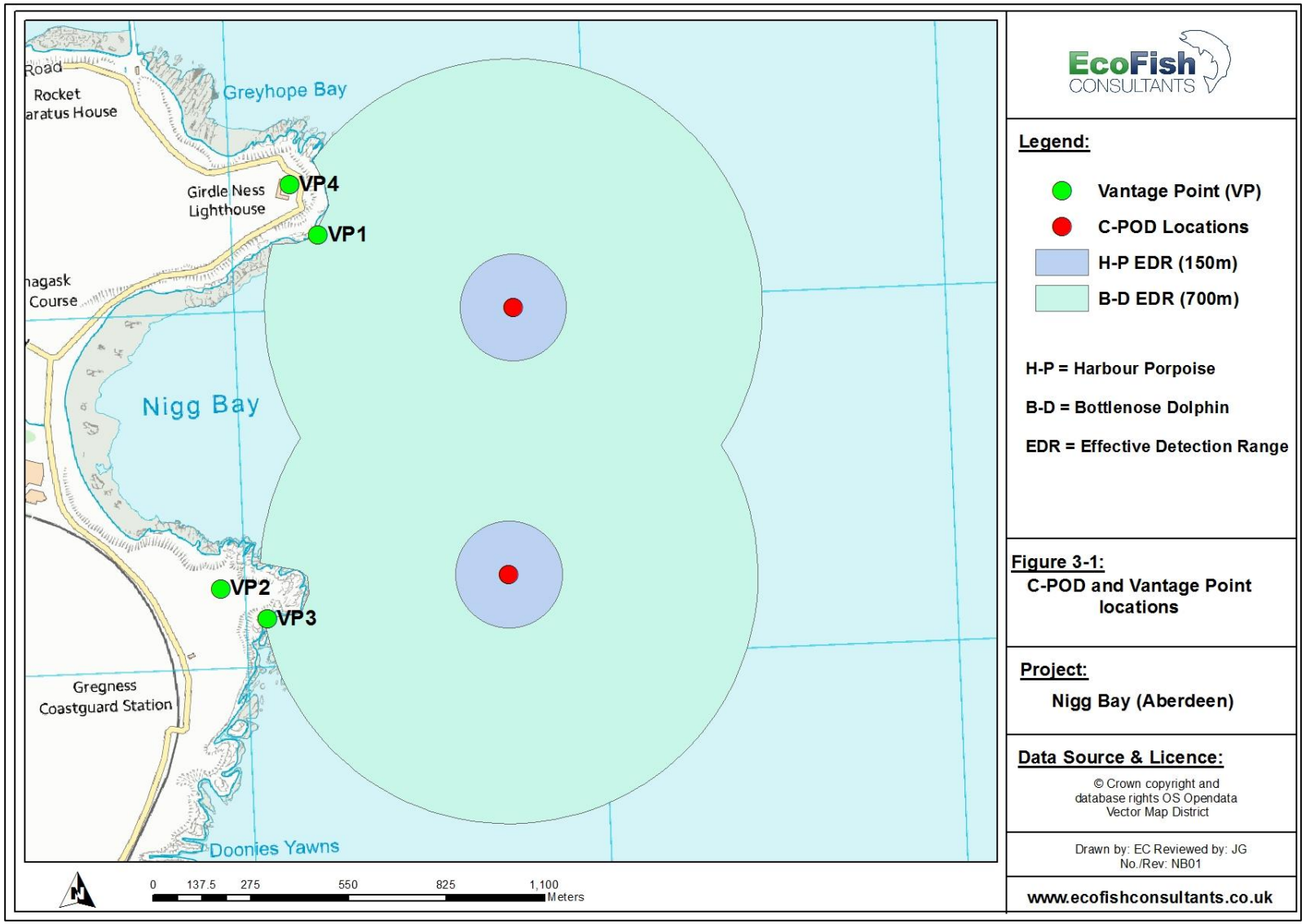

Figure 3-1: C-POD and Vantage Point Locations

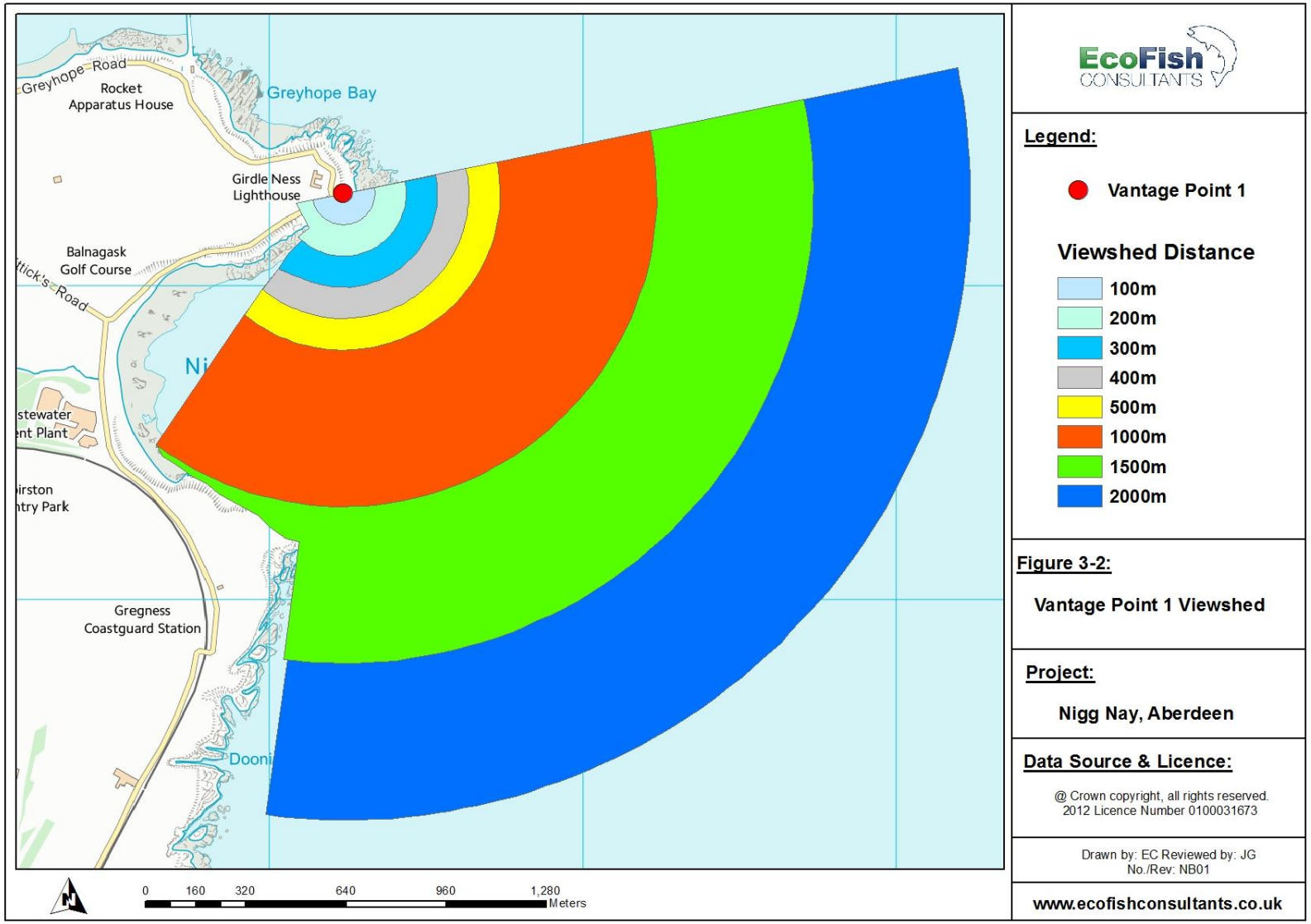

Figure: 3-2: Vantage Point 1 Viewshed

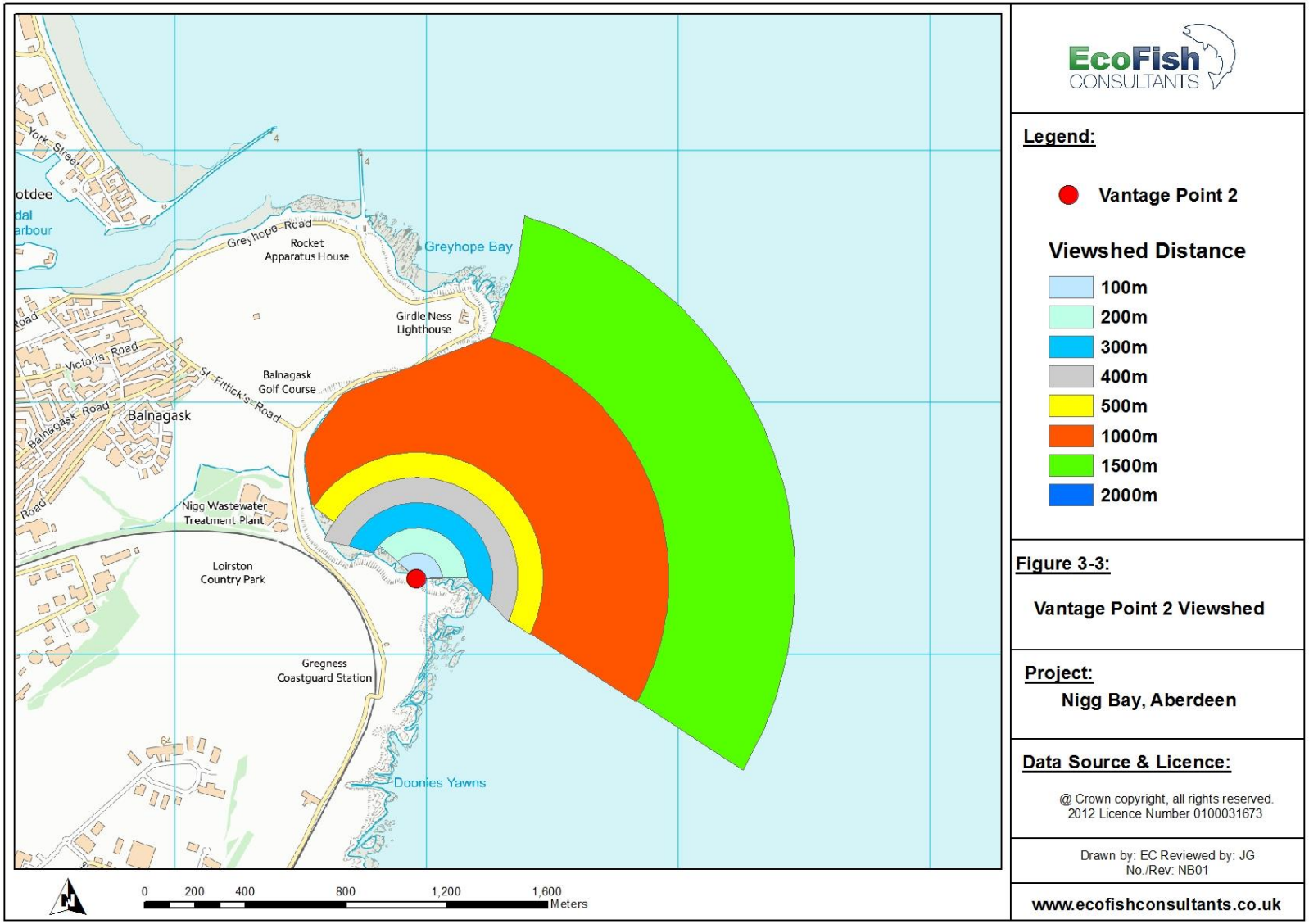

Figure 3-3: Vantage Point 2 Viewshed

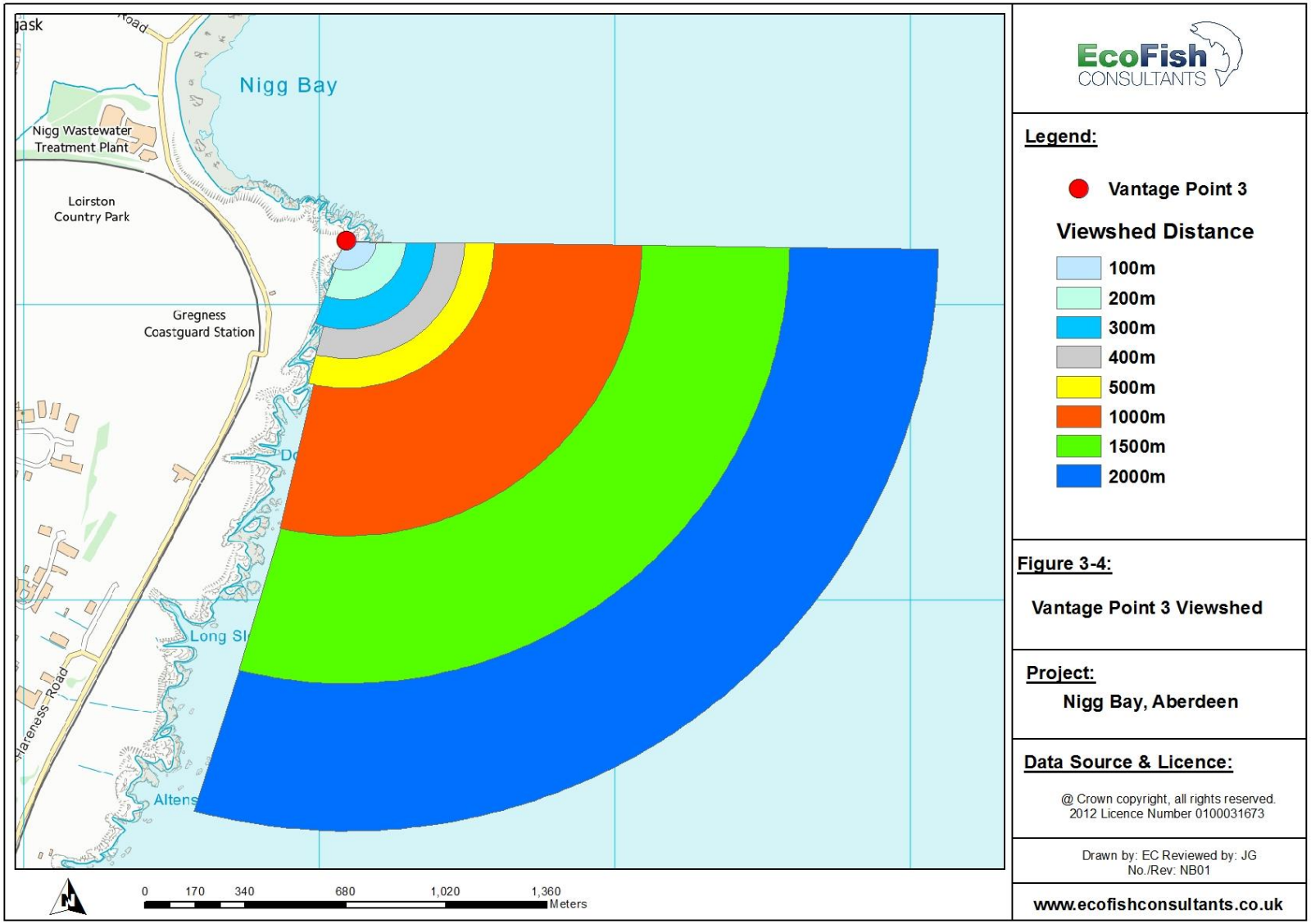

Figure 3-4: Vantage Point 3 Viewshed

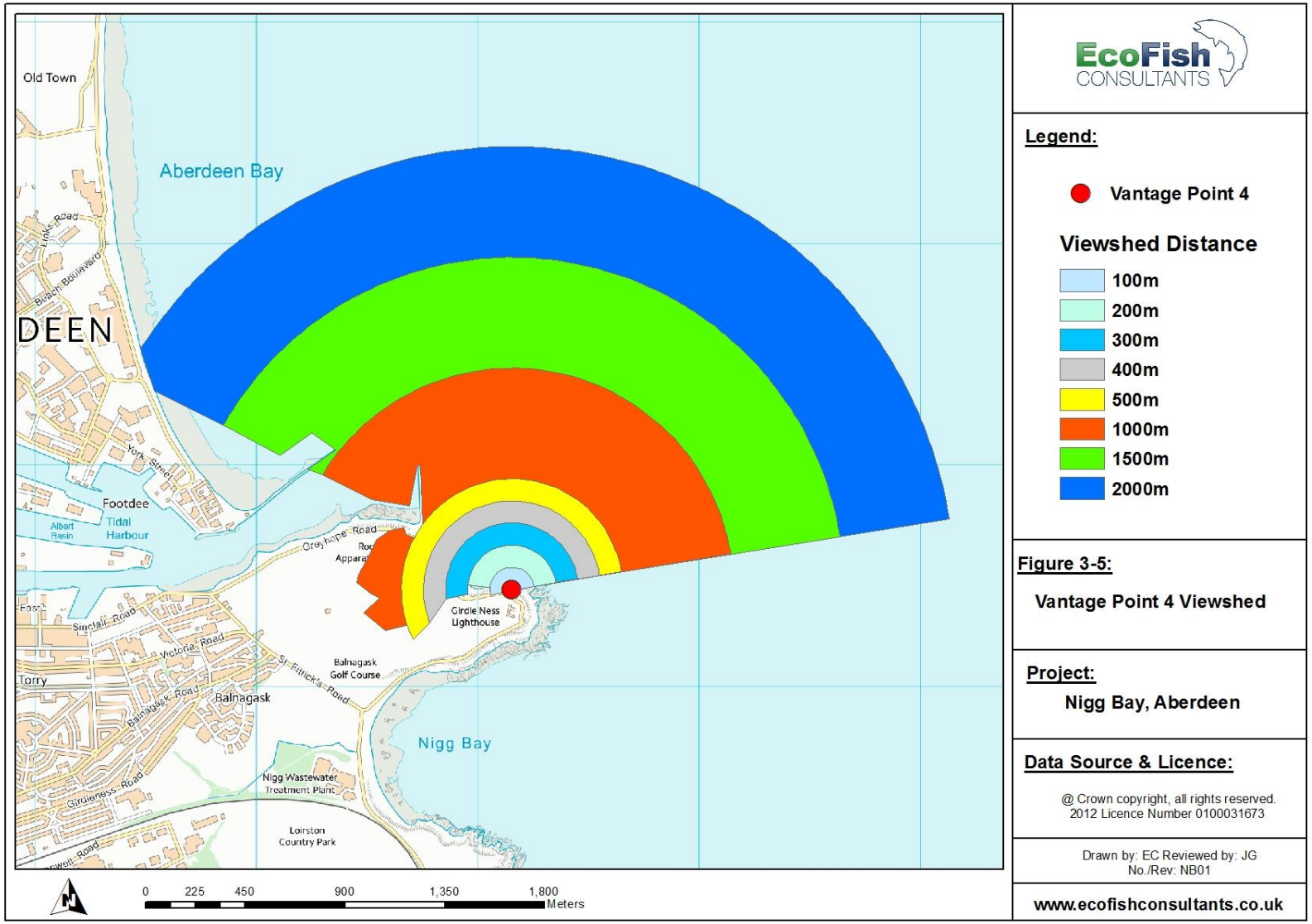

Figure 3-5: Vantage Point 4 Viewshed

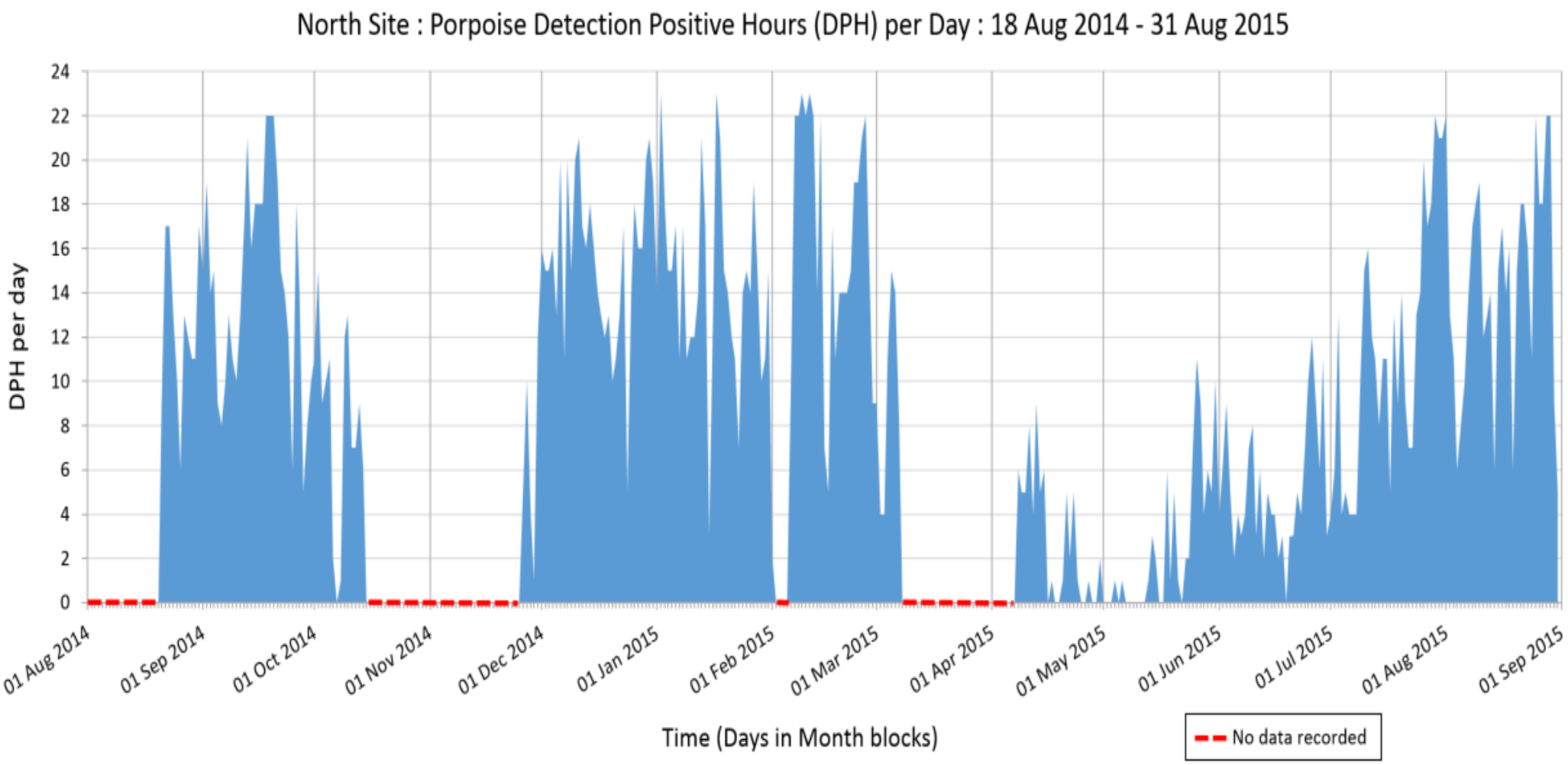

Figure 4-1: Porpoise DPH North Seasonal

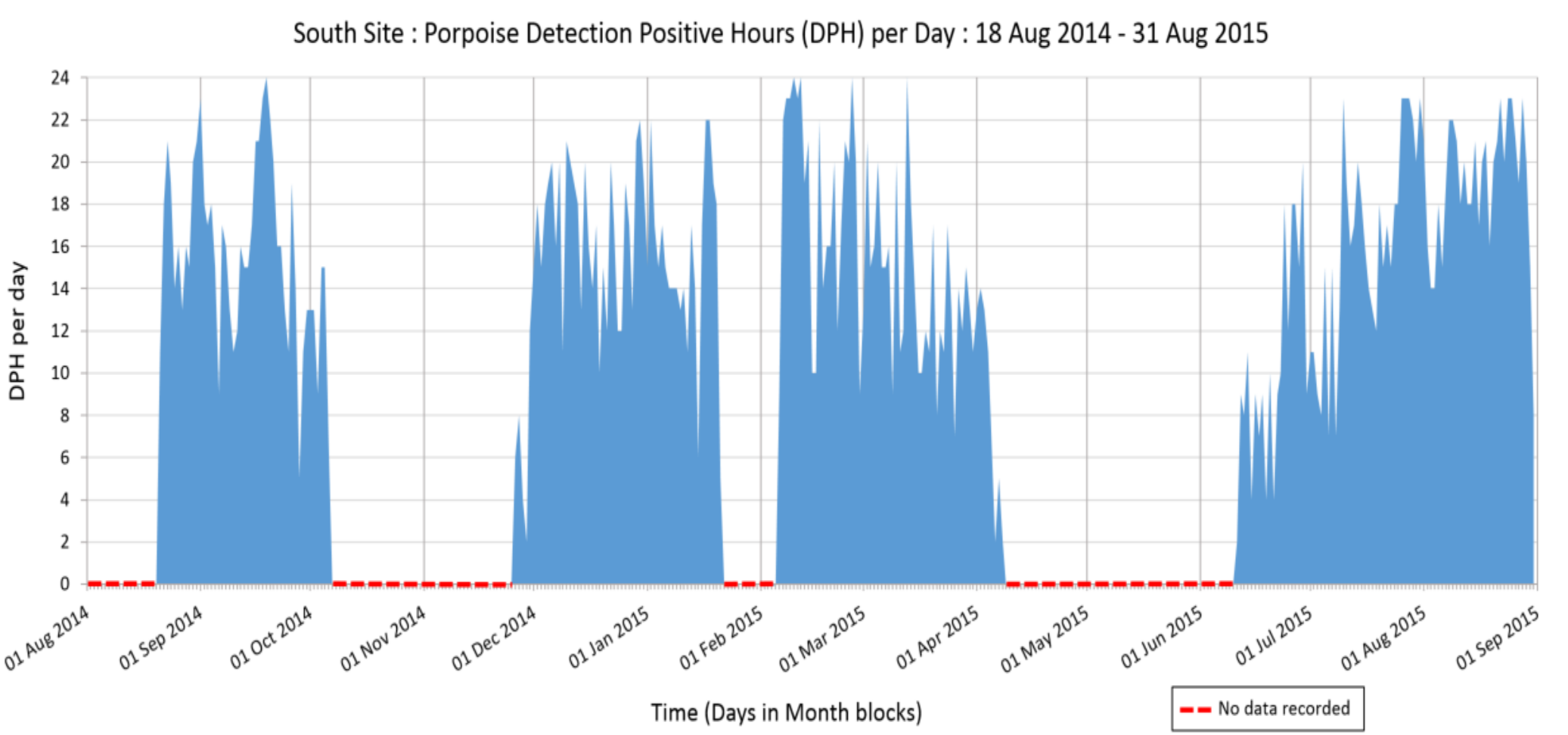

Figure 4-2: Porpoise DPH South Seasonal

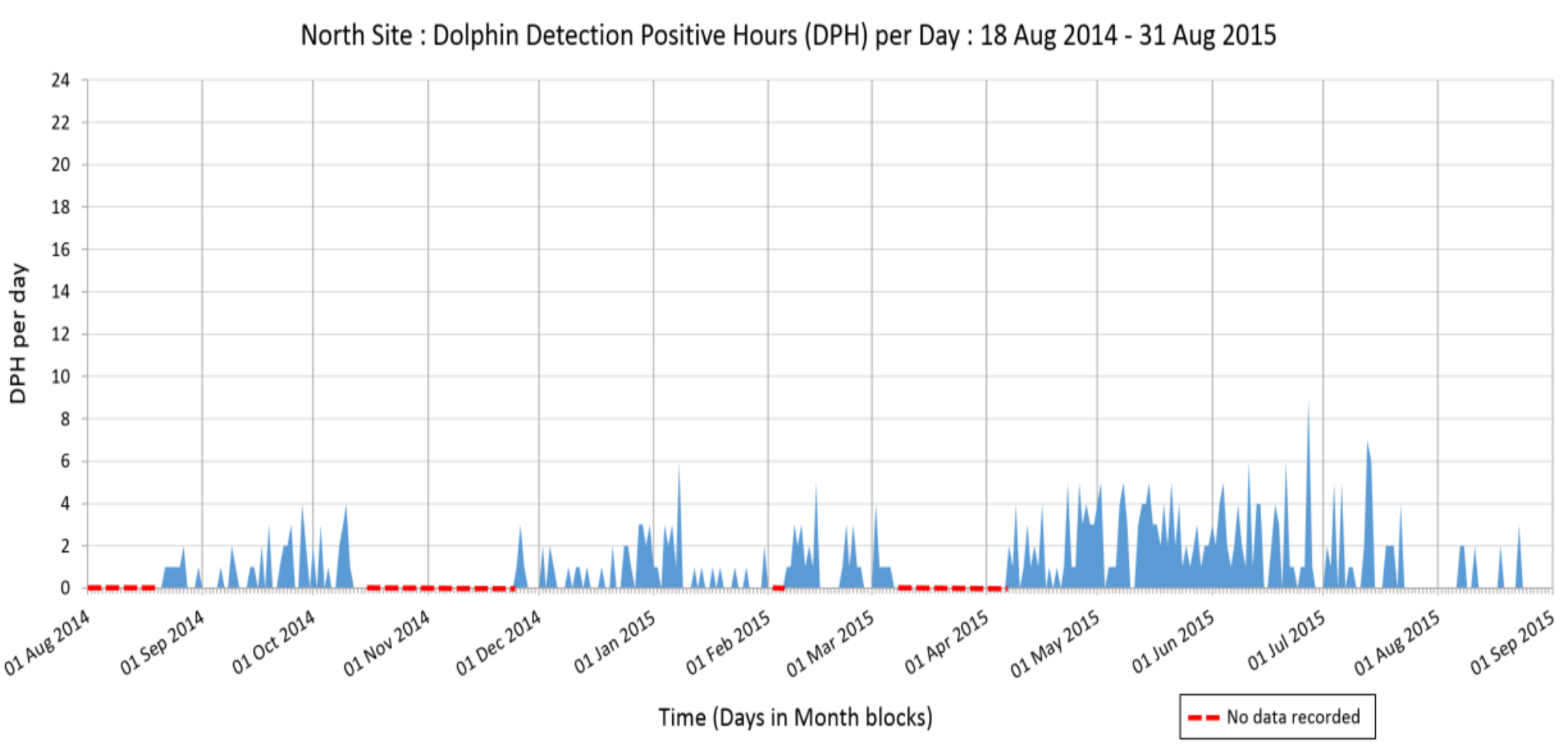

Figure 4-3: Dolphin DPH North Seasonal

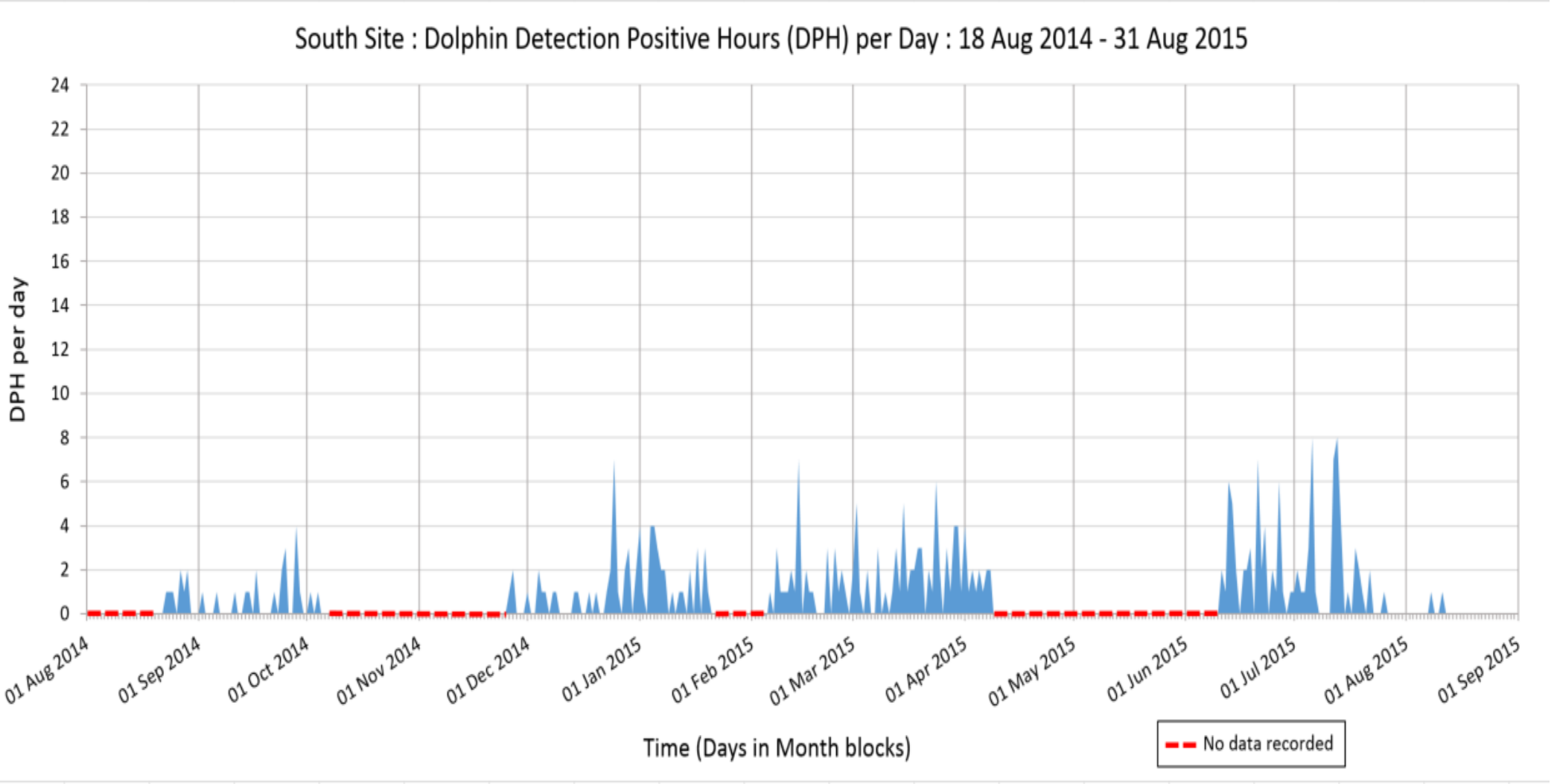

Figure 4-4: Dolphin DPH South Seasonal

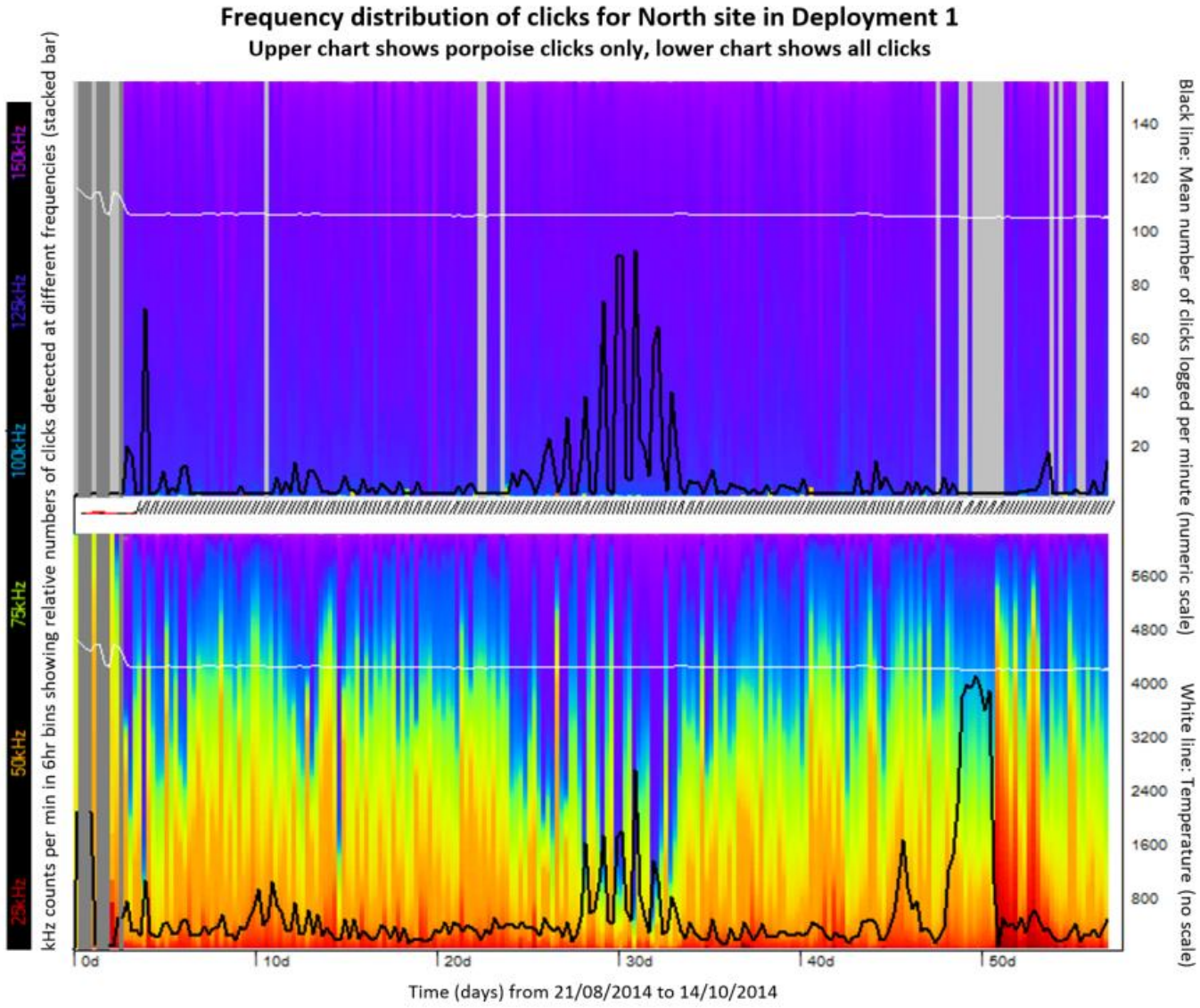

Figure 4-5: Porpoise Activity at North Site for Deployment 1

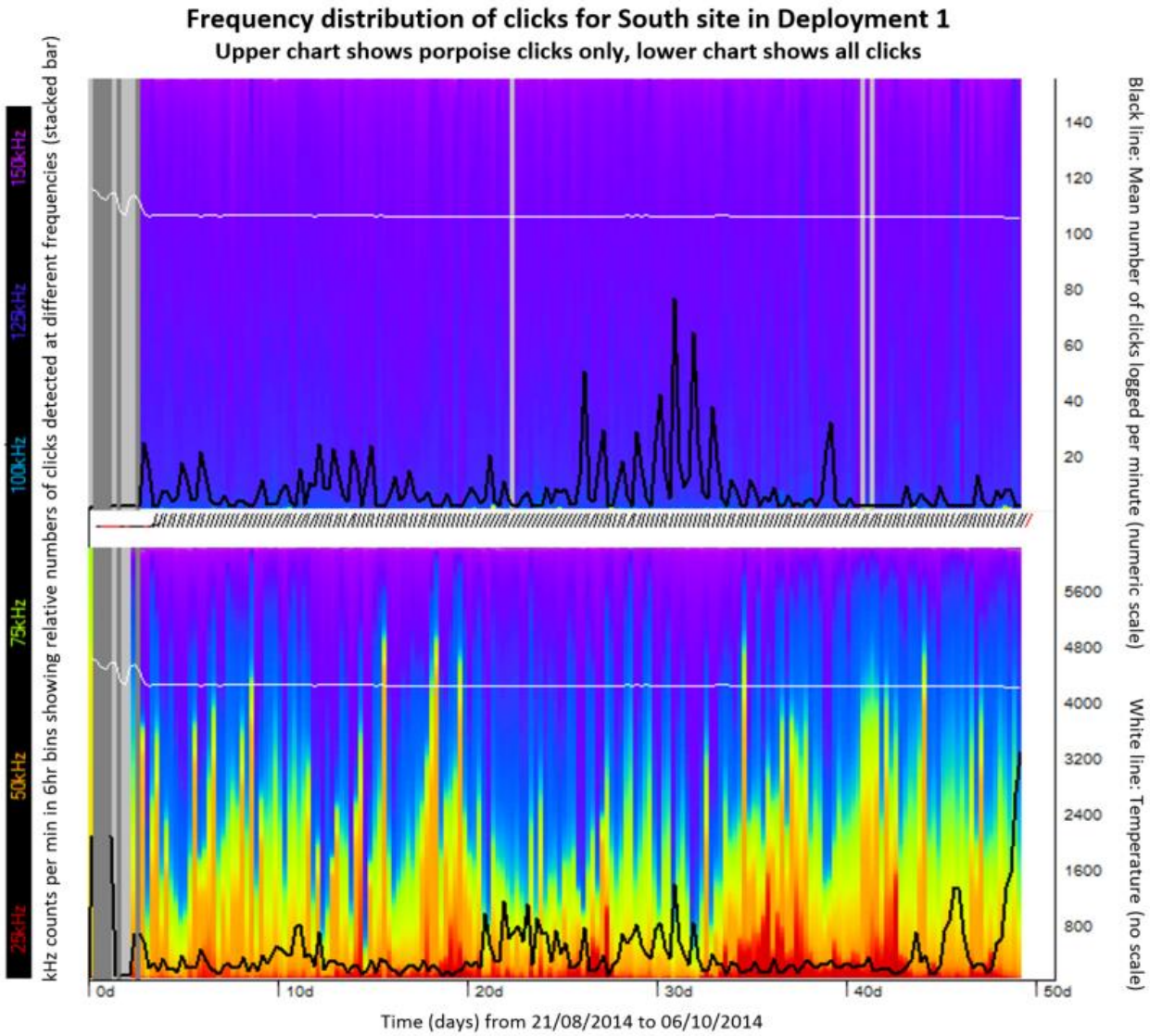

Figure 4-6: Porpoise Activity at South Site for Deployment 1

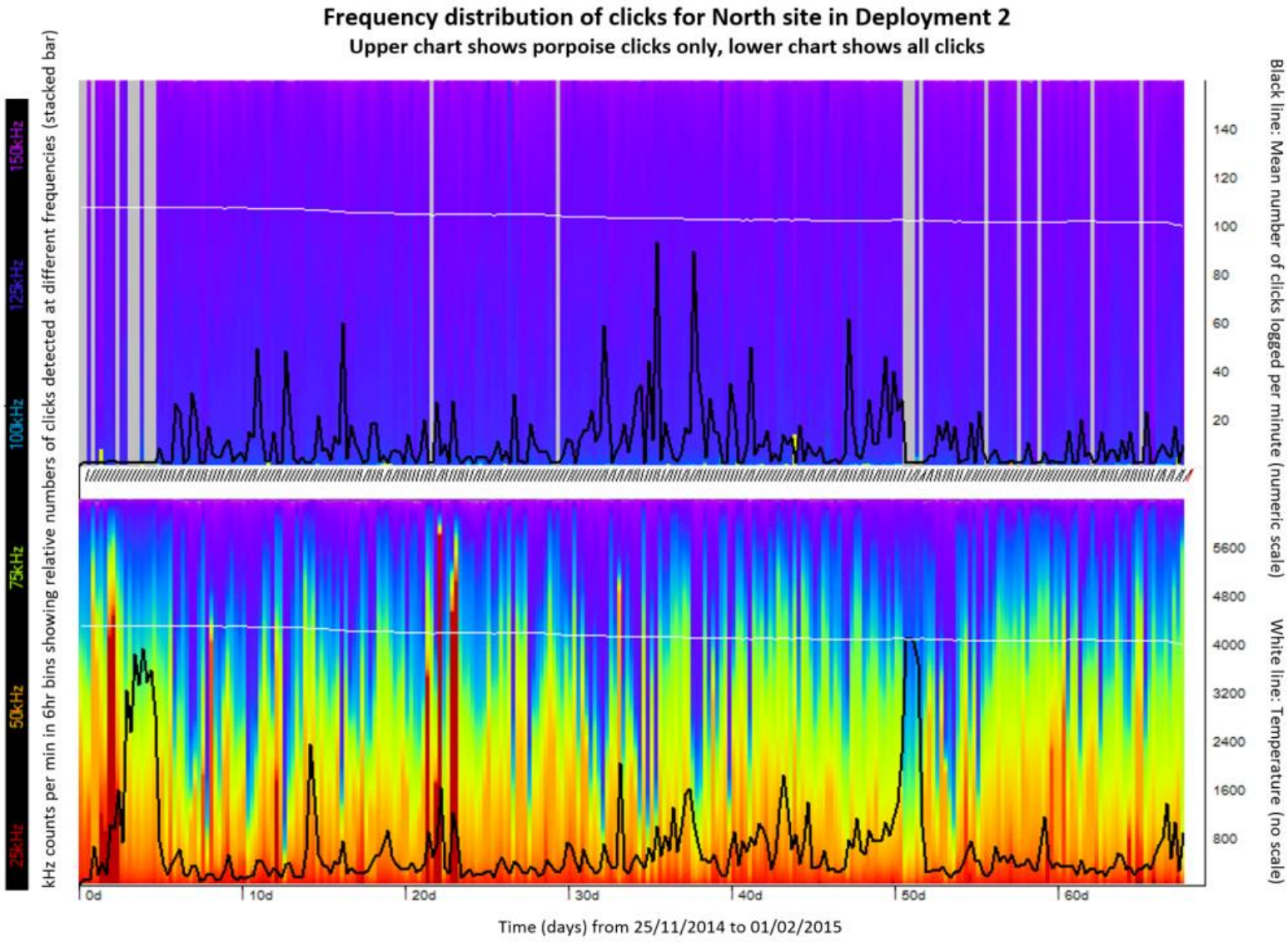

Figure 4-7: Porpoise Activity at North Site for Deployment 2

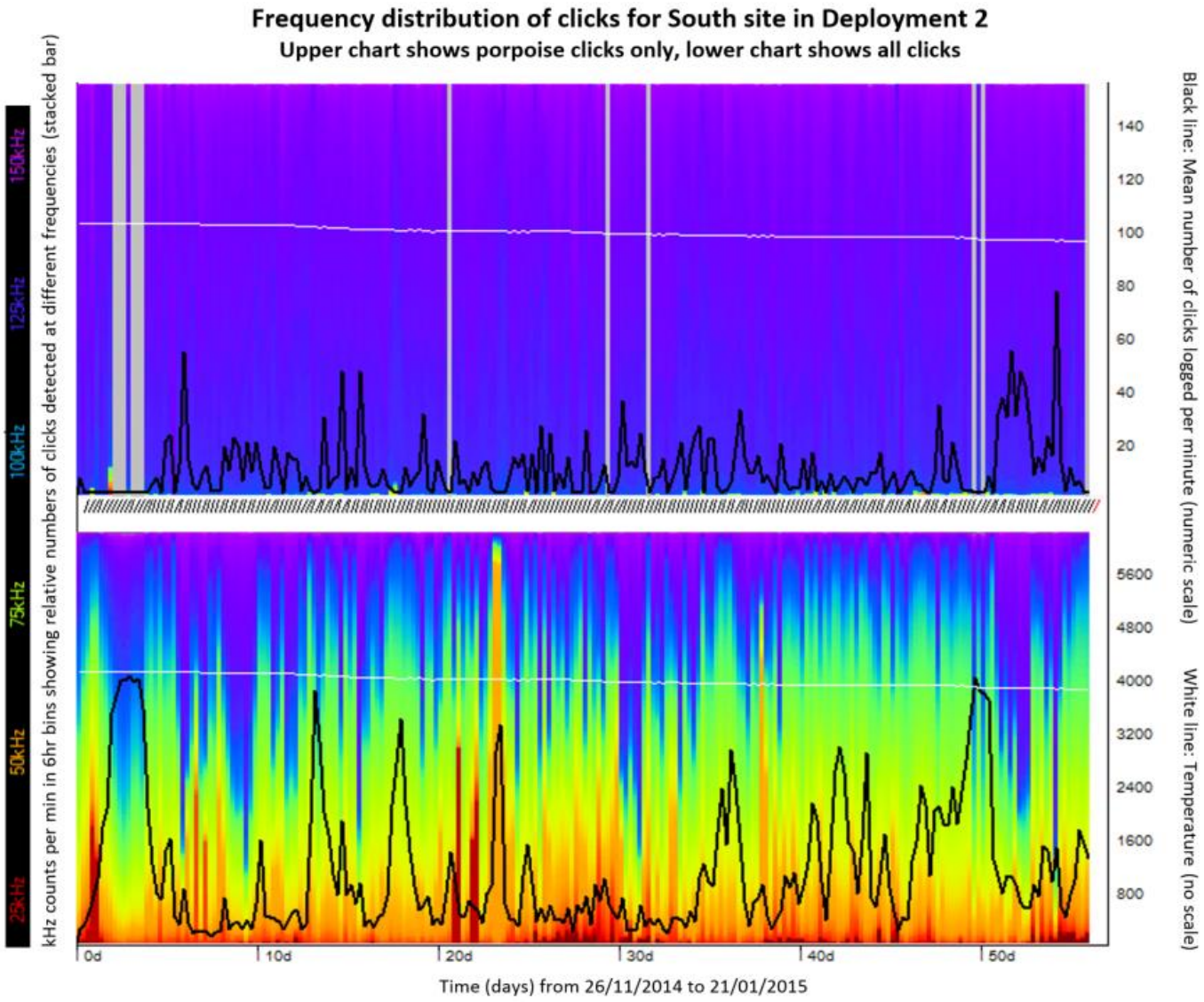

Figure 4-8: Porpoise Activity at South Site for Deployment 2

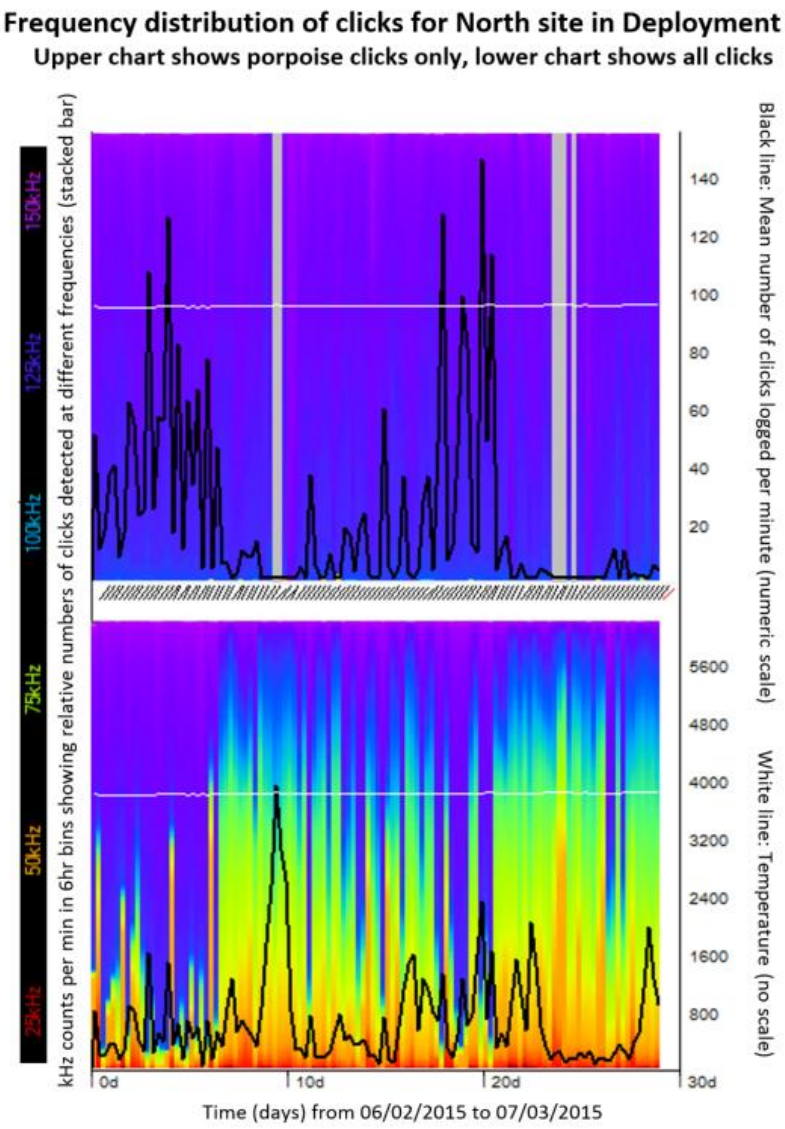

Figure 4-9: Porpoise Activity at North Site for Deployment 3

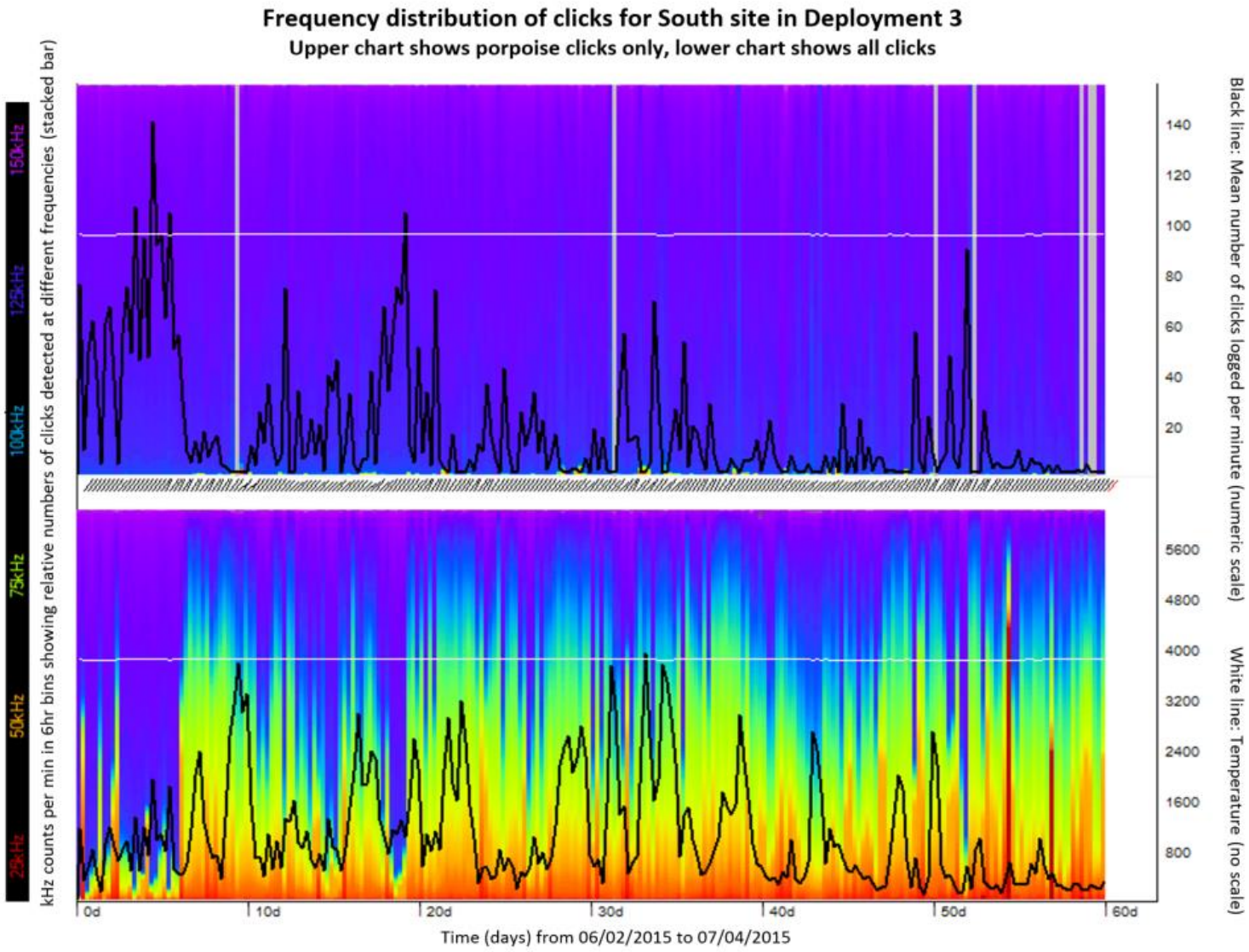

Figure 4-10: Porpoise Activity at South Site for Deployment 3

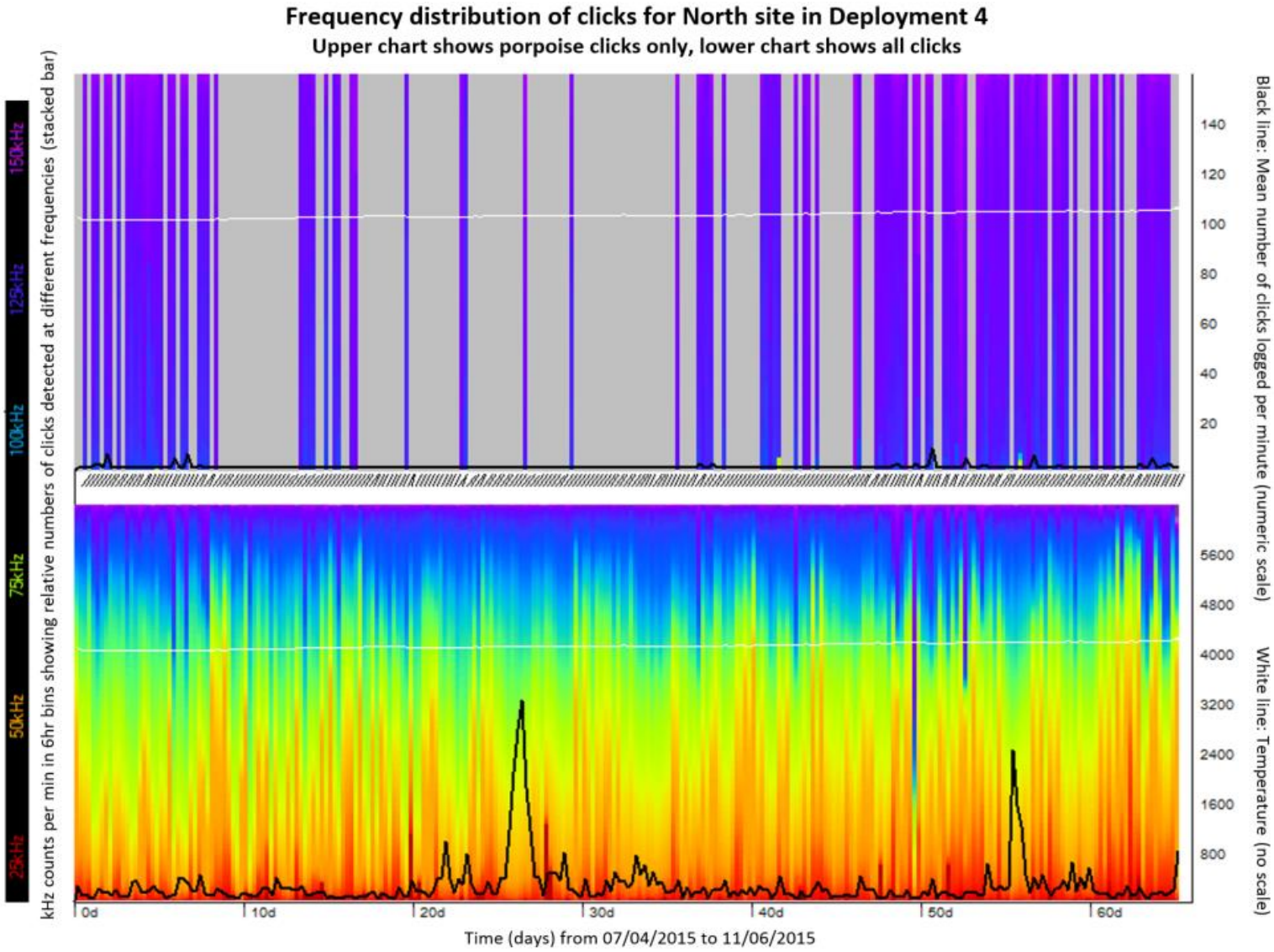

Figure 4-11: Porpoise Activity at North Site for Deployment 4

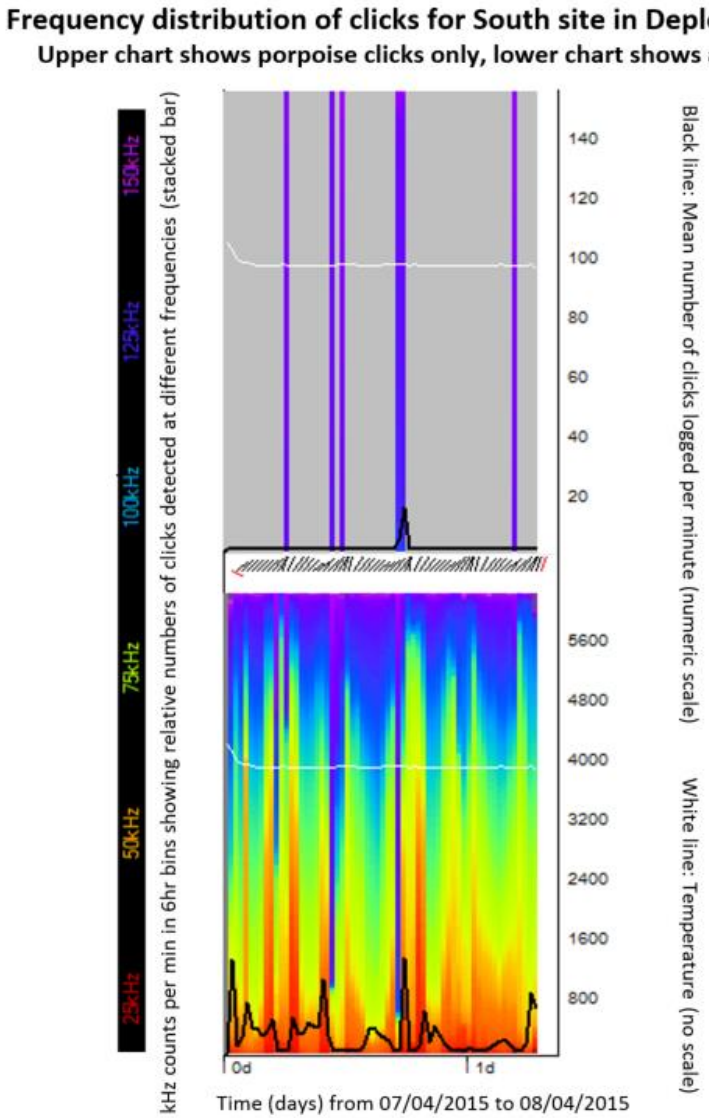

Figure 4-12: Porpoise Activity at South Site for Deployment 4

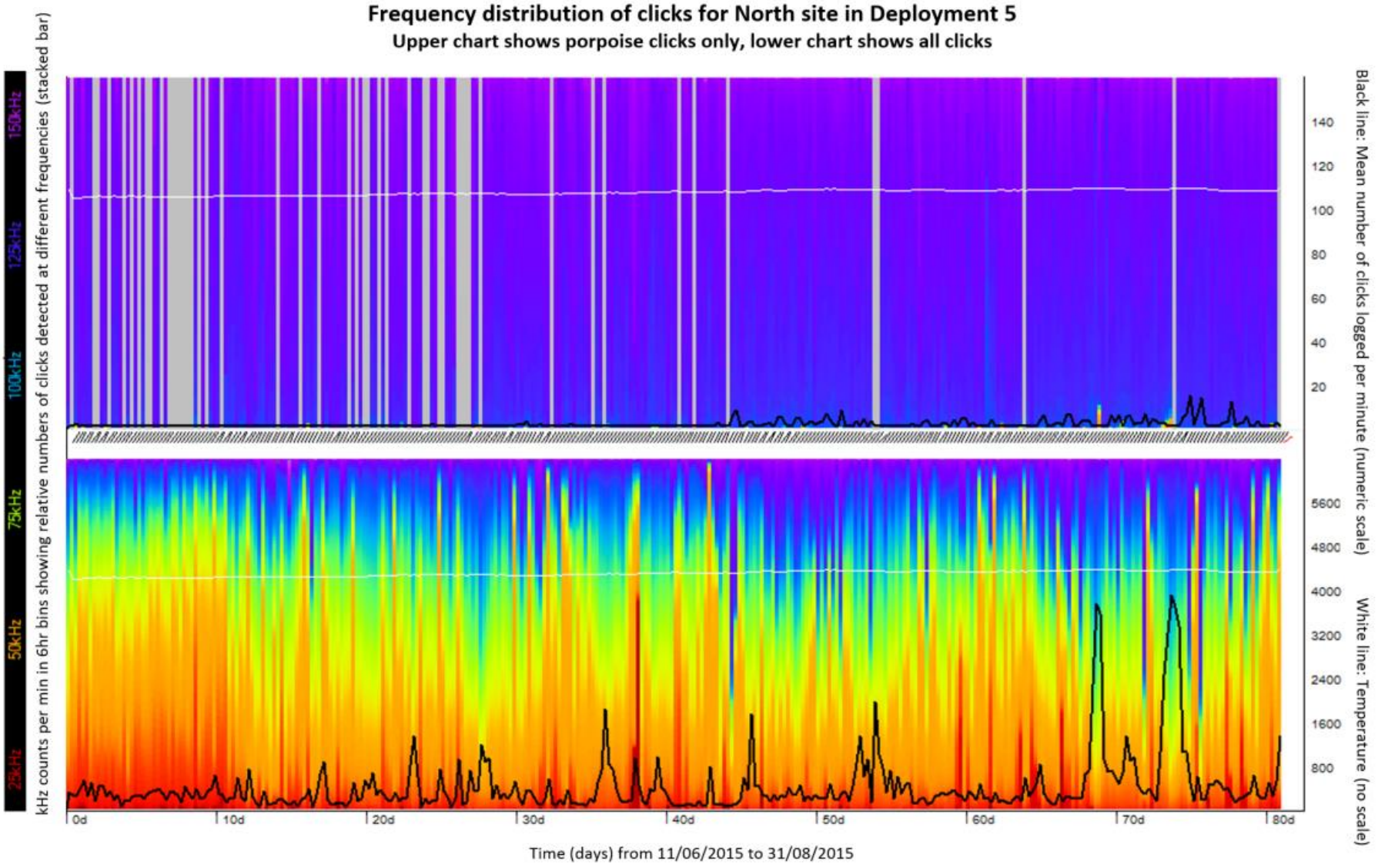

Figure 4-13: Porpoise Activity at North Site for Deployment 5

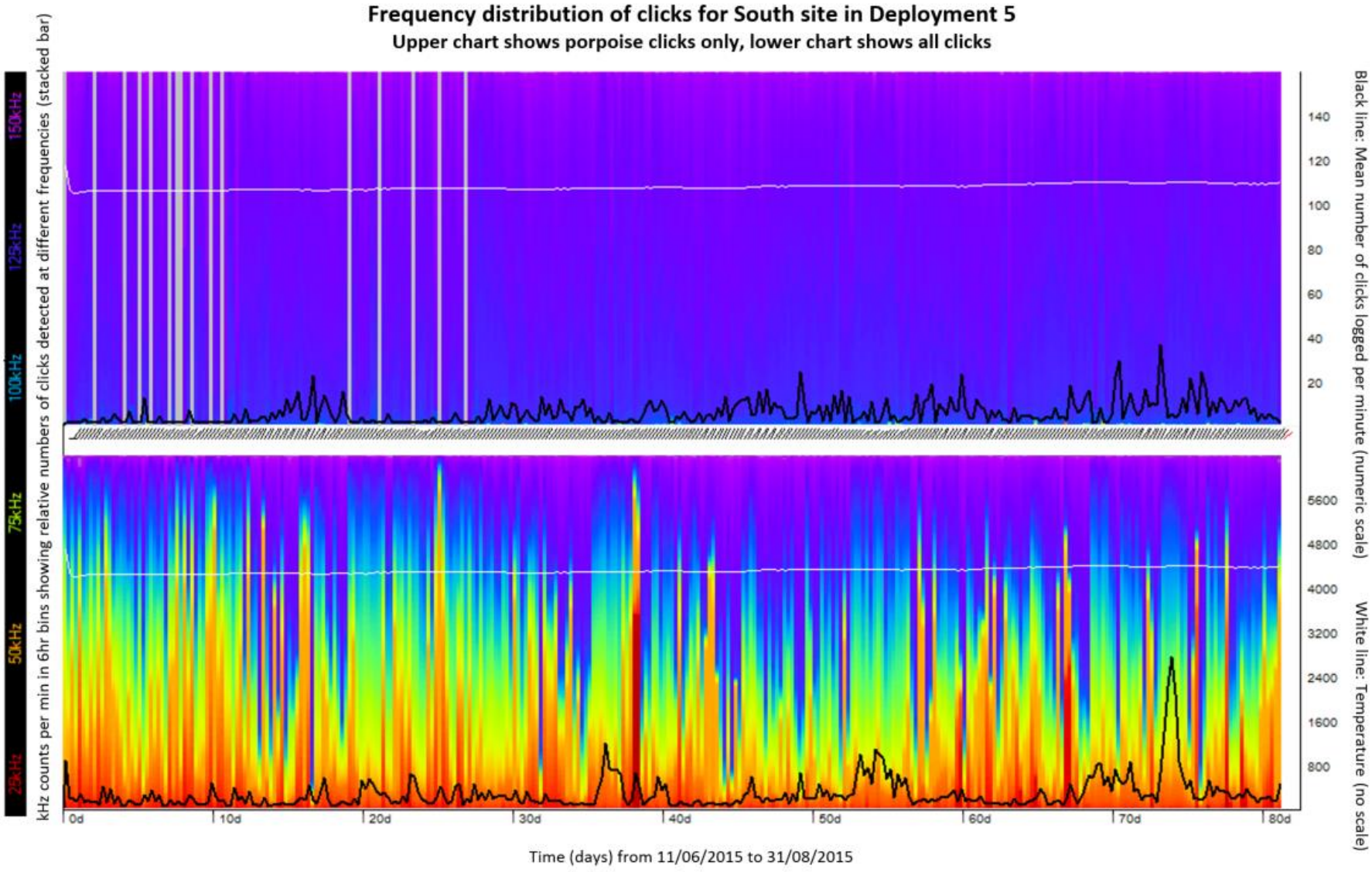

Figure 4-14: Porpoise Activity at South Site for Deployment 5

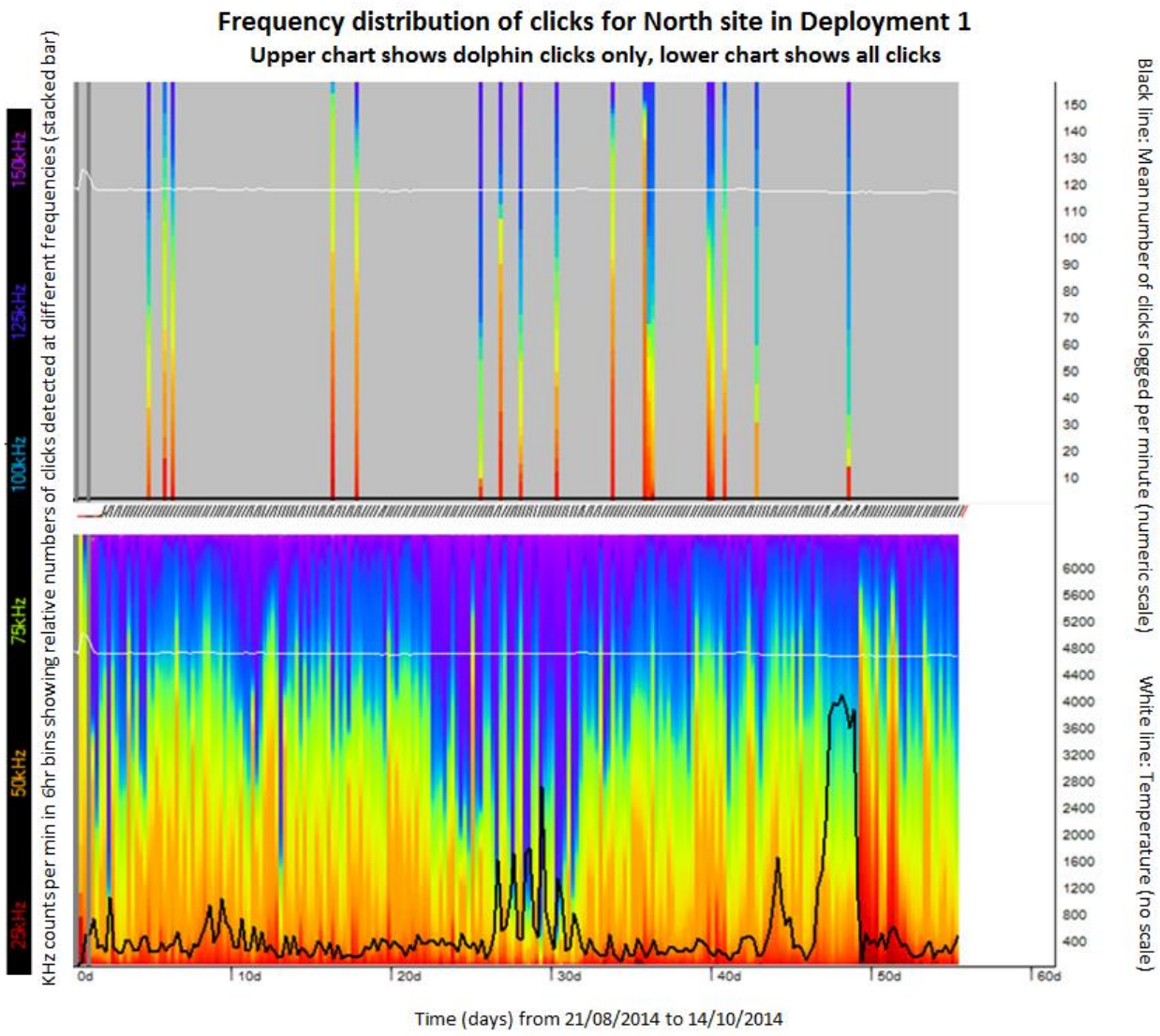

Figure 4-15: Dolphin Activity at North Site for Deployment 1

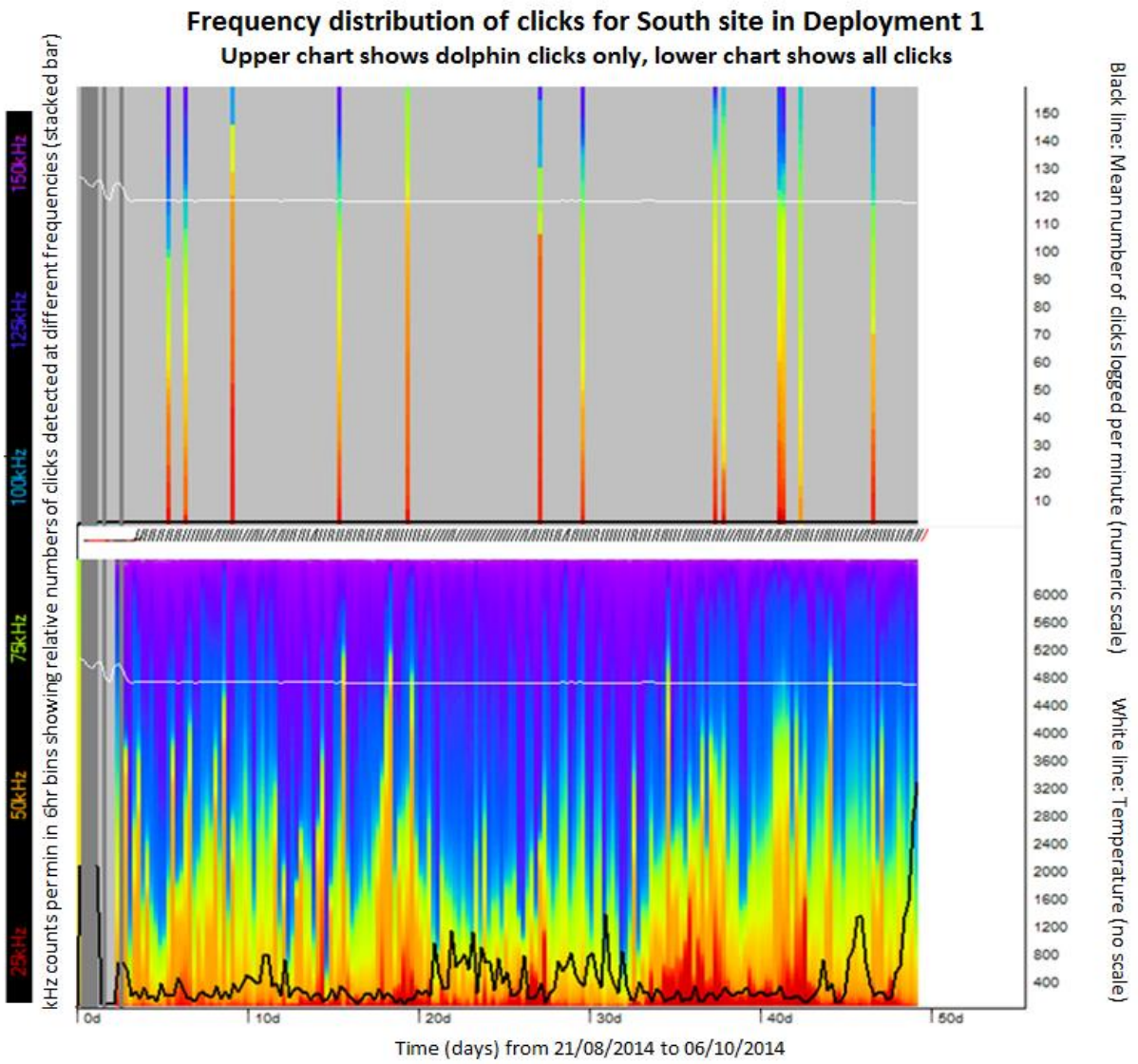

Figure 4-16: Dolphin Activity at South Site for Deployment 1

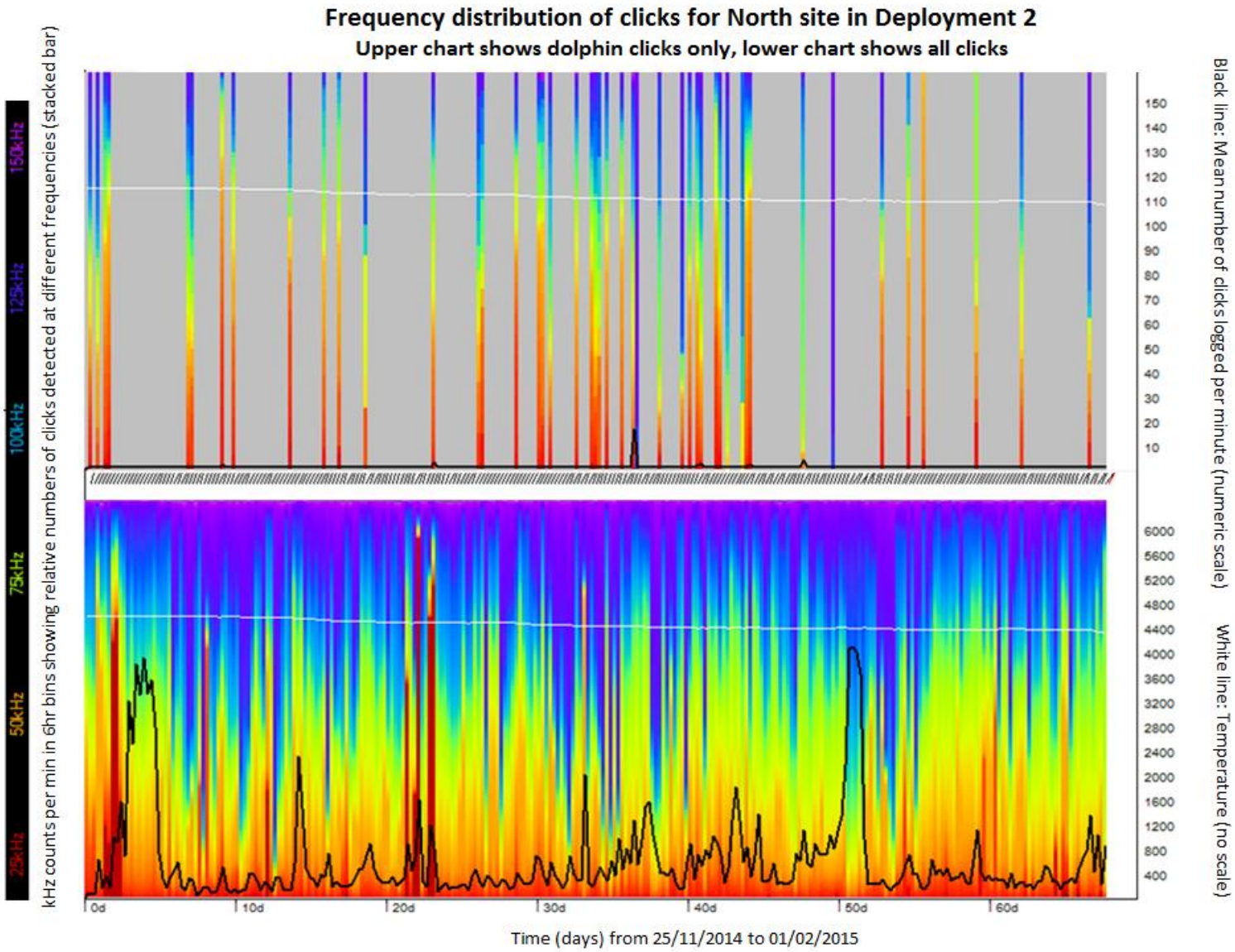

Figure 4-17: Dolphin Activity at North Site for Deployment 2

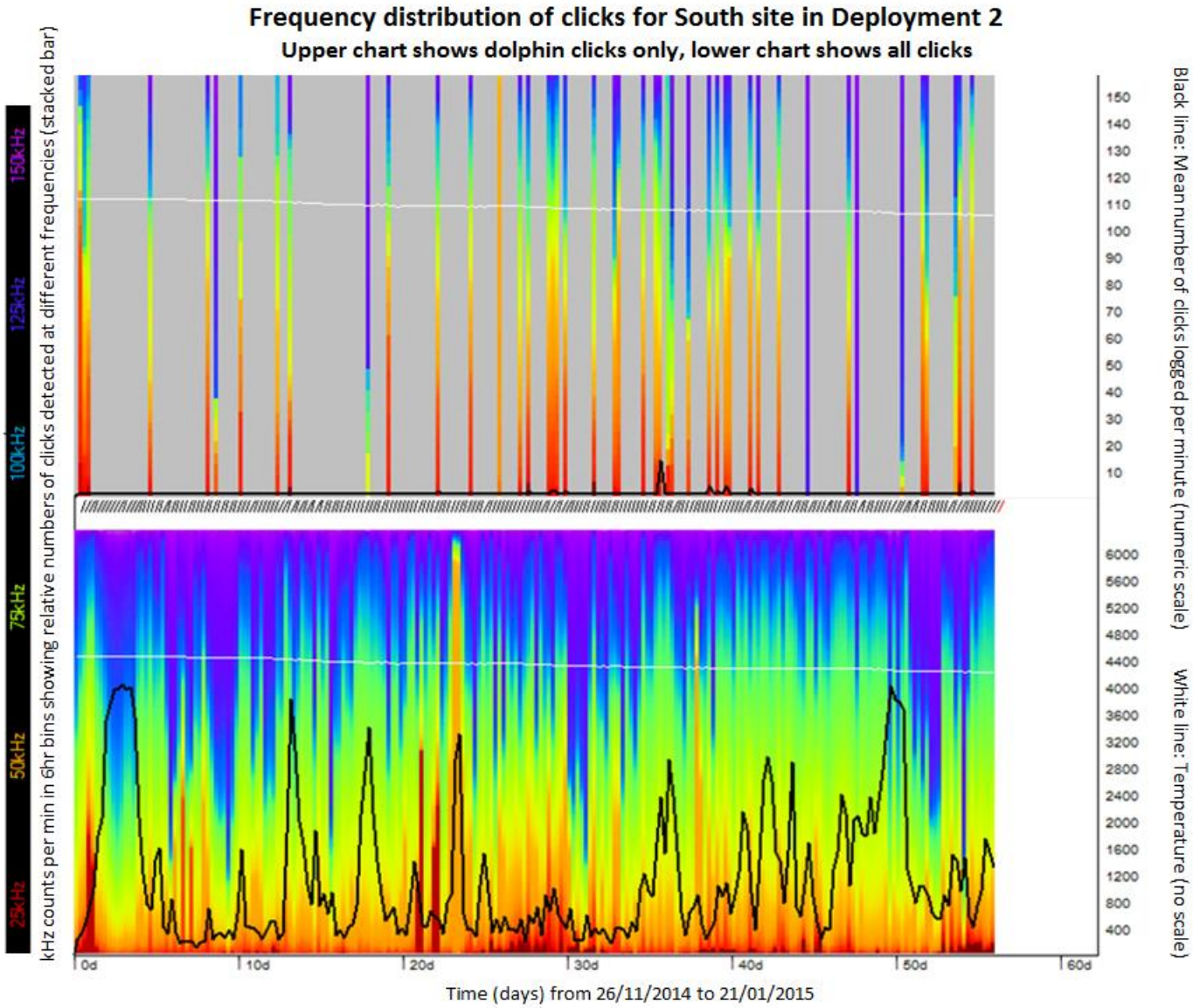

Figure 4-18: Dolphin Activity at South Site for Deployment 2

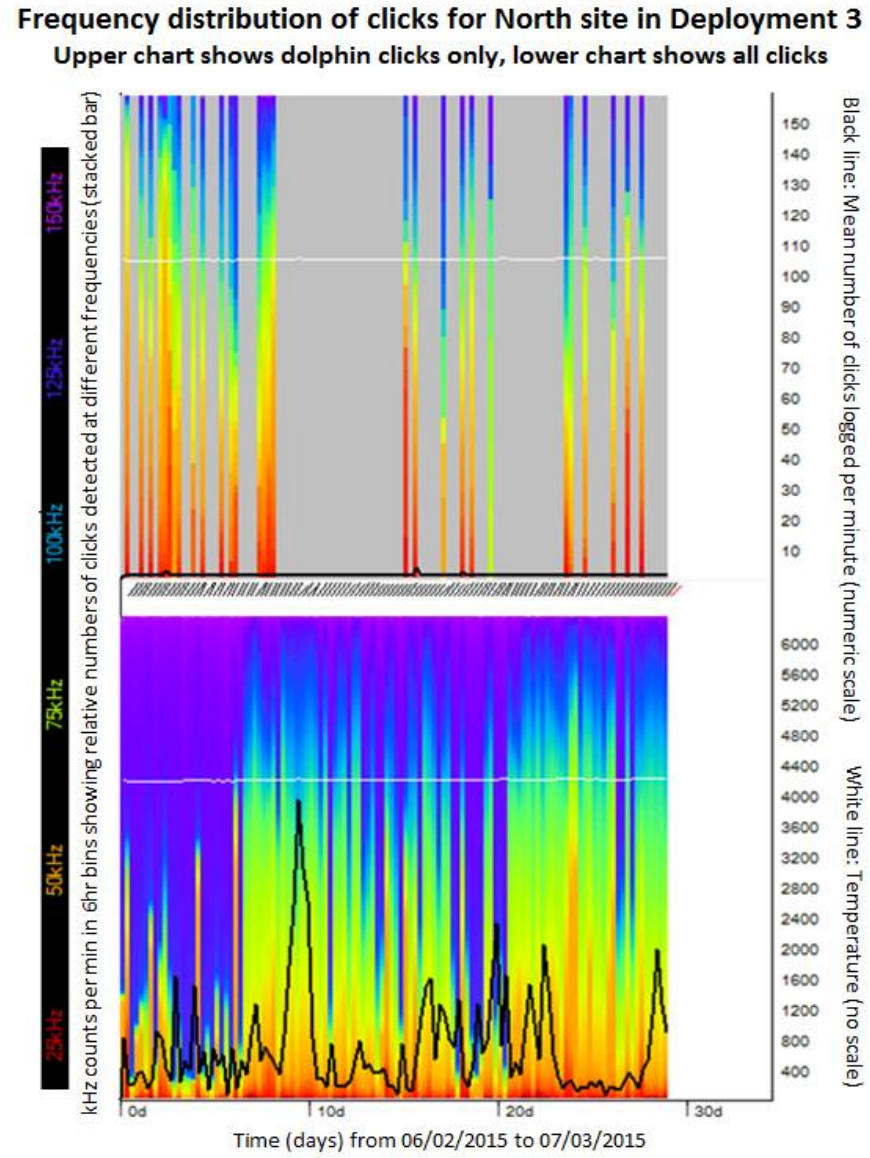

Figure 4-19: Dolphin Activity at North Site for Deployment 3

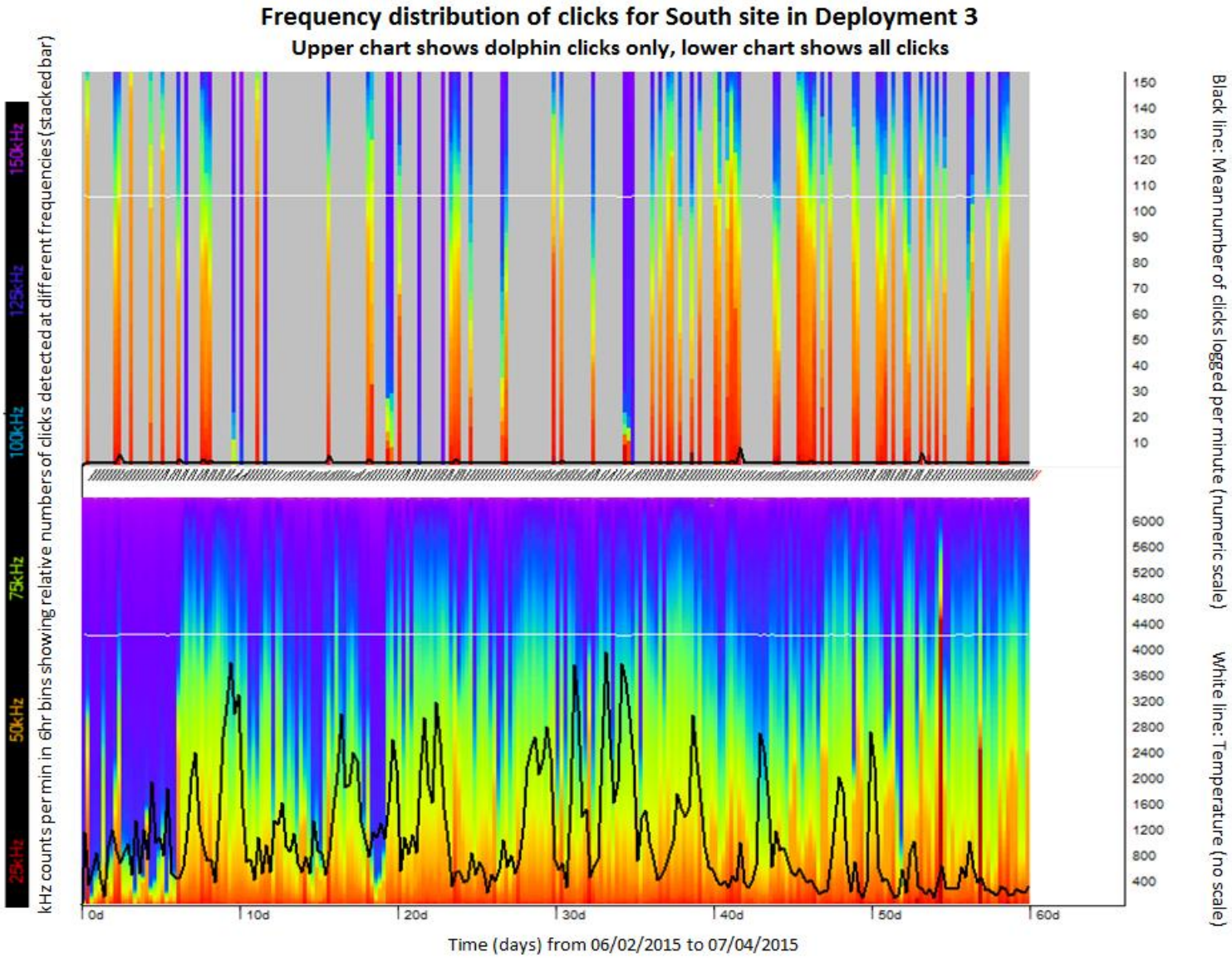

Figure 4-20: Dolphin Activity at South Site for Deployment 3

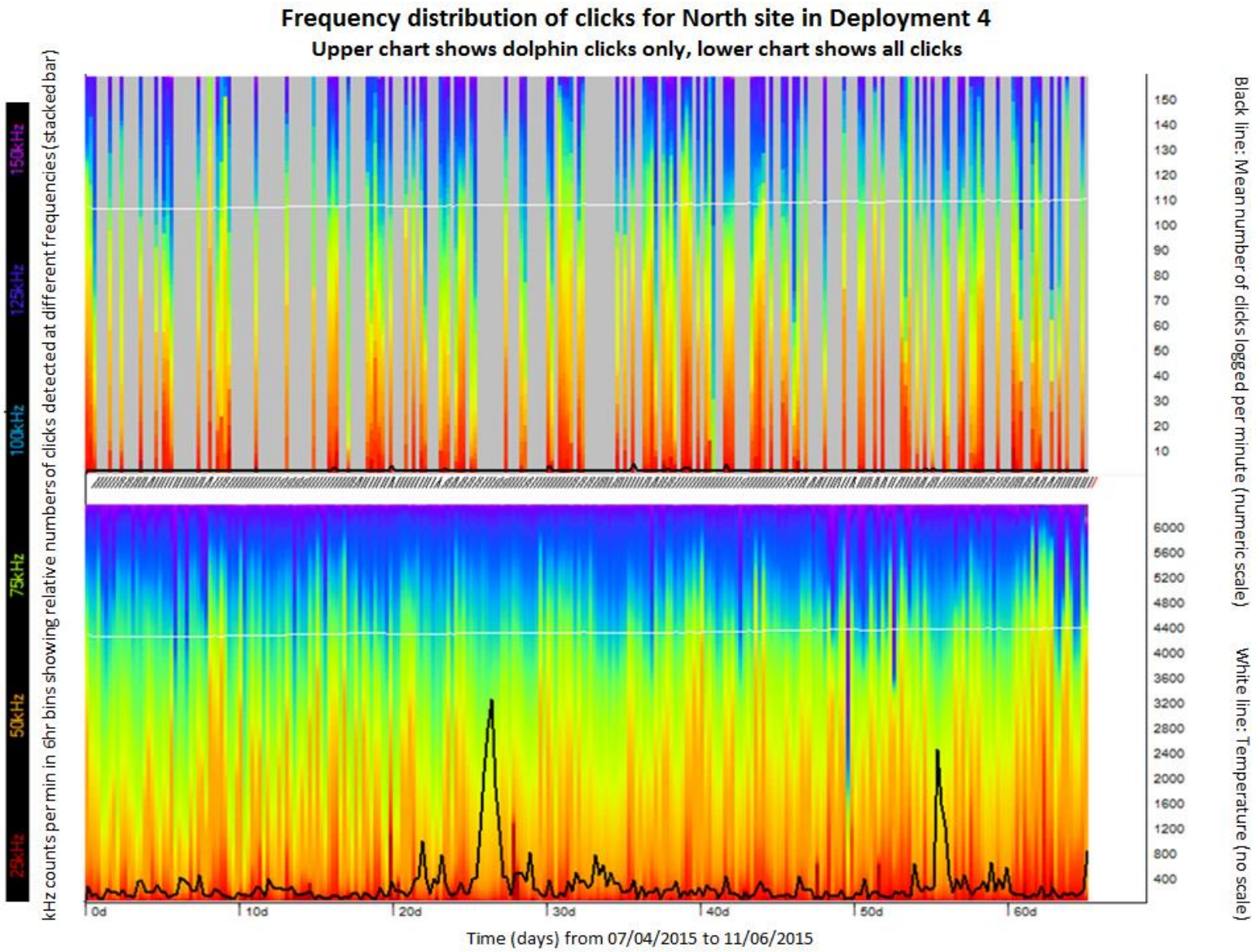

Figure 4-21: Dolphin Activity at North Site for Deployment 4

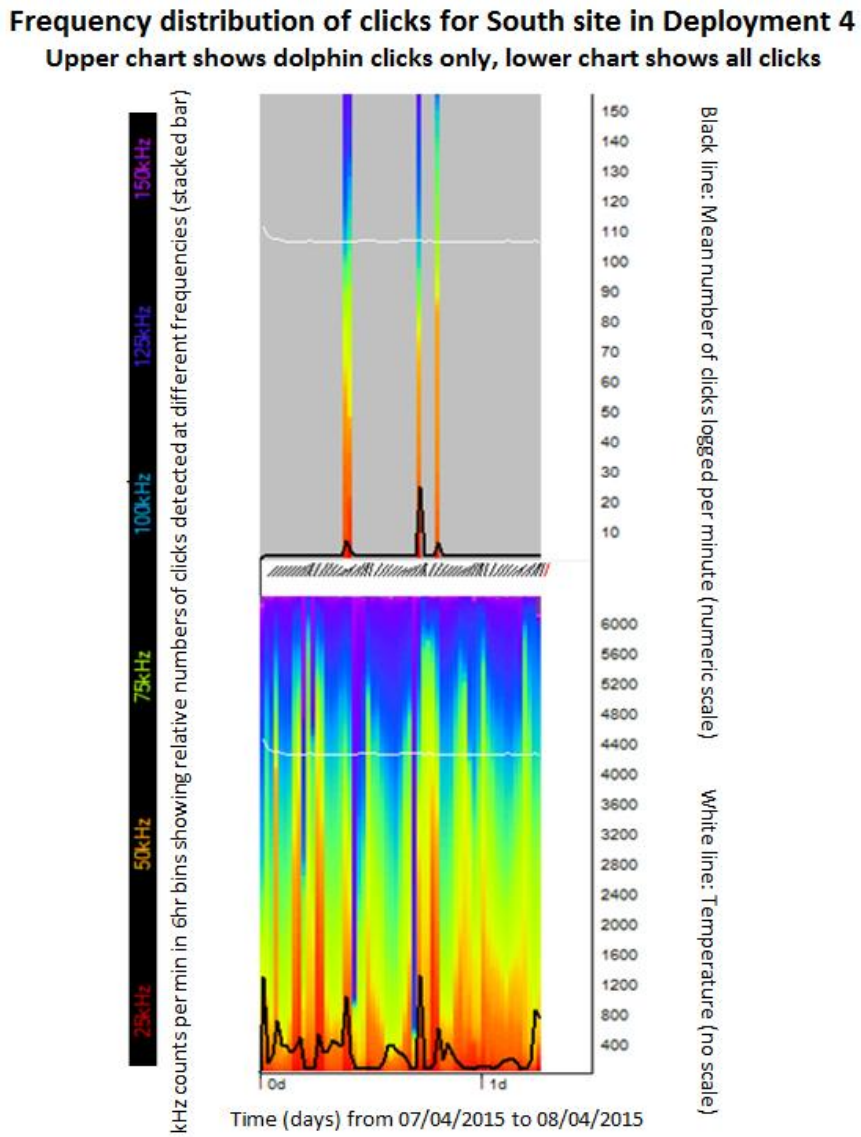

Figure 4-22: Dolphin Activity at South Site for Deployment 4

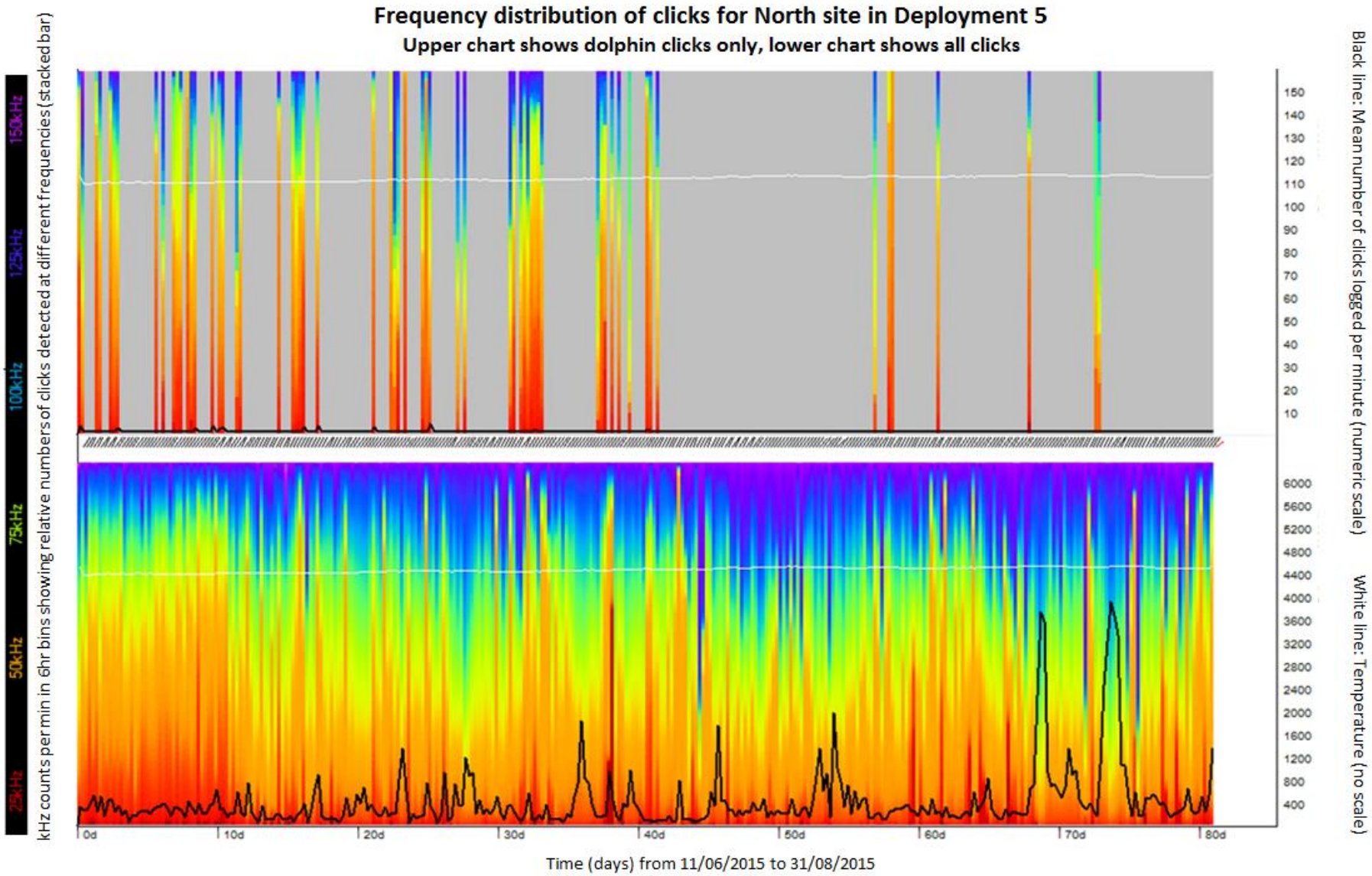

Figure 4-23: Dolphin Activity at North Site for Deployment 5

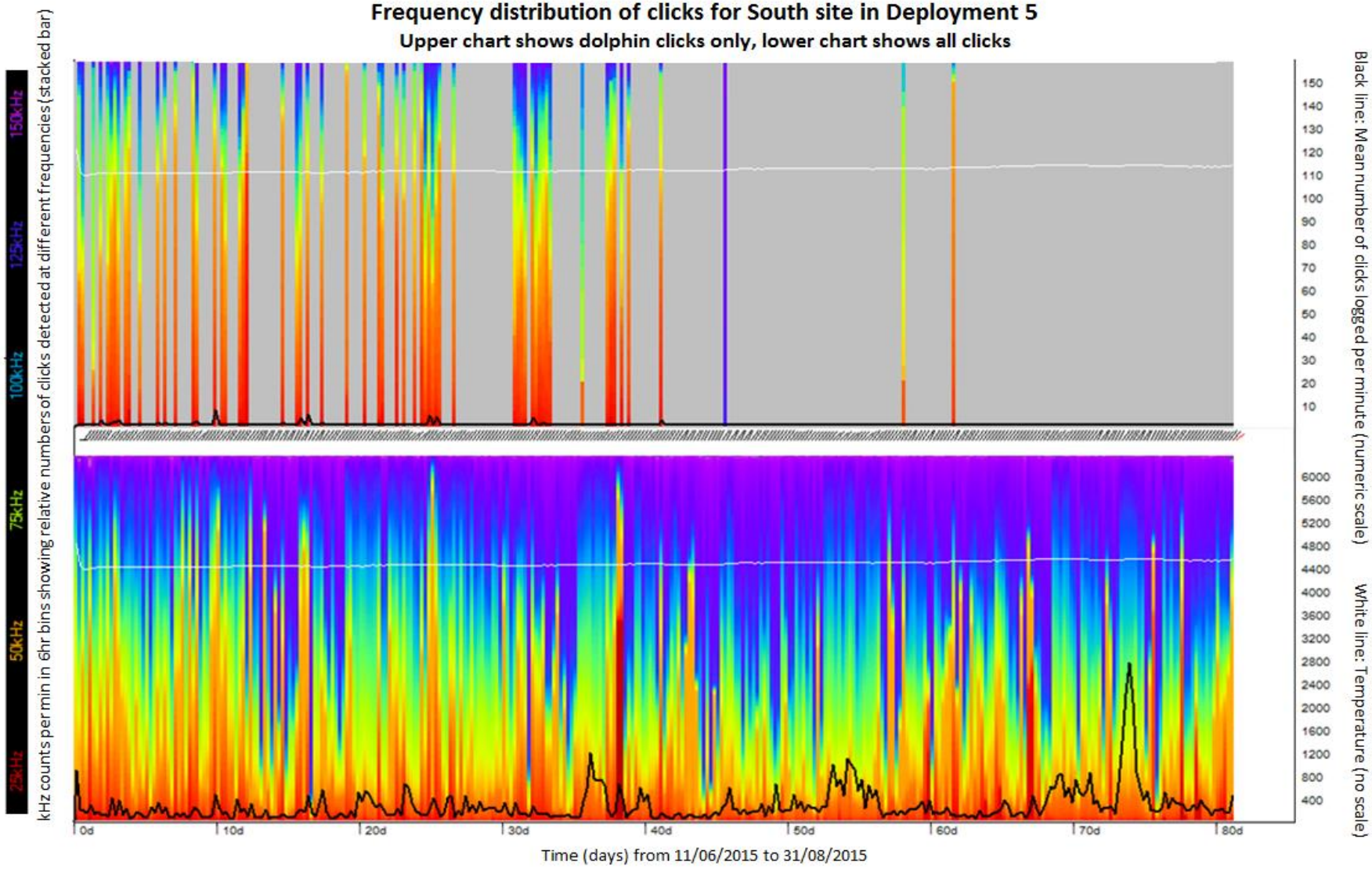

Figure 4-24: Dolphin Activity at South Site for Deployment 5

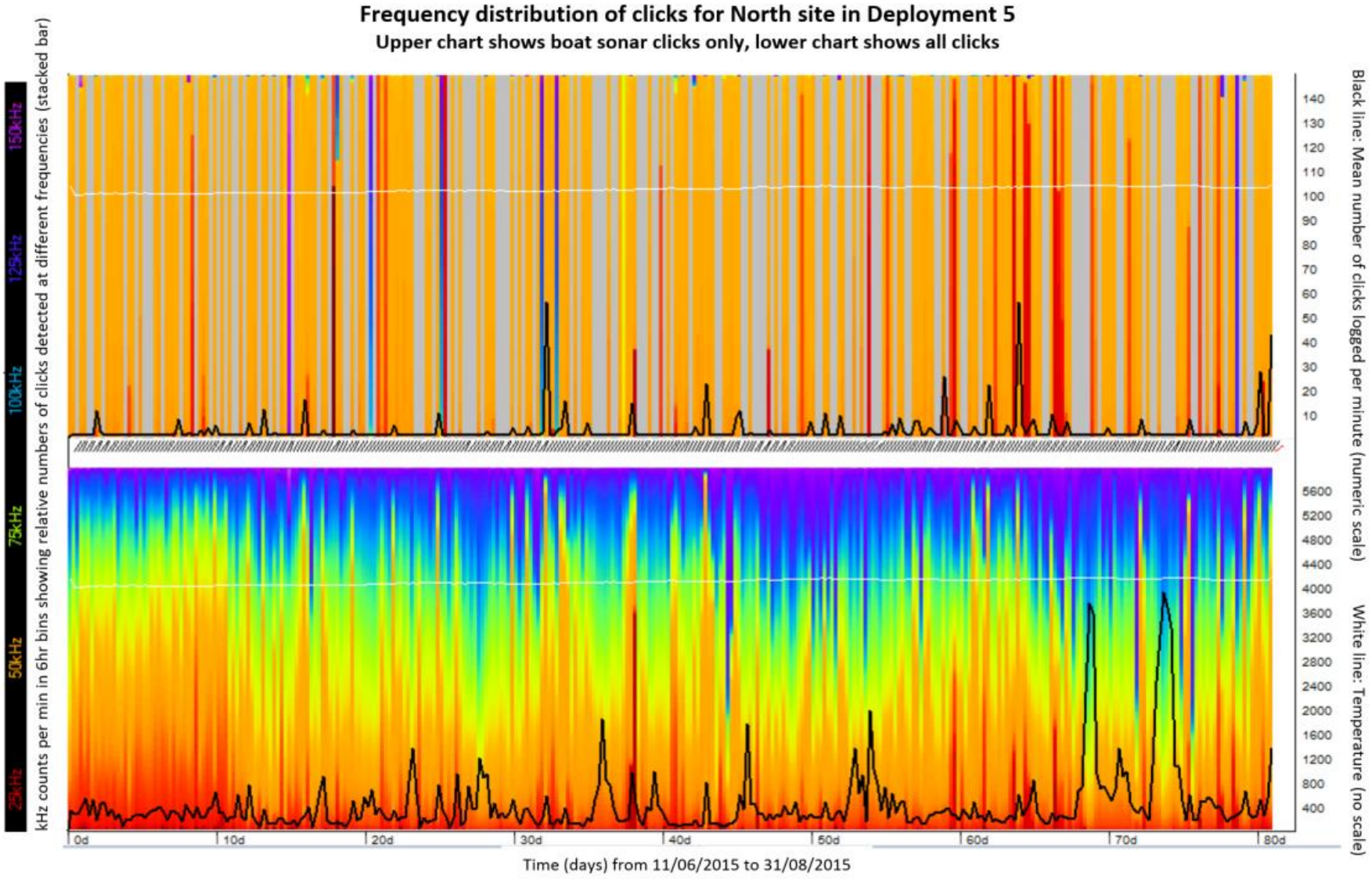

Figure 4-25: Example of Boat Sonar Detections from Deployment 5 at North Site

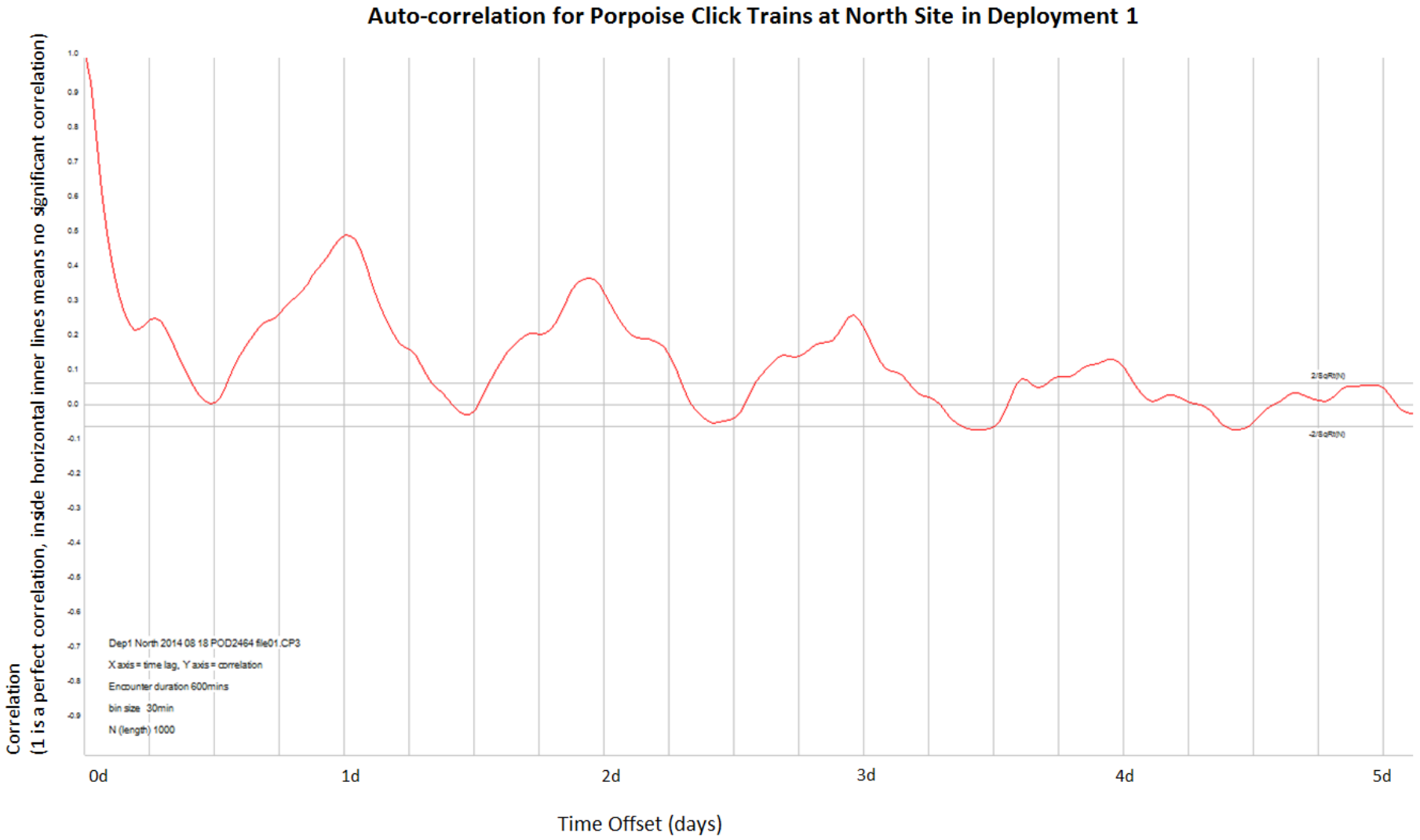

Figure 4-26: Auto-correlation for porpoise detections at North site deployment 1

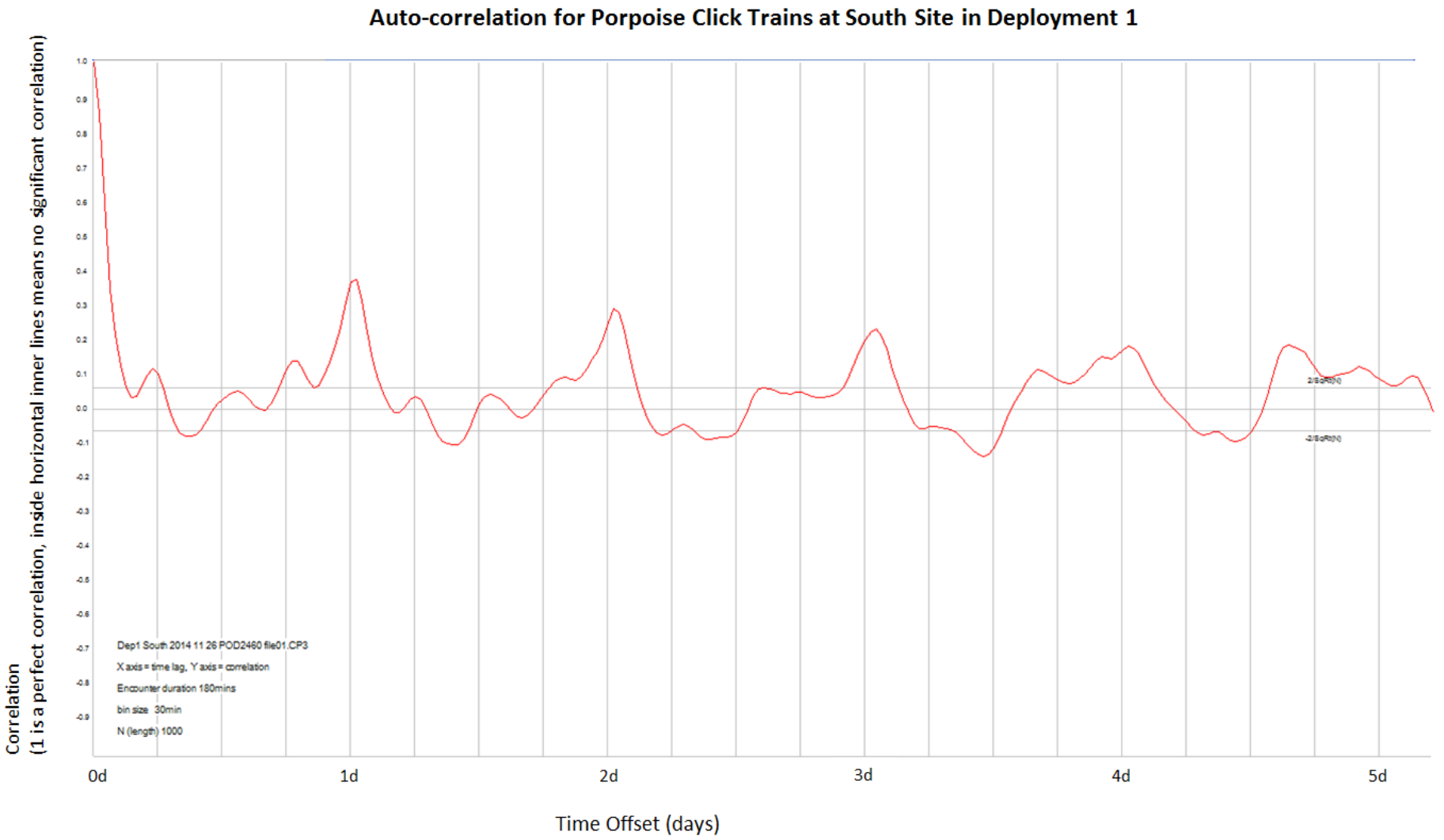

Figure 4-27: Auto-correlation for porpoise detections at South site deployment 1

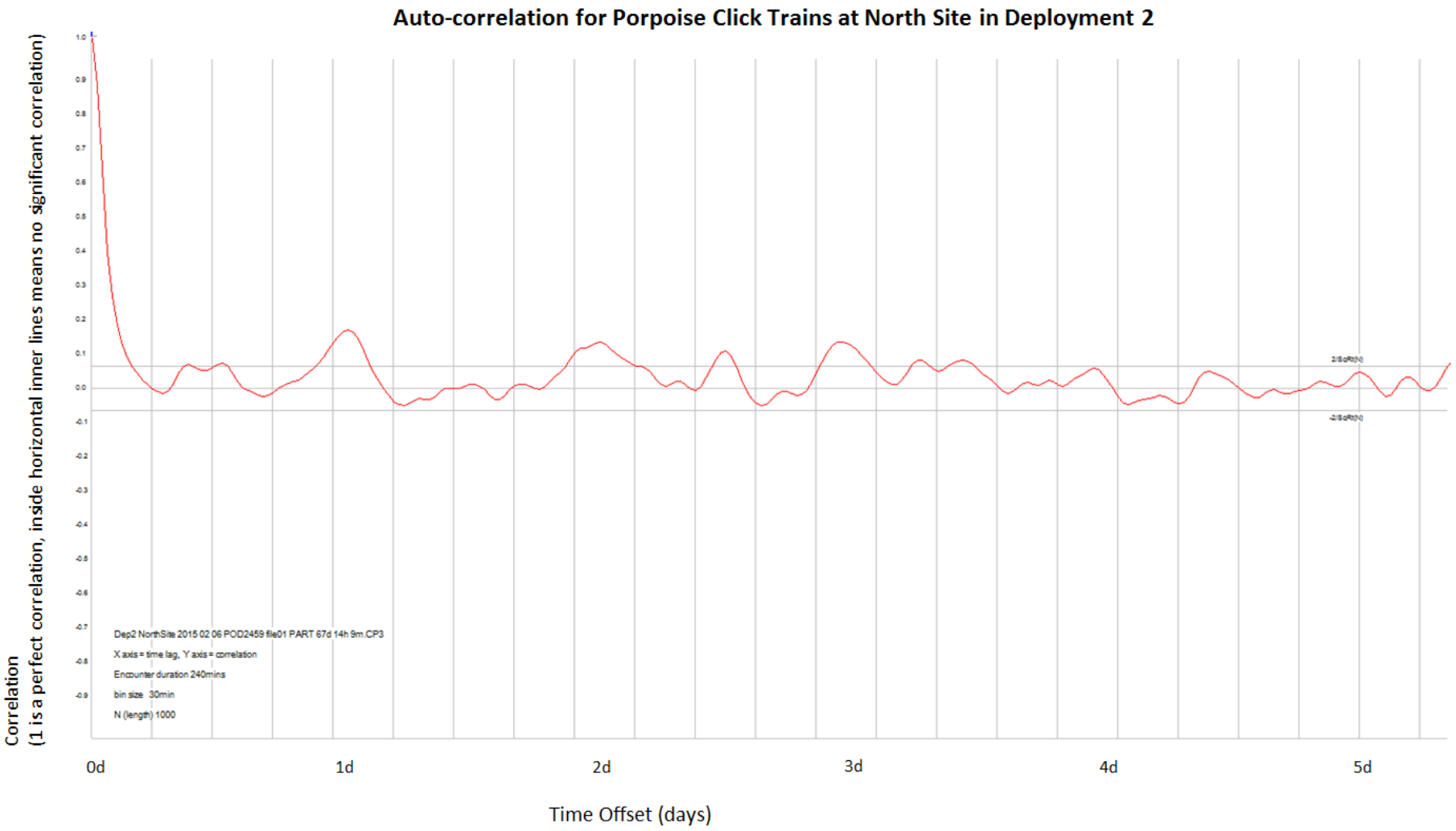

Figure 4-28: Auto-correlation for porpoise detections at North site deployment 2

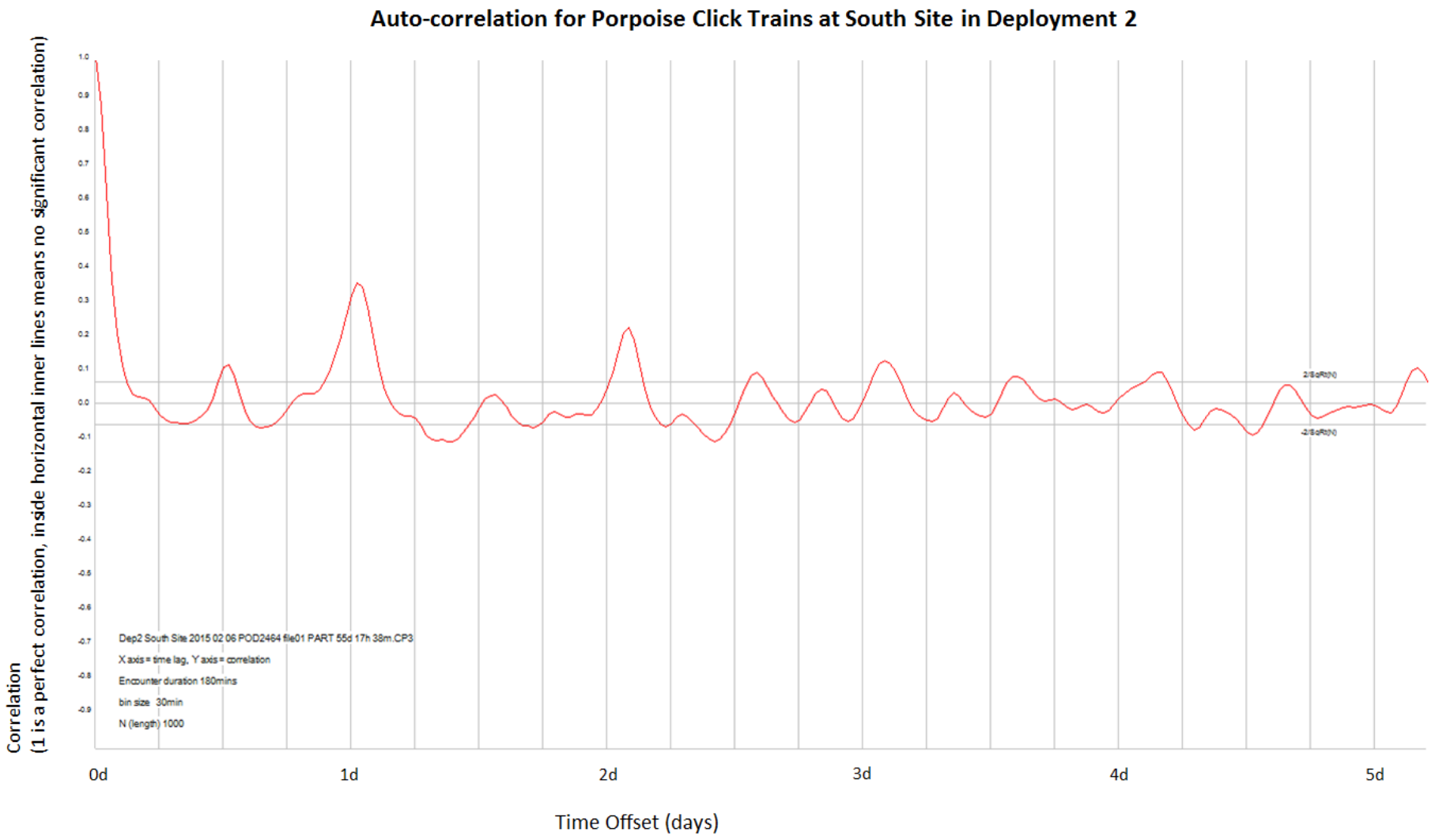

Figure 4-29: Auto-correlation for porpoise detections at South site deployment 2

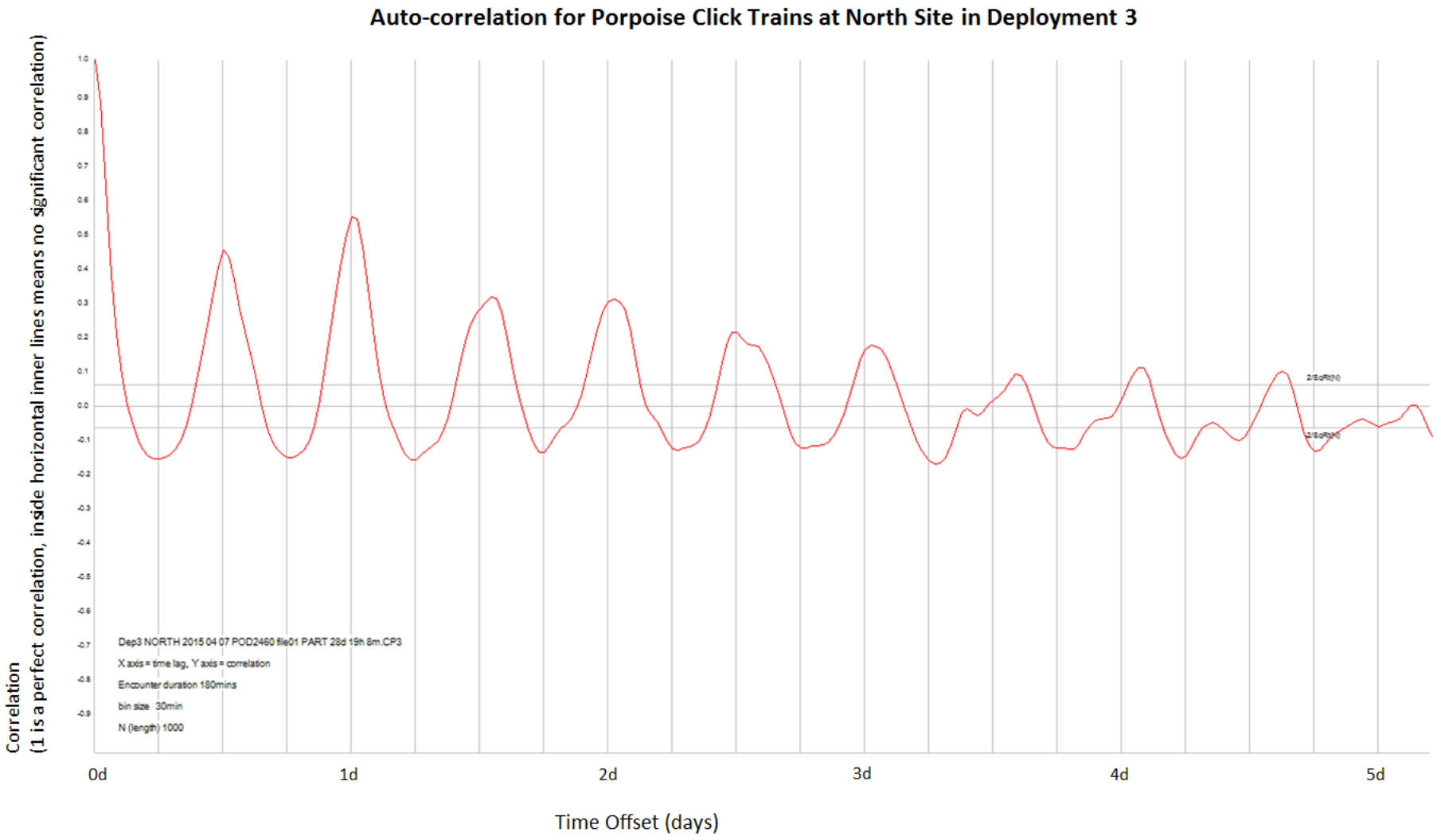

Figure 4-30: Auto-correlation for porpoise detections at North site deployment 3

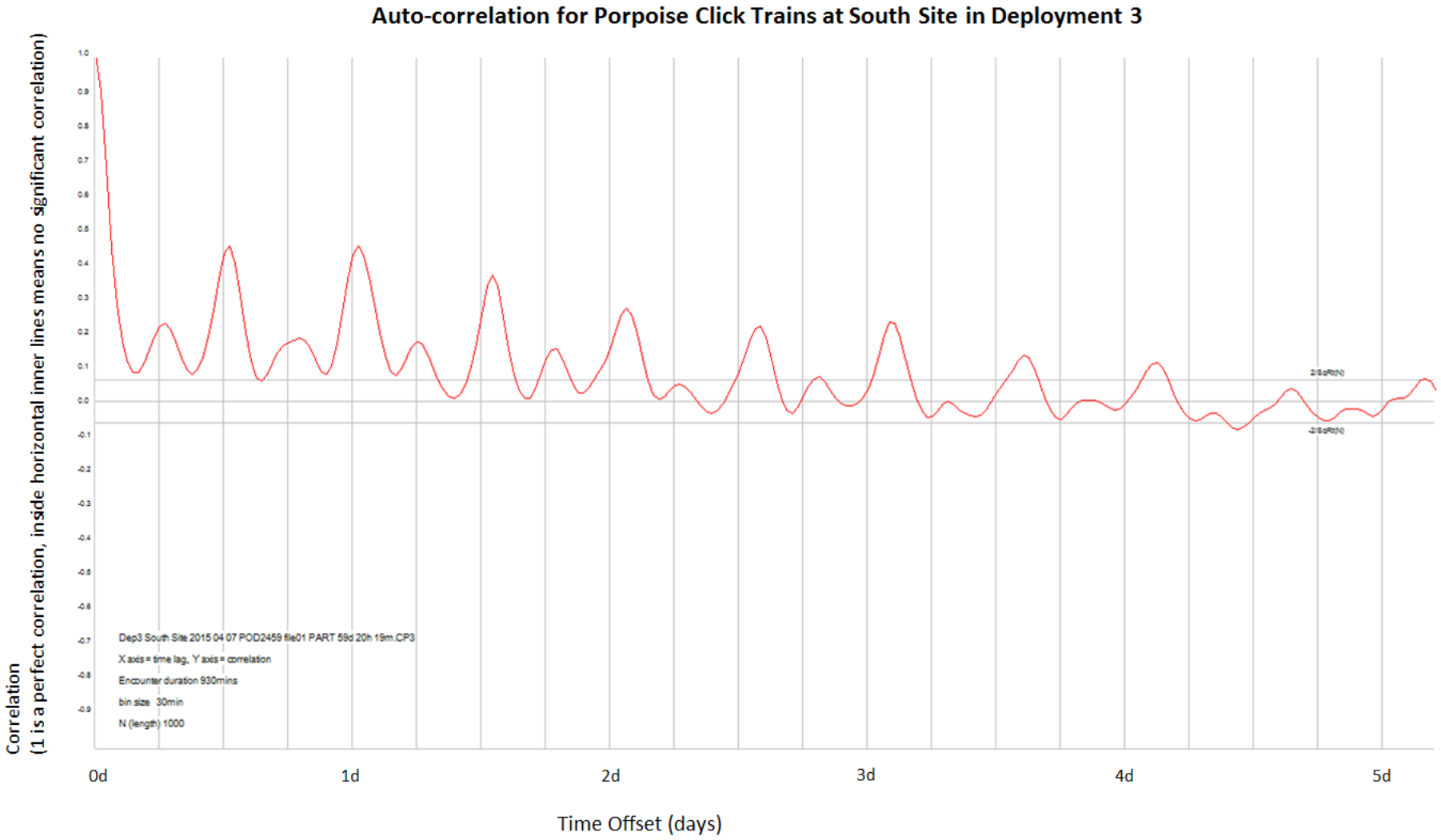

Figure 4-31: Auto-correlation for porpoise detections at South site deployment 3

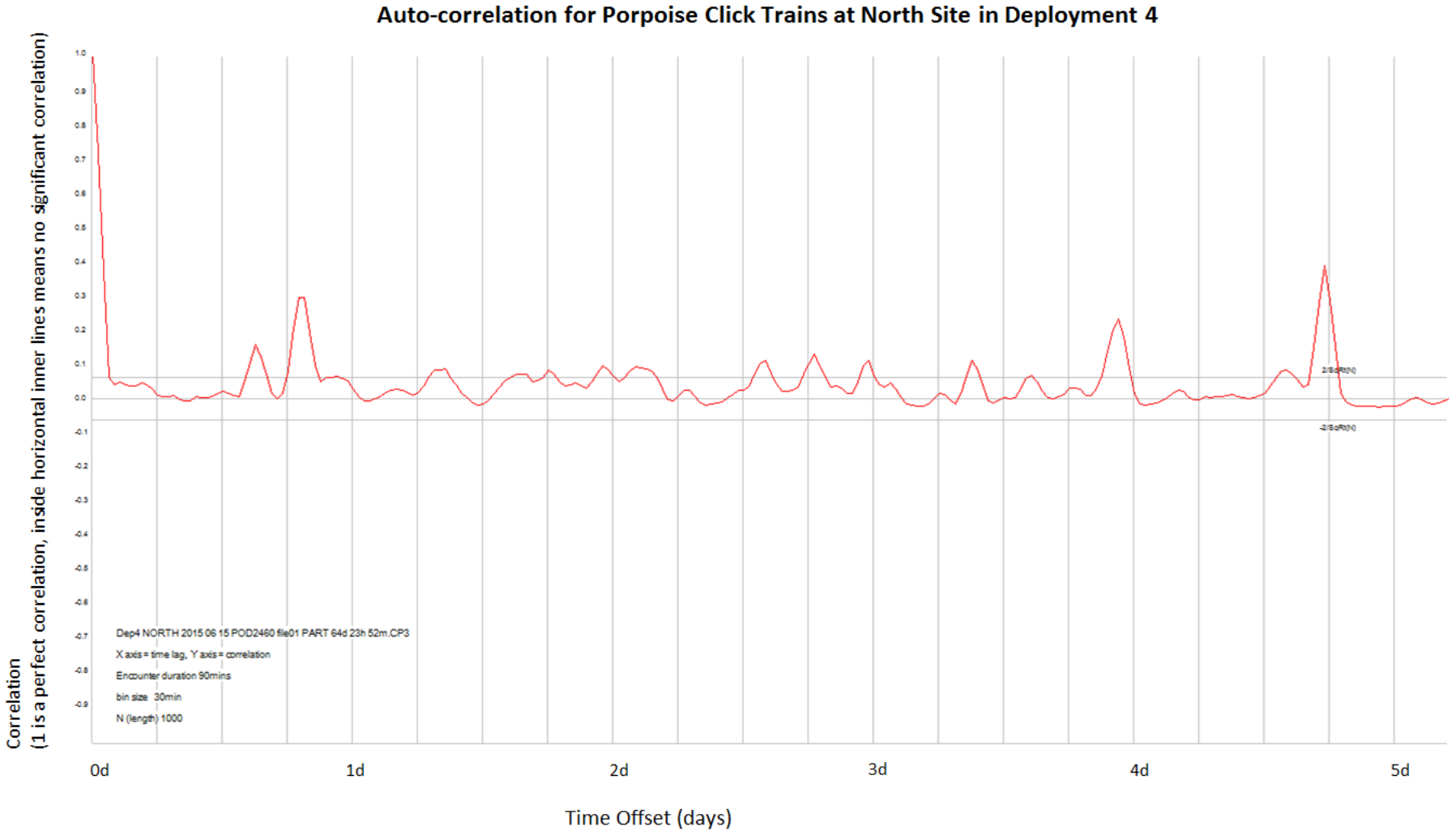

Figure 4-32: Auto-correlation for porpoise detections at North site deployment 4

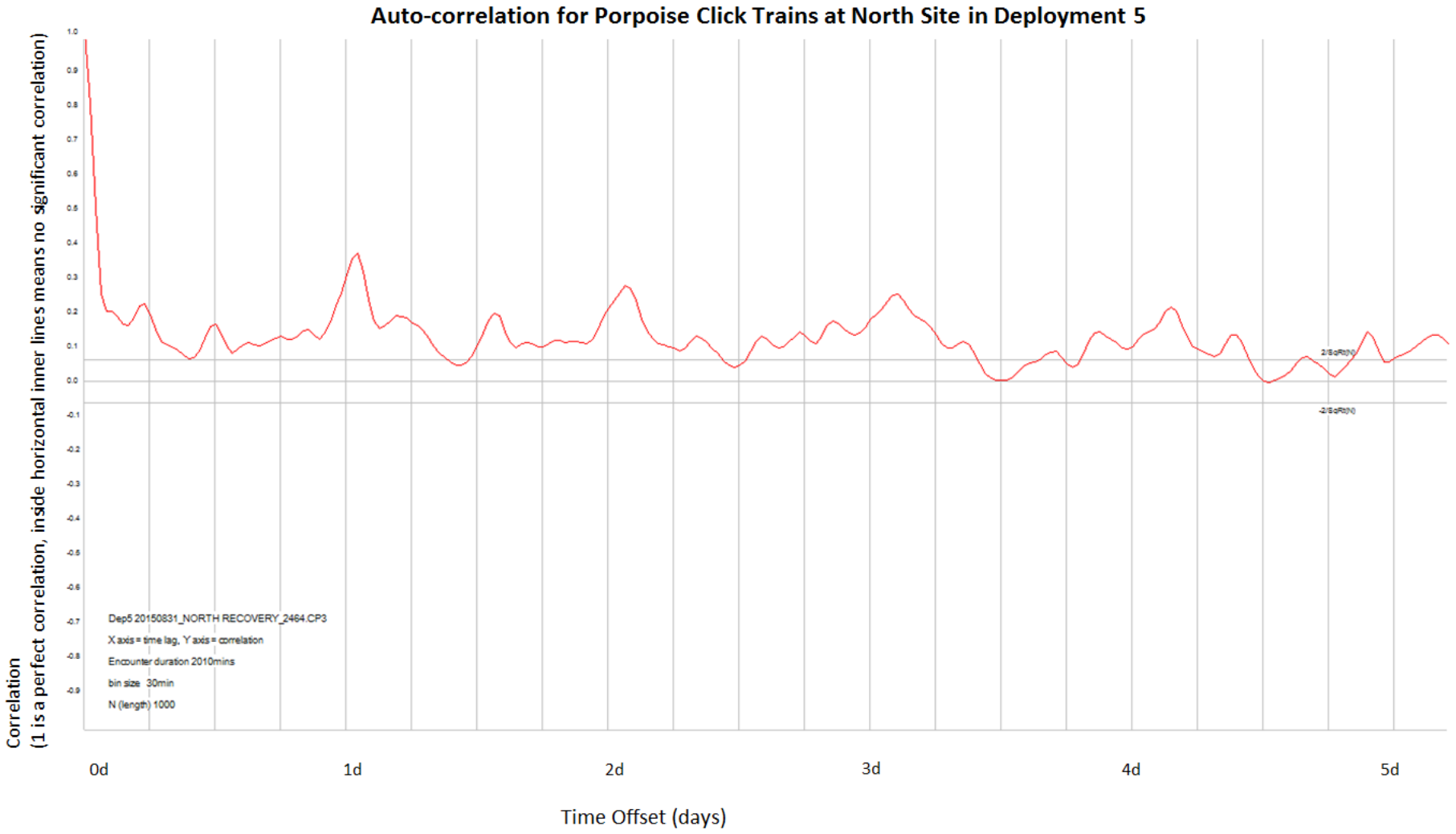

Figure 4-33: Auto-correlation for porpoise detections at North site deployment 5

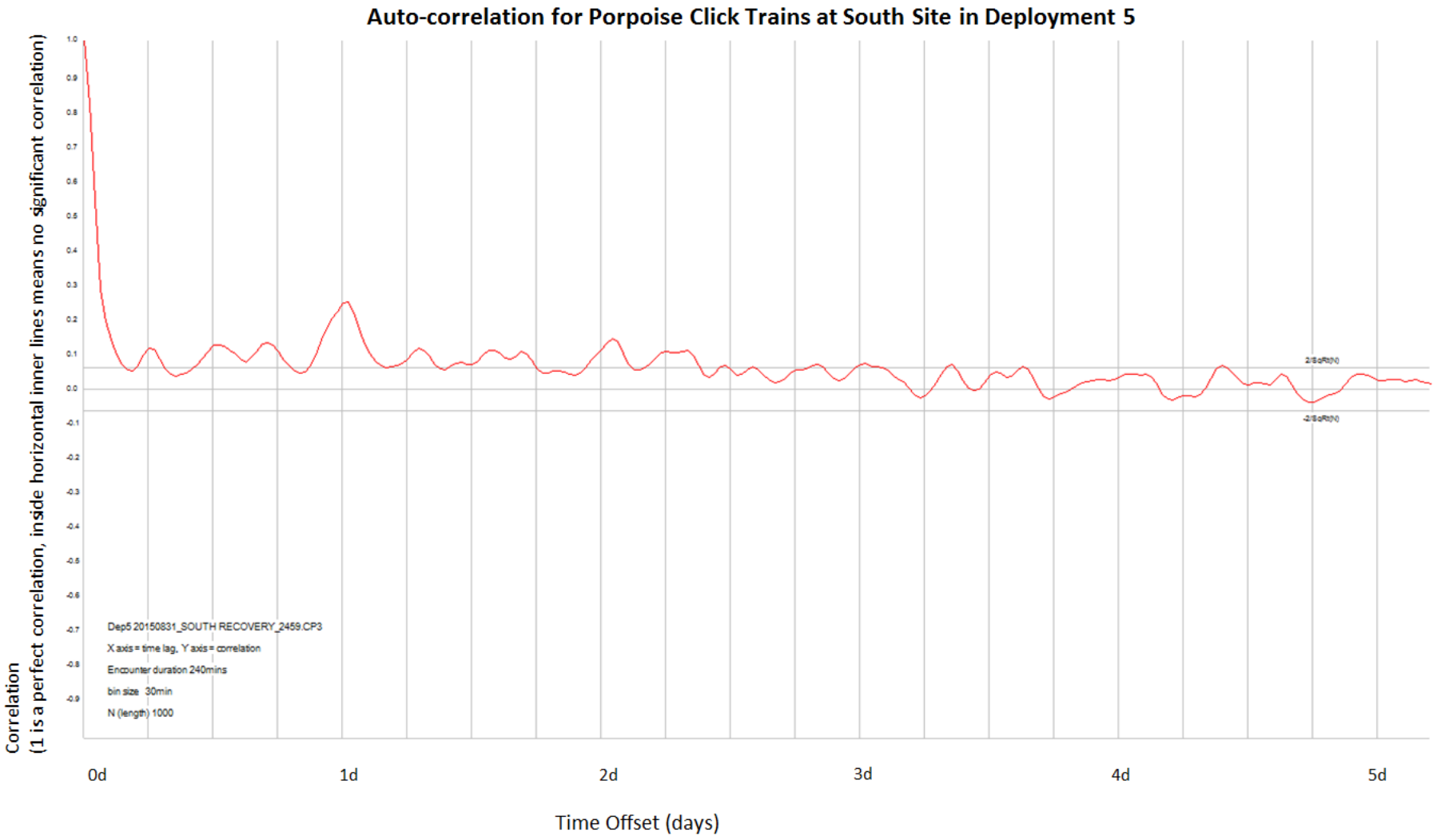

Figure 4-34: Auto-correlation for porpoise detections at South site deployment 5

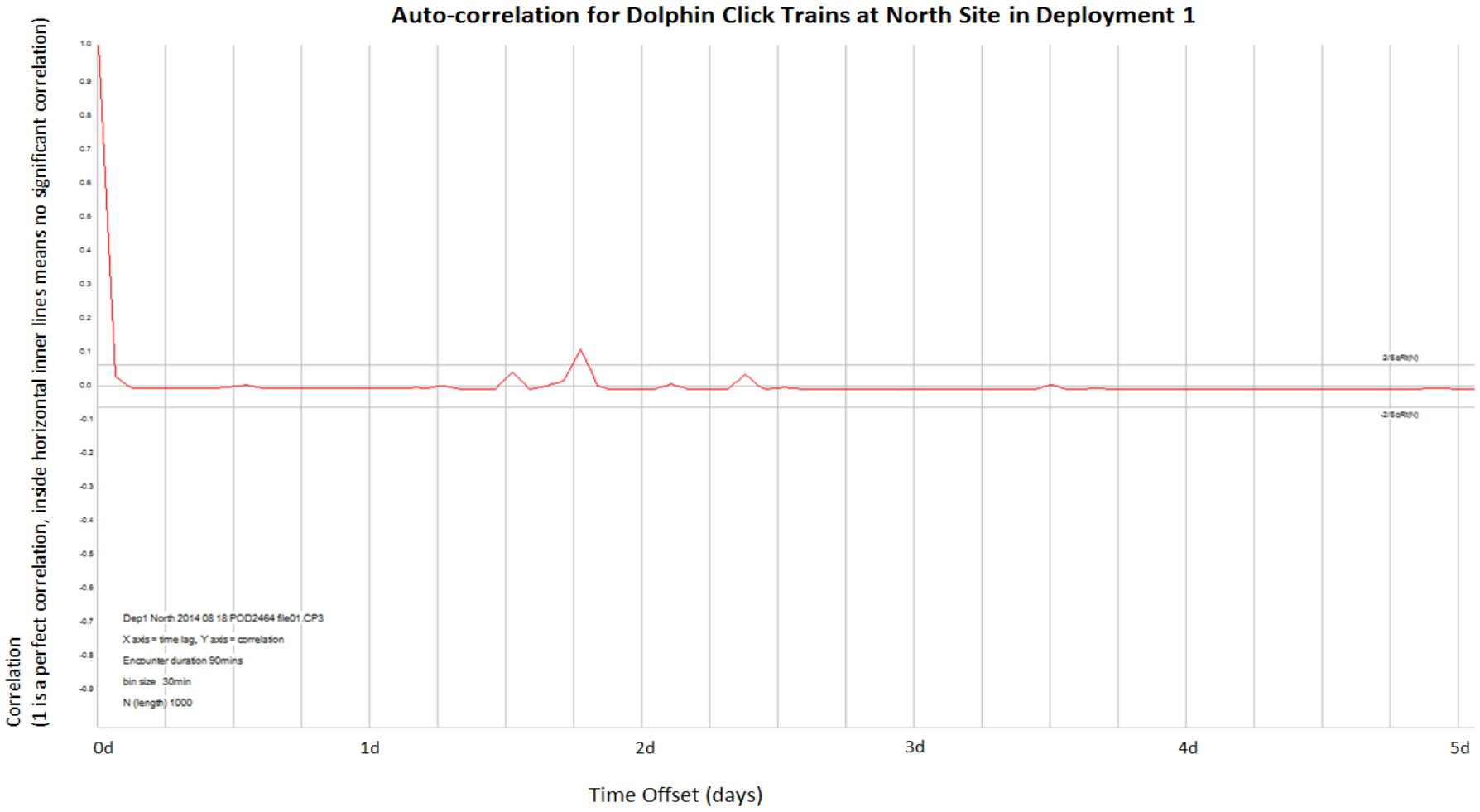

Figure 4-35: Auto-correlation for dolphin detections at North site deployment 1

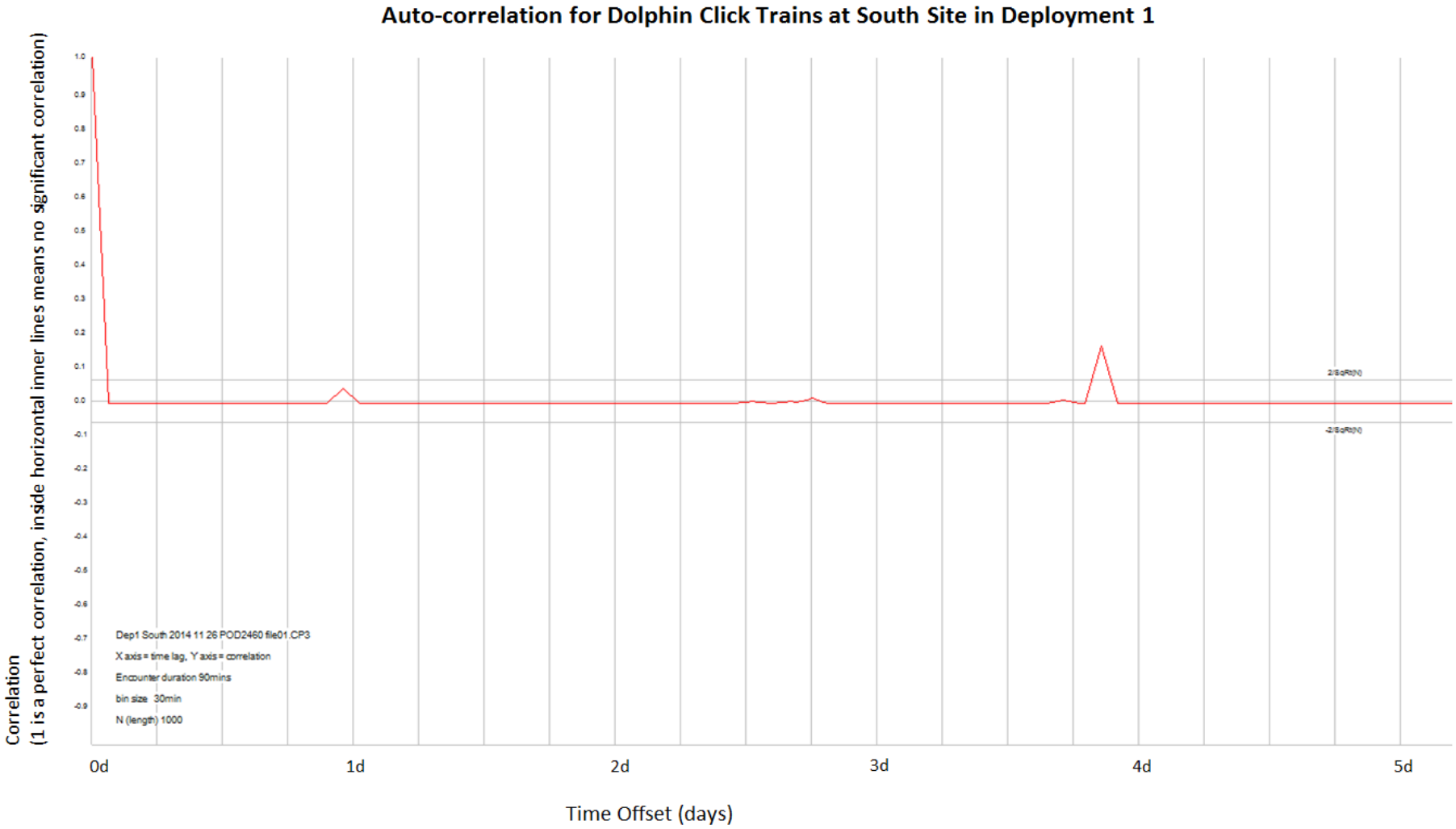

Figure 4-36: Auto-correlation for dolphin detections at South site deployment 1

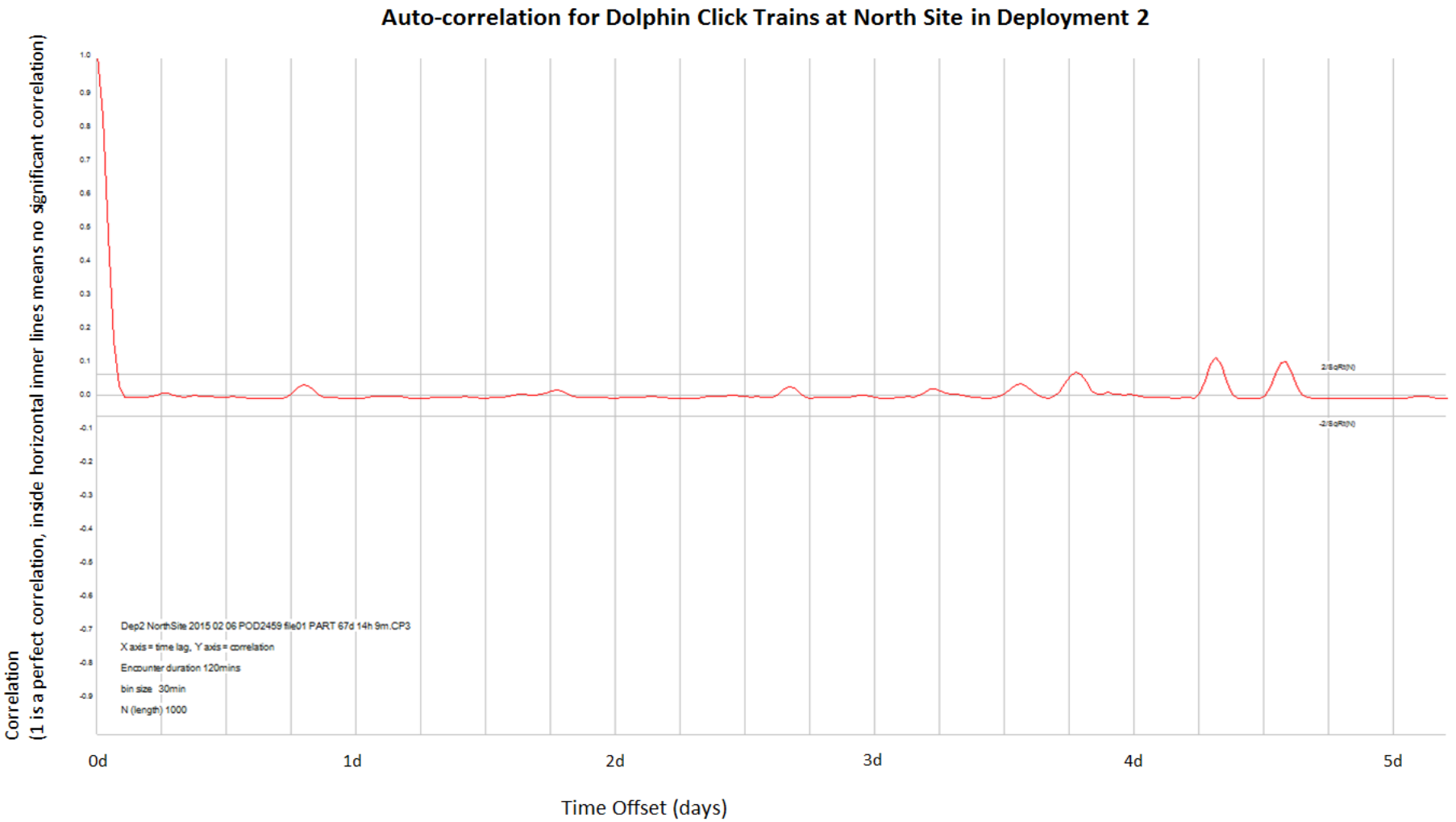

Figure 4-37: *Auto-correlation for dolphin detections at* *North site deployment 2*

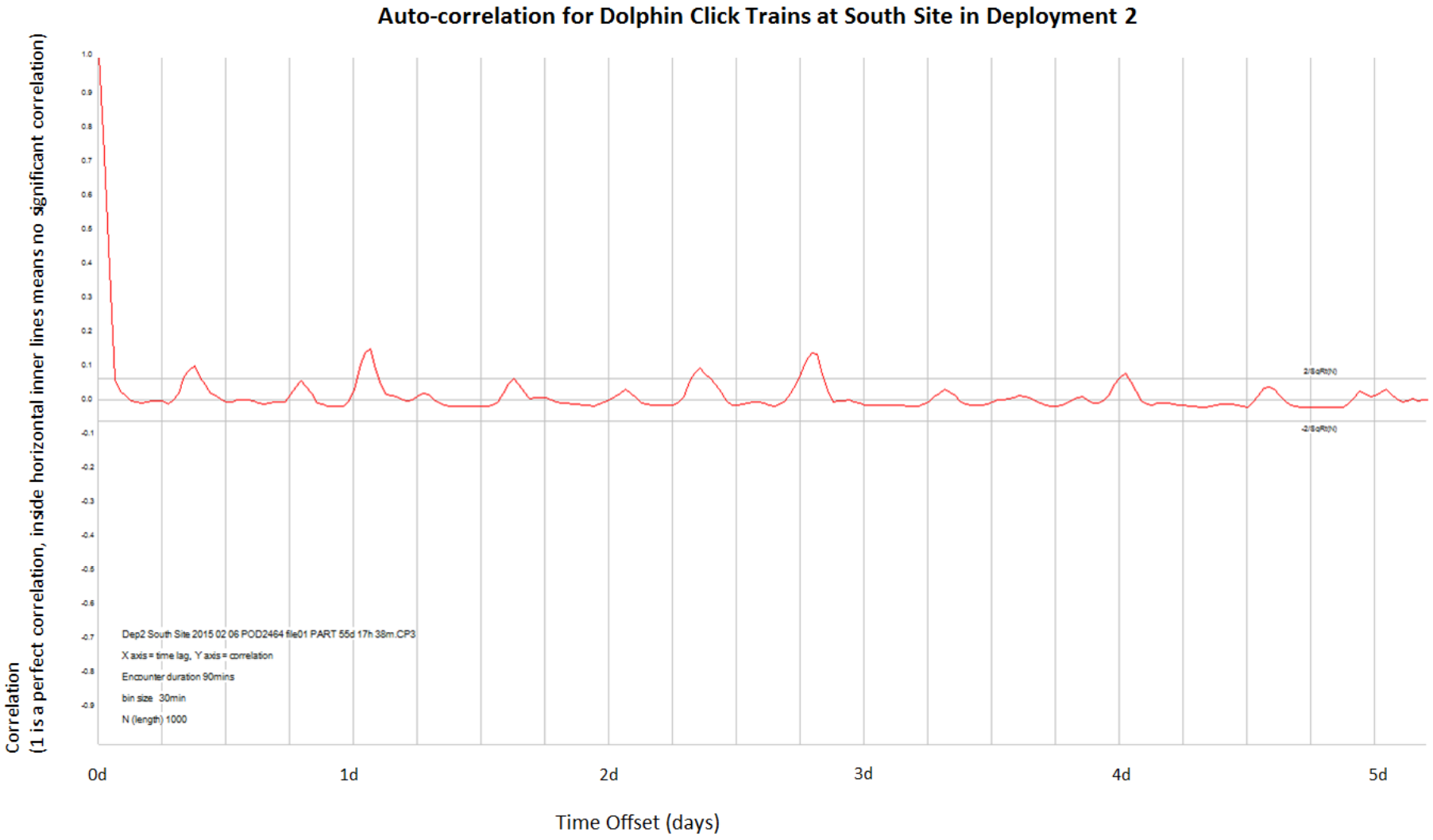

Figure 4-38: *Auto-correlation for dolphin detections at South site deployment 2*

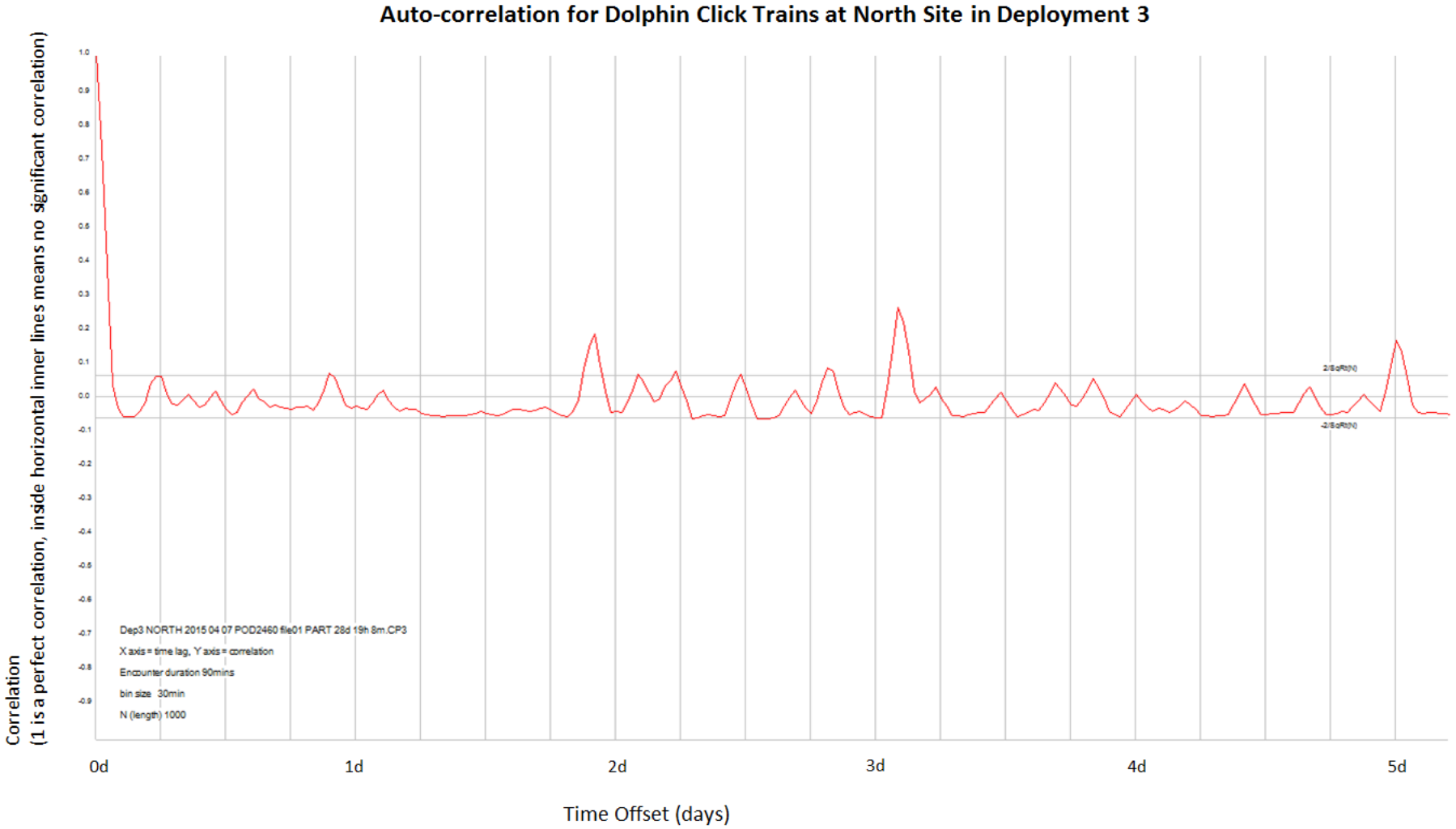

Figure 4-39: Auto-correlation for dolphin detections at North site deployment 3

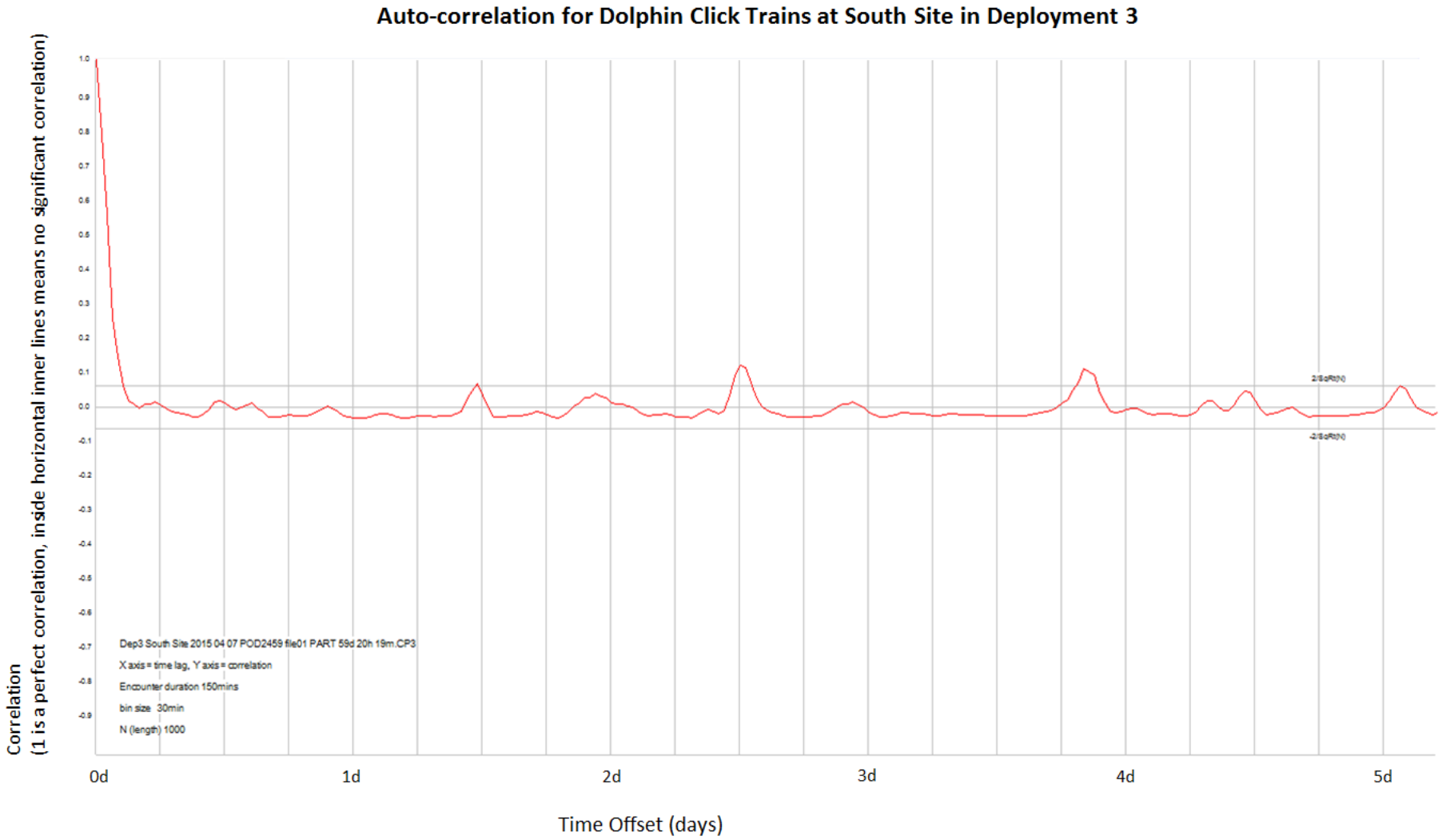

Figure 4-40: Auto-correlation for dolphin detections at South site deployment 3

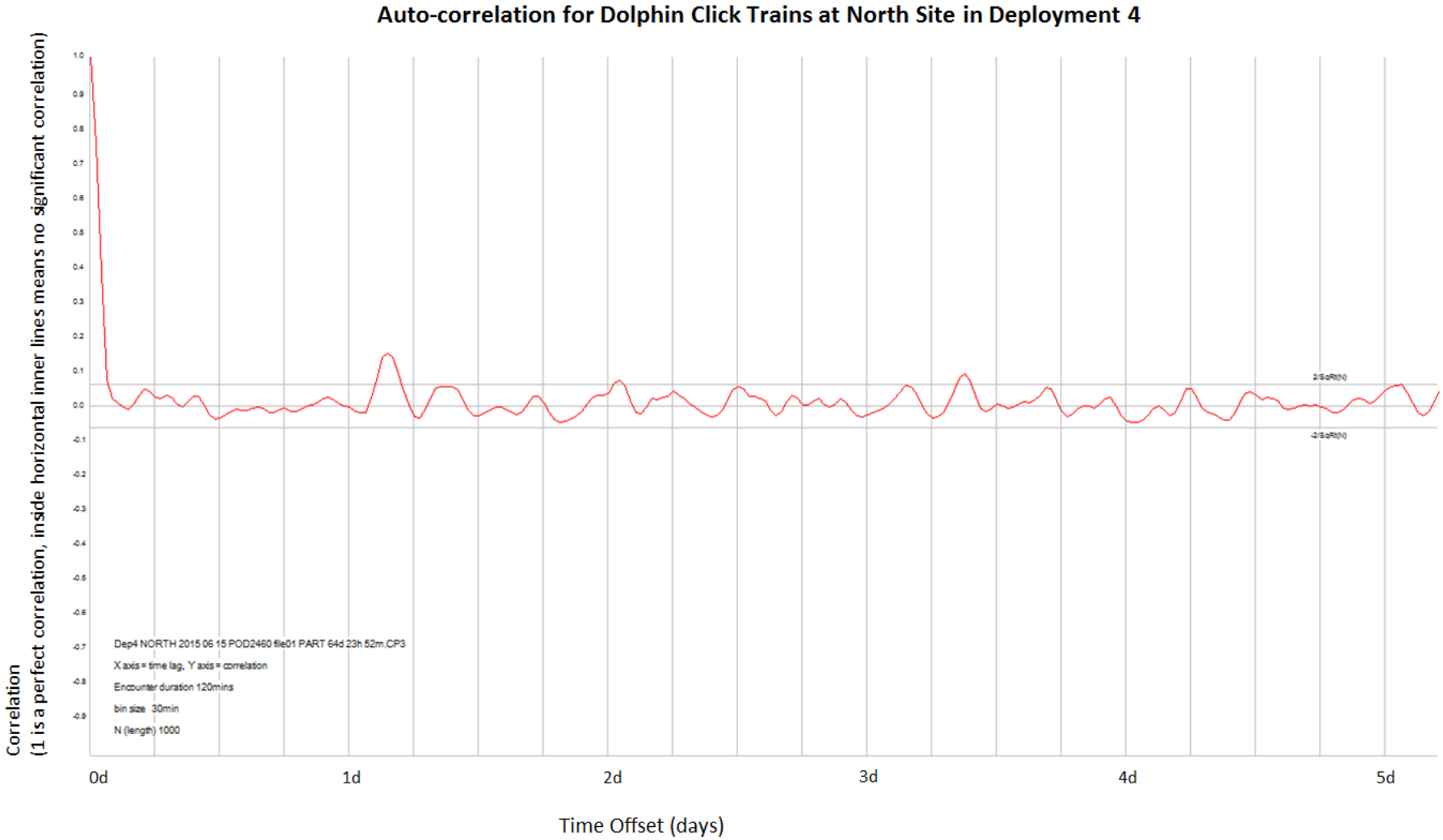

Figure 4-41: Auto-correlation for dolphin detections at North site deployment 4

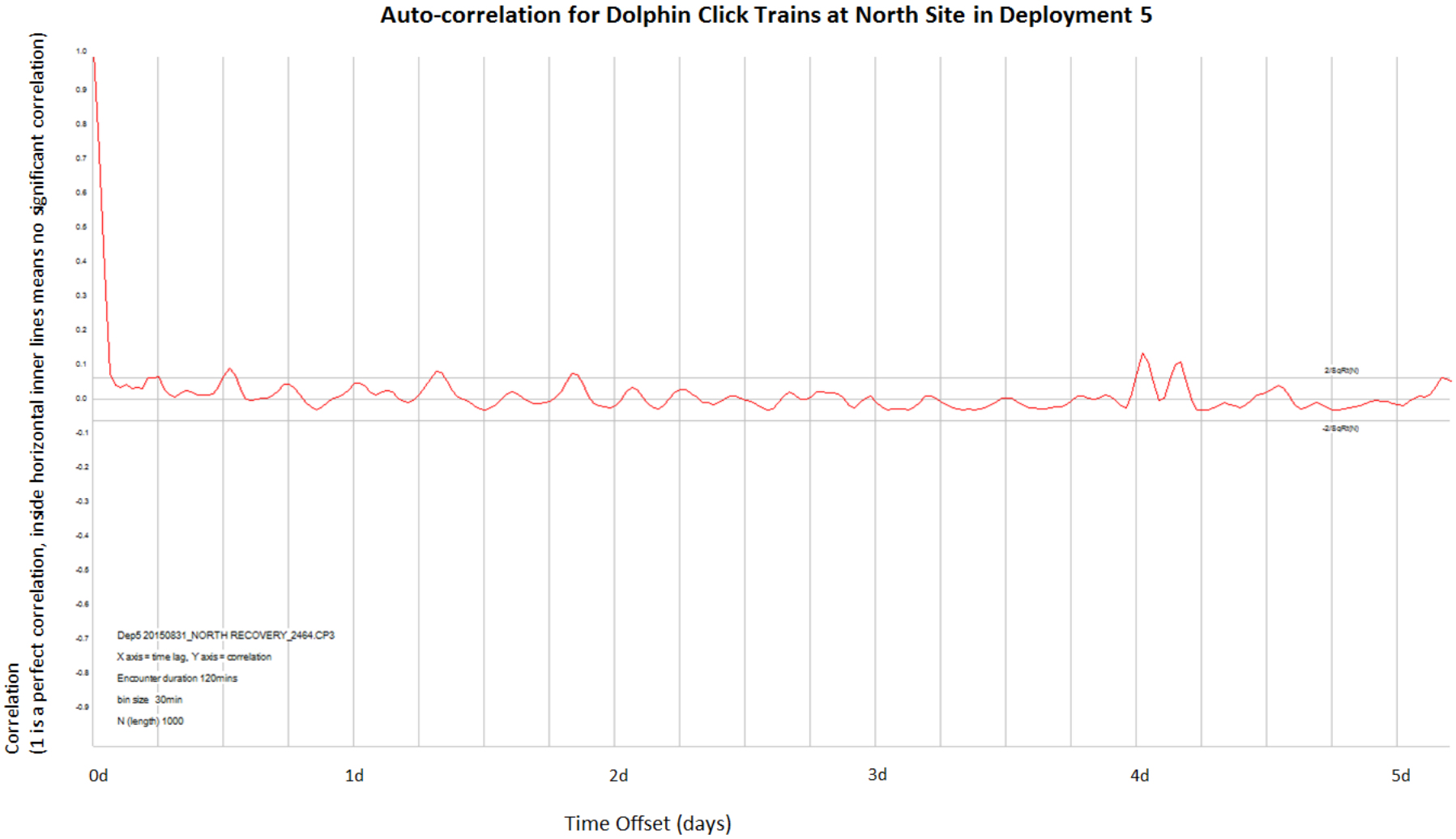

Figure 4-42: Auto-correlation for dolphin detections at North site deployment 5

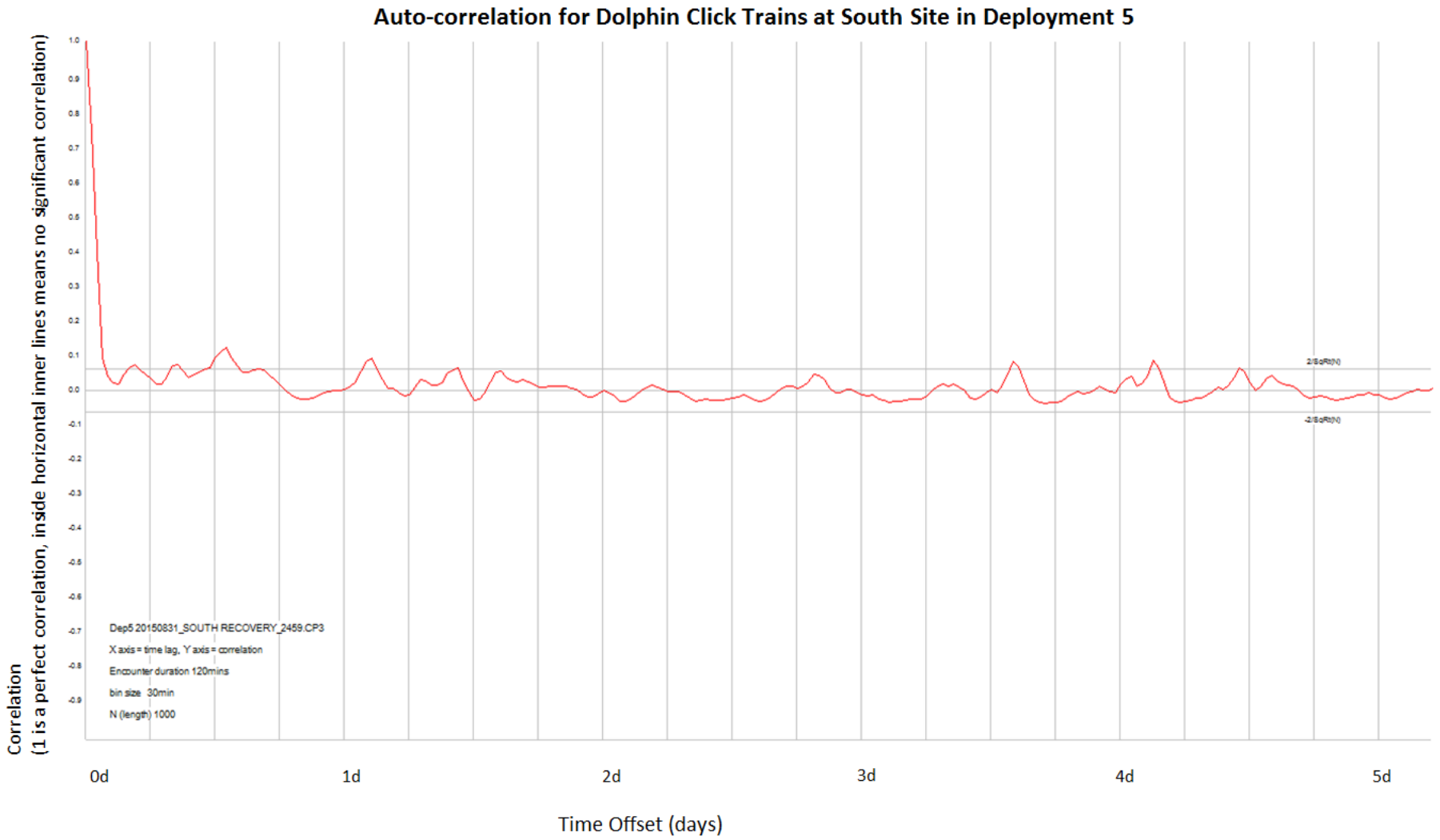

Figure 4-43: Auto-correlation for dolphin detections at South site deployment 5

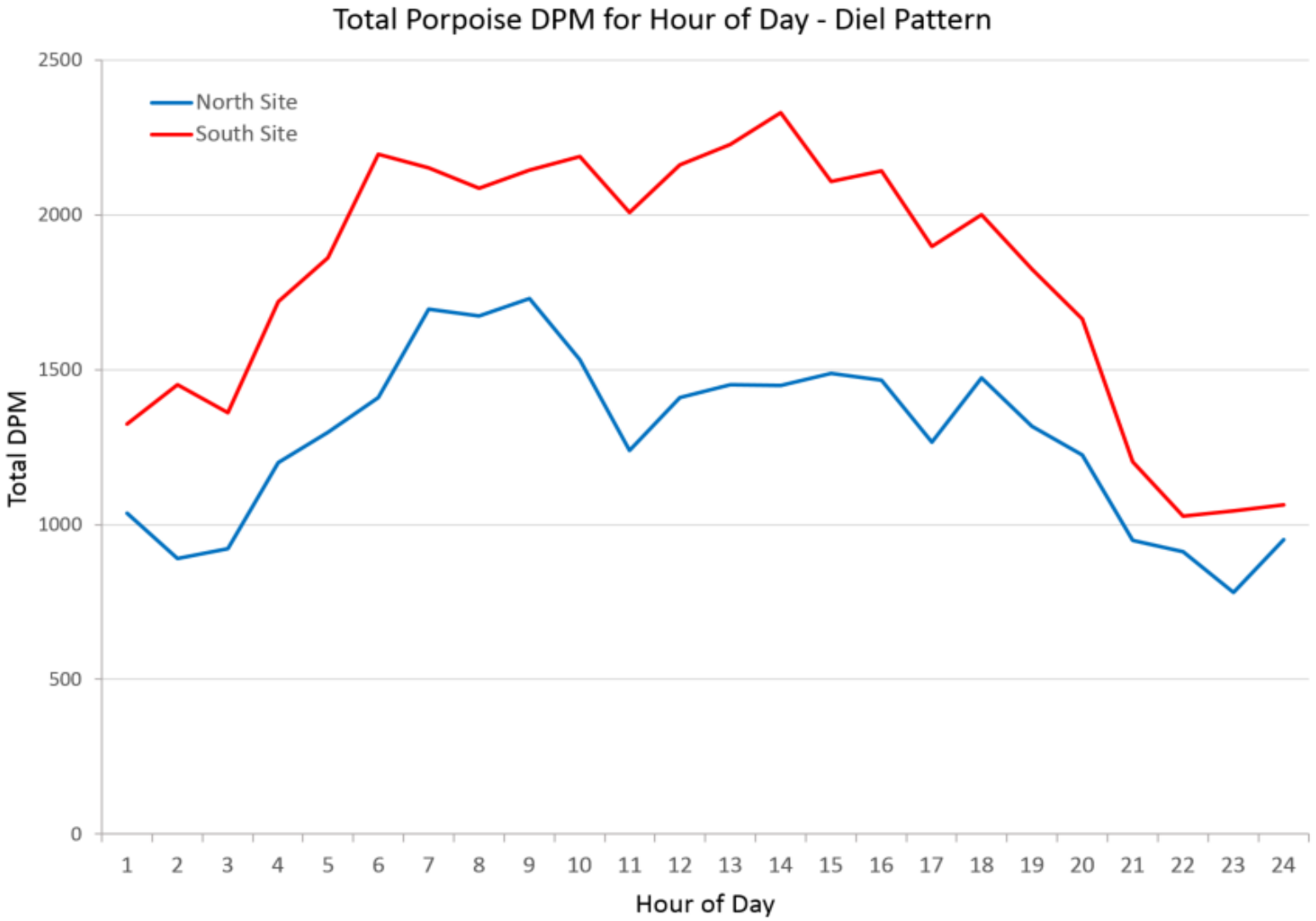

Figure 4-44: Total Porpoise DPM for Hour of Day

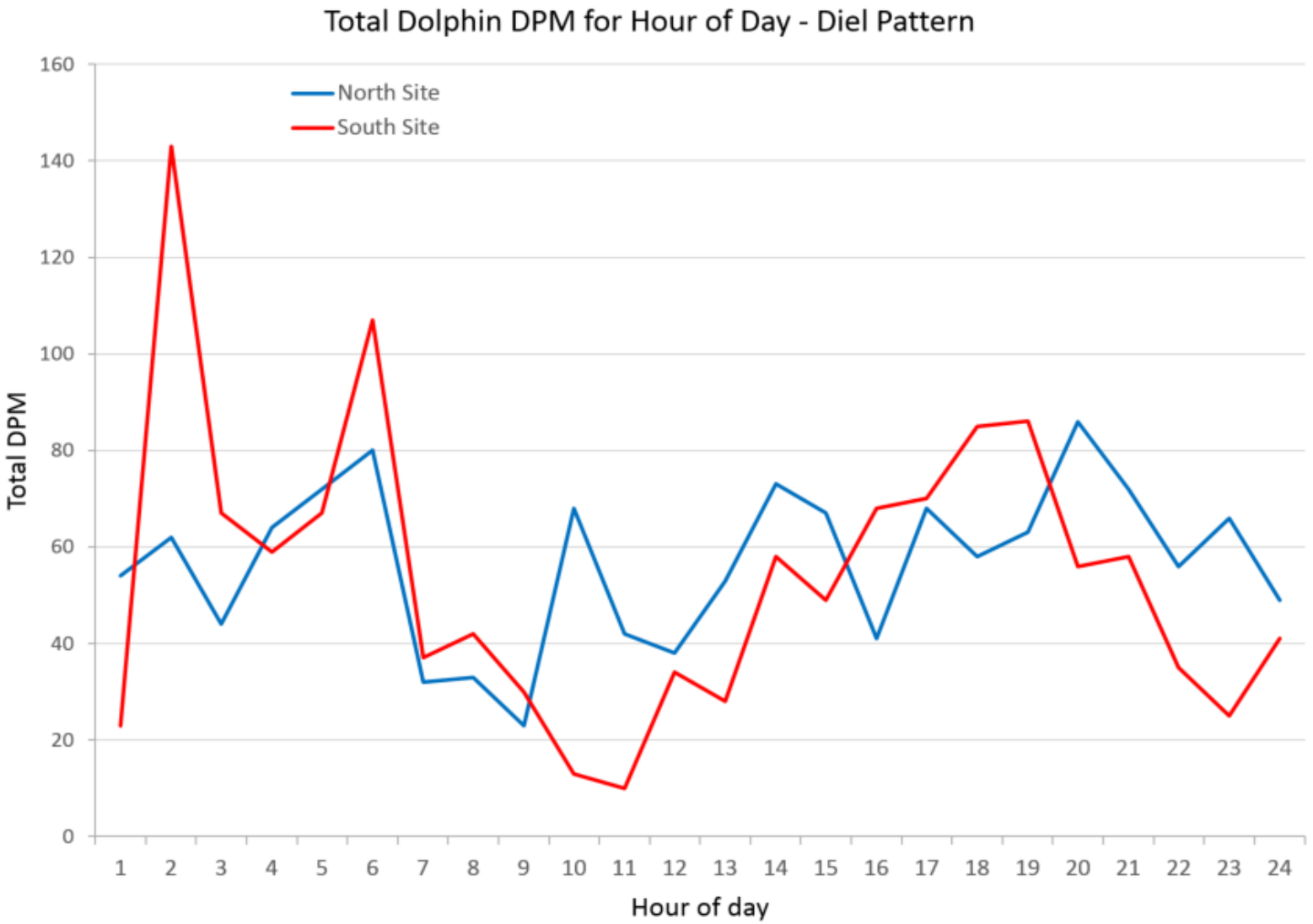

Figure 4-45: Total Dolphin DPM for Hour of Day

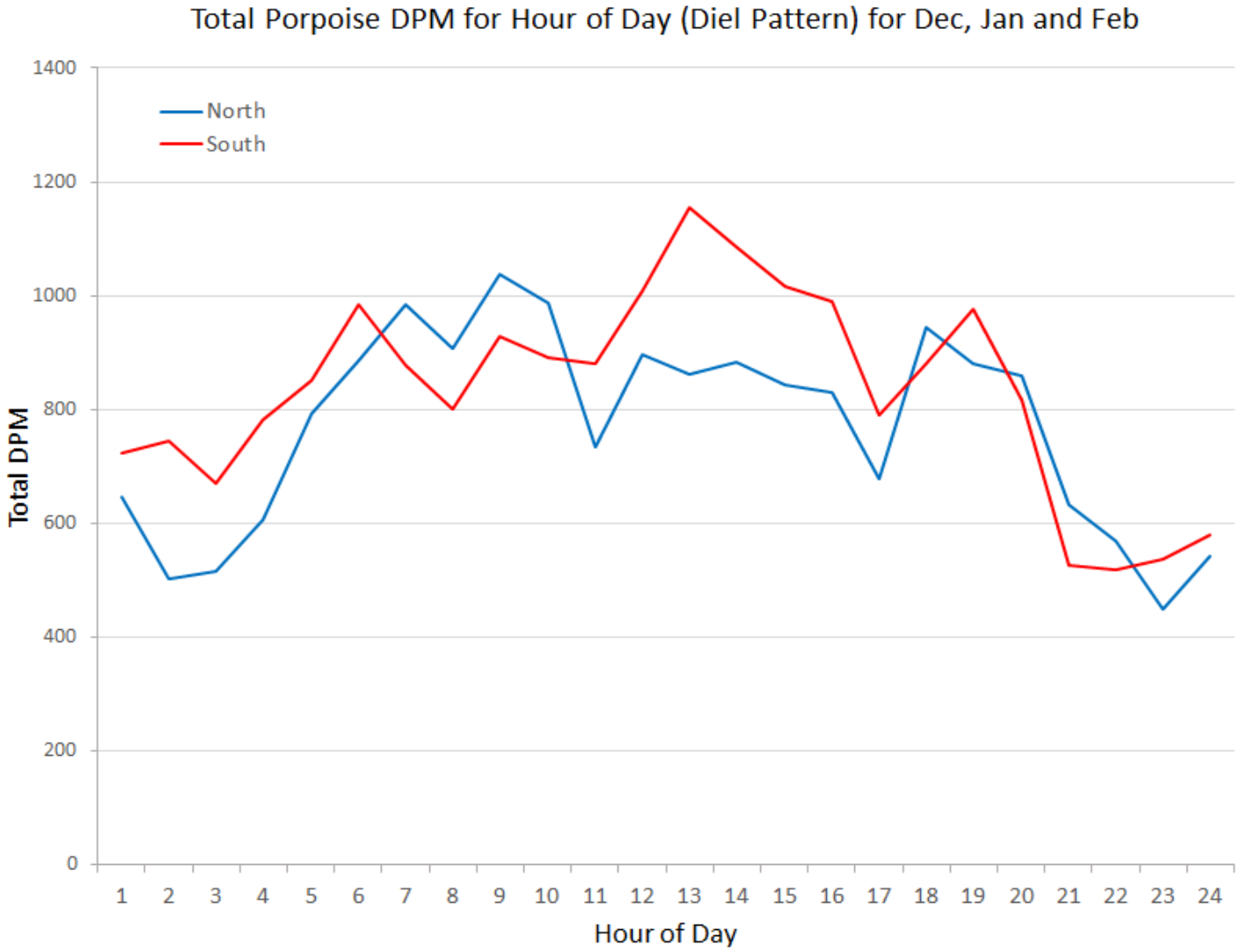

Figure 4-46.1. Total Porpoise DPM for hour of day across winter months

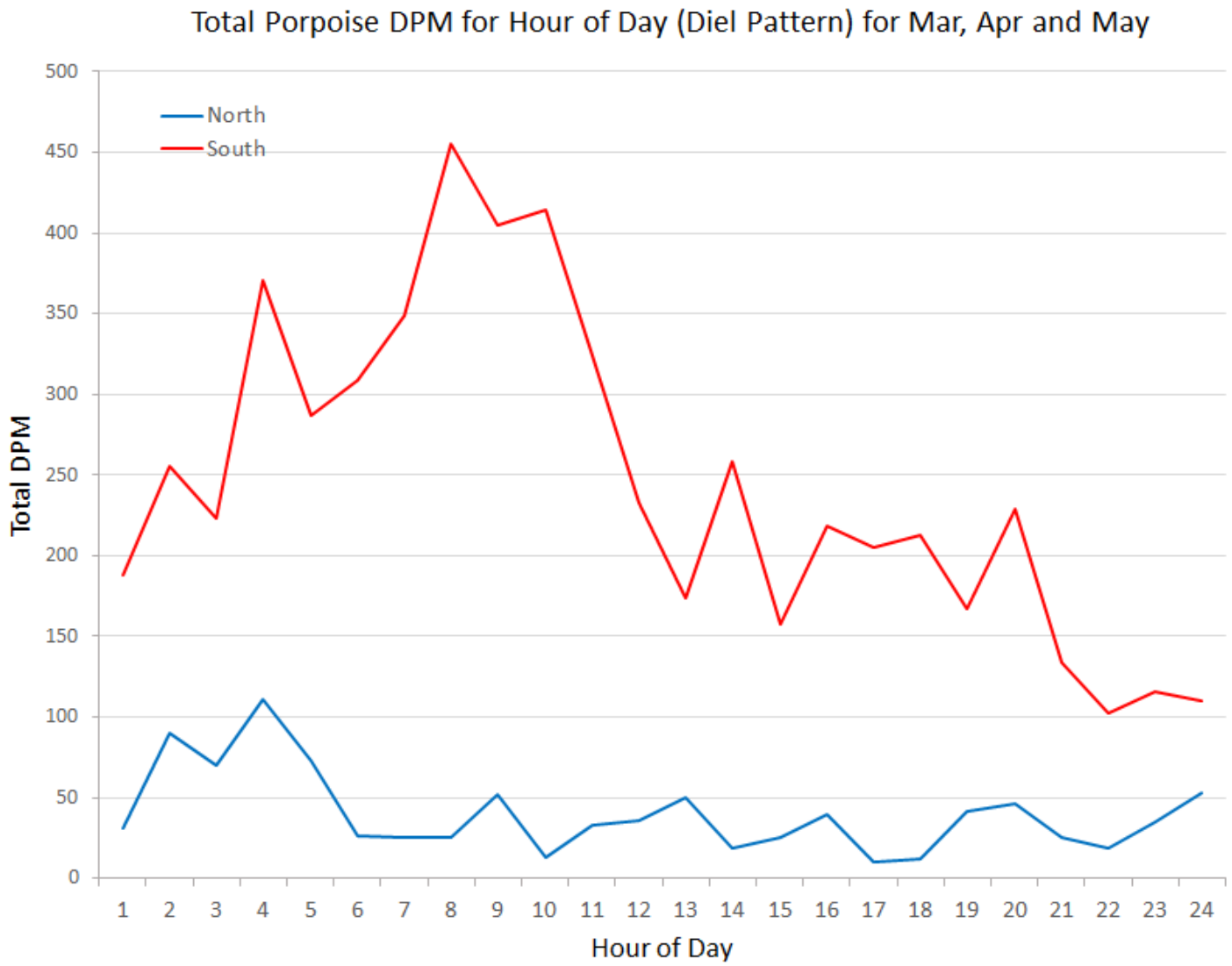

Figure 4-46.2. Total Porpoise DPM for hour of day across spring months

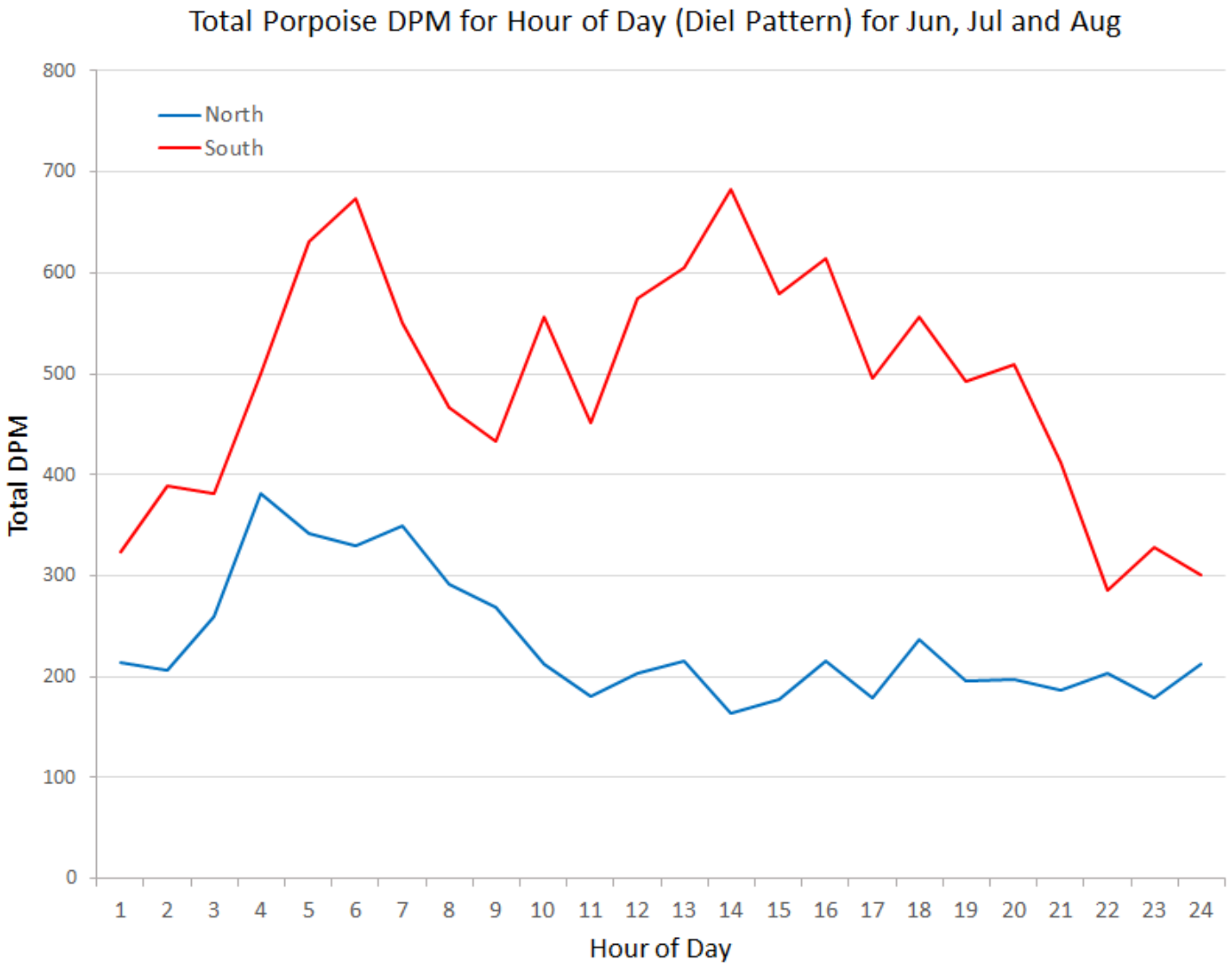

Figure 4-46.3. Total Porpoise DPM for hour of day across summer months

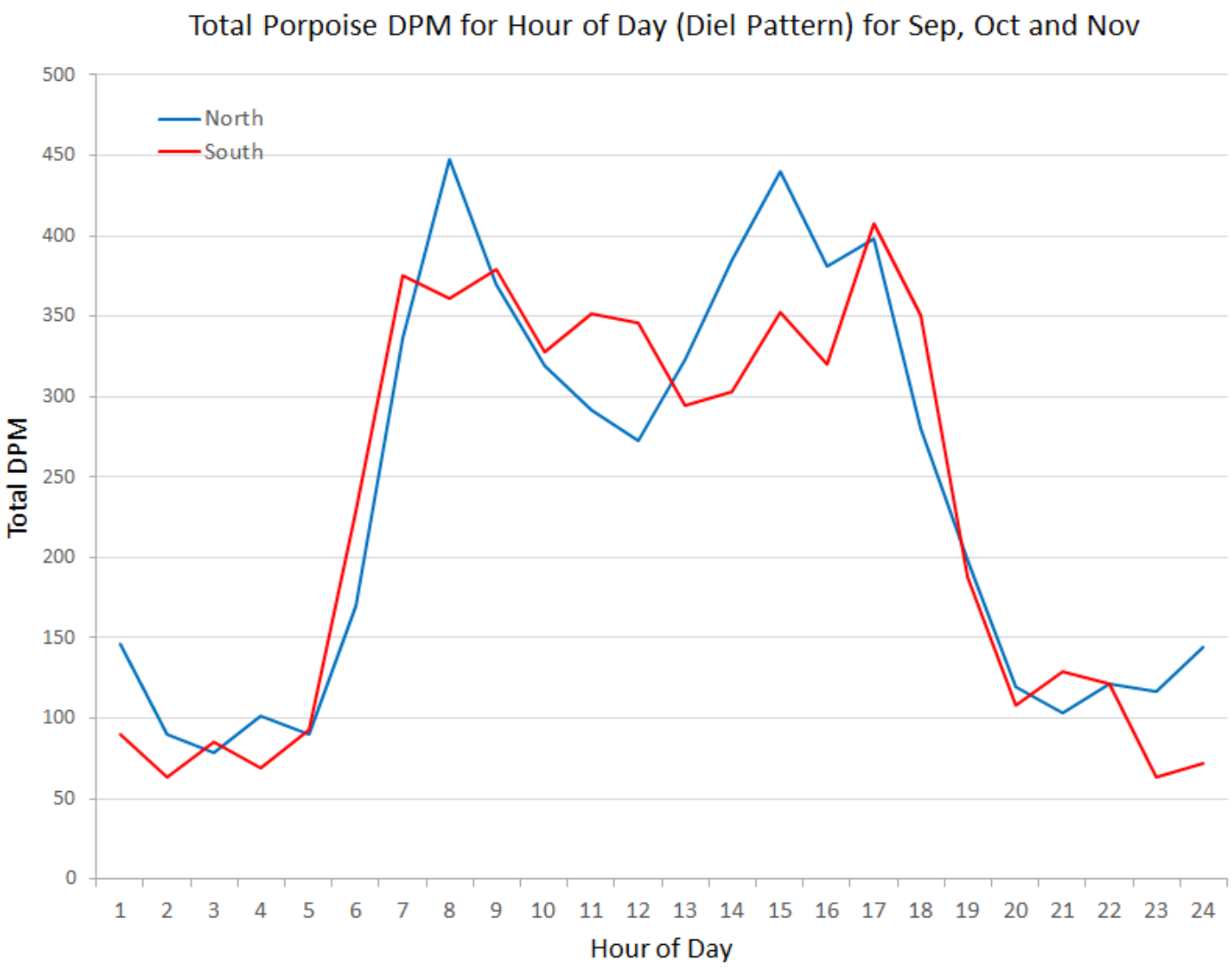

Figure 4-46.4. Total Porpoise DPM for hour of day across autumn months

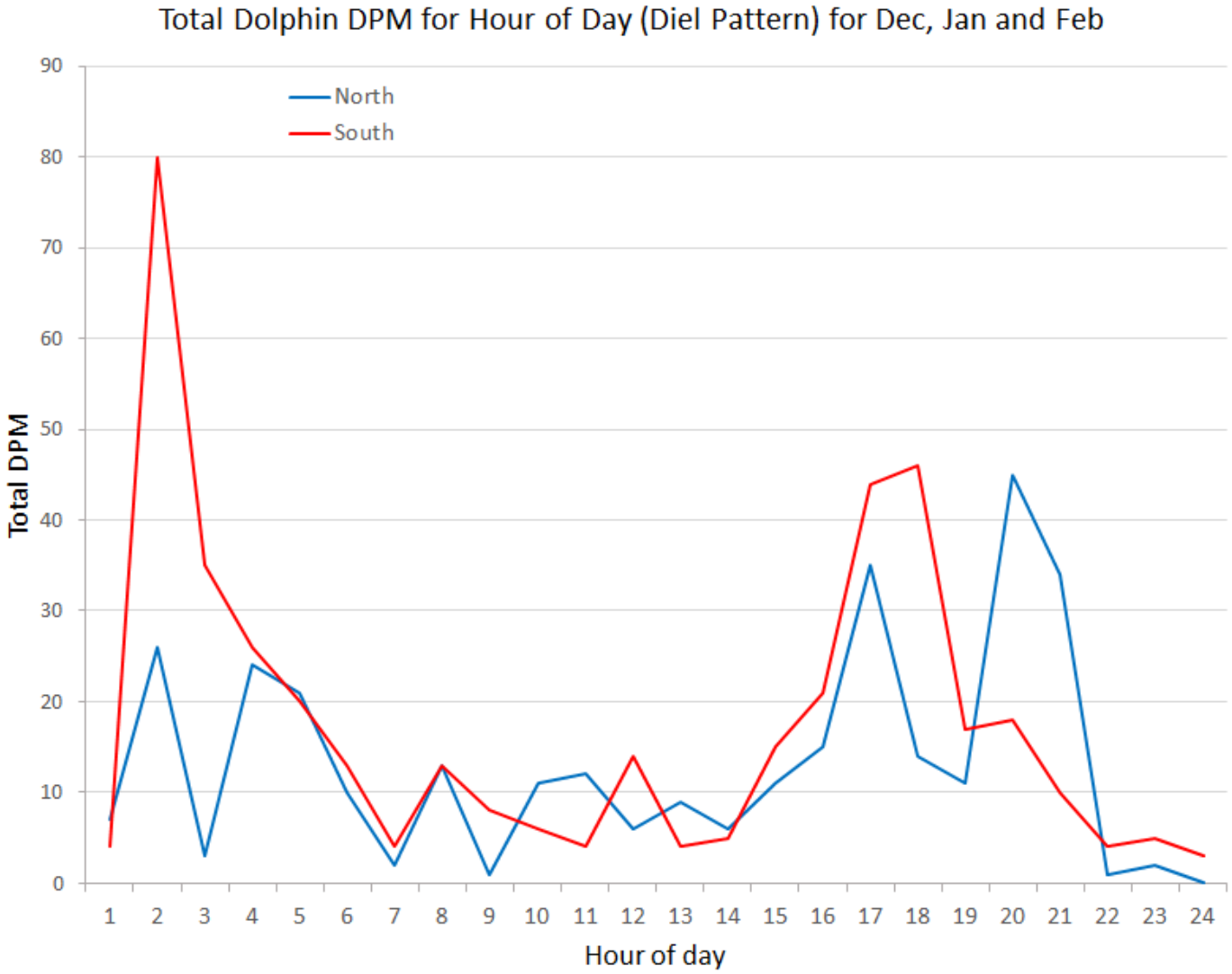

Figure 4-47.1. Total Dolphin DPM for hour of day across winter months

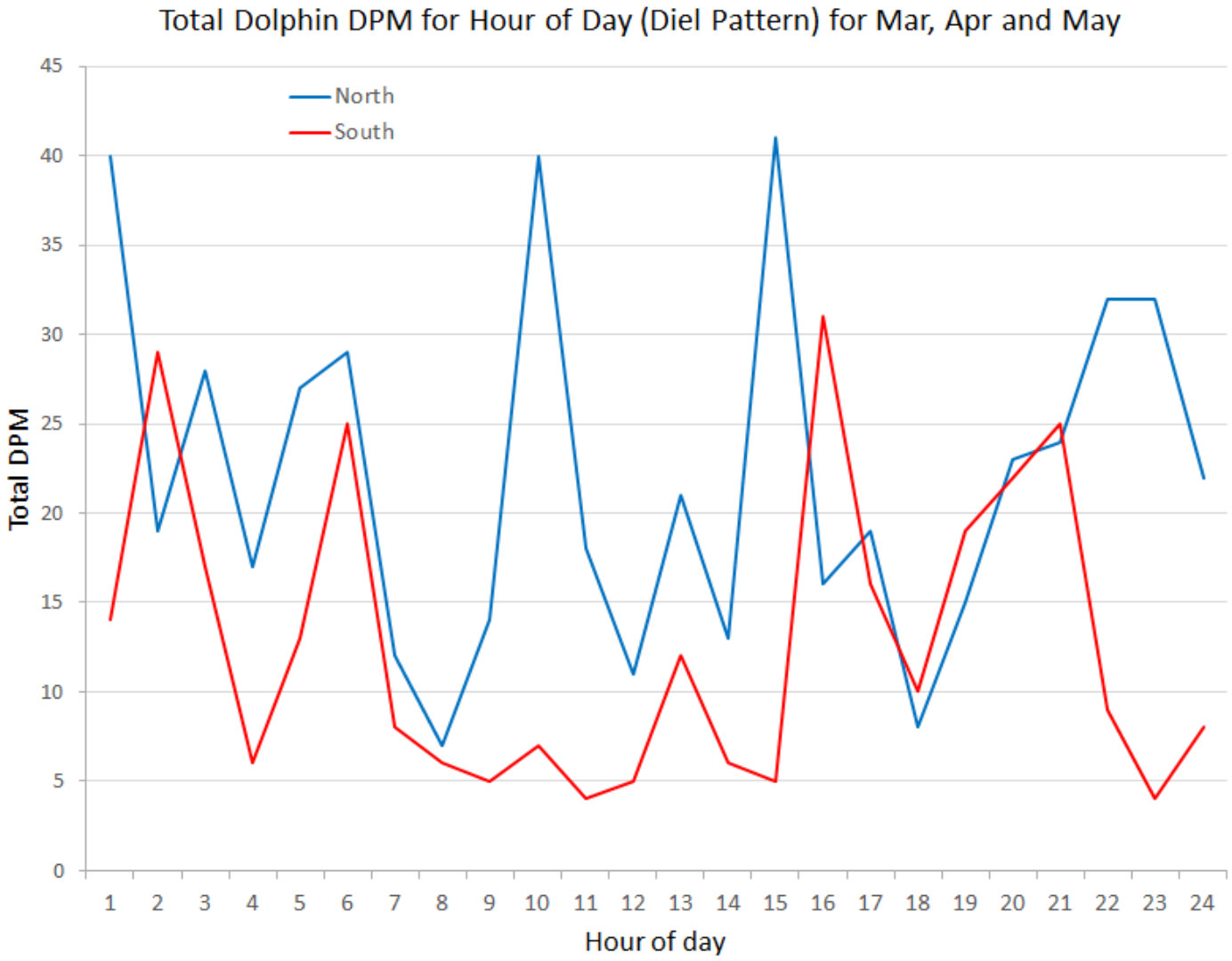

Figure 4-47.2. Total Dolphin DPM for hour of day across spring months

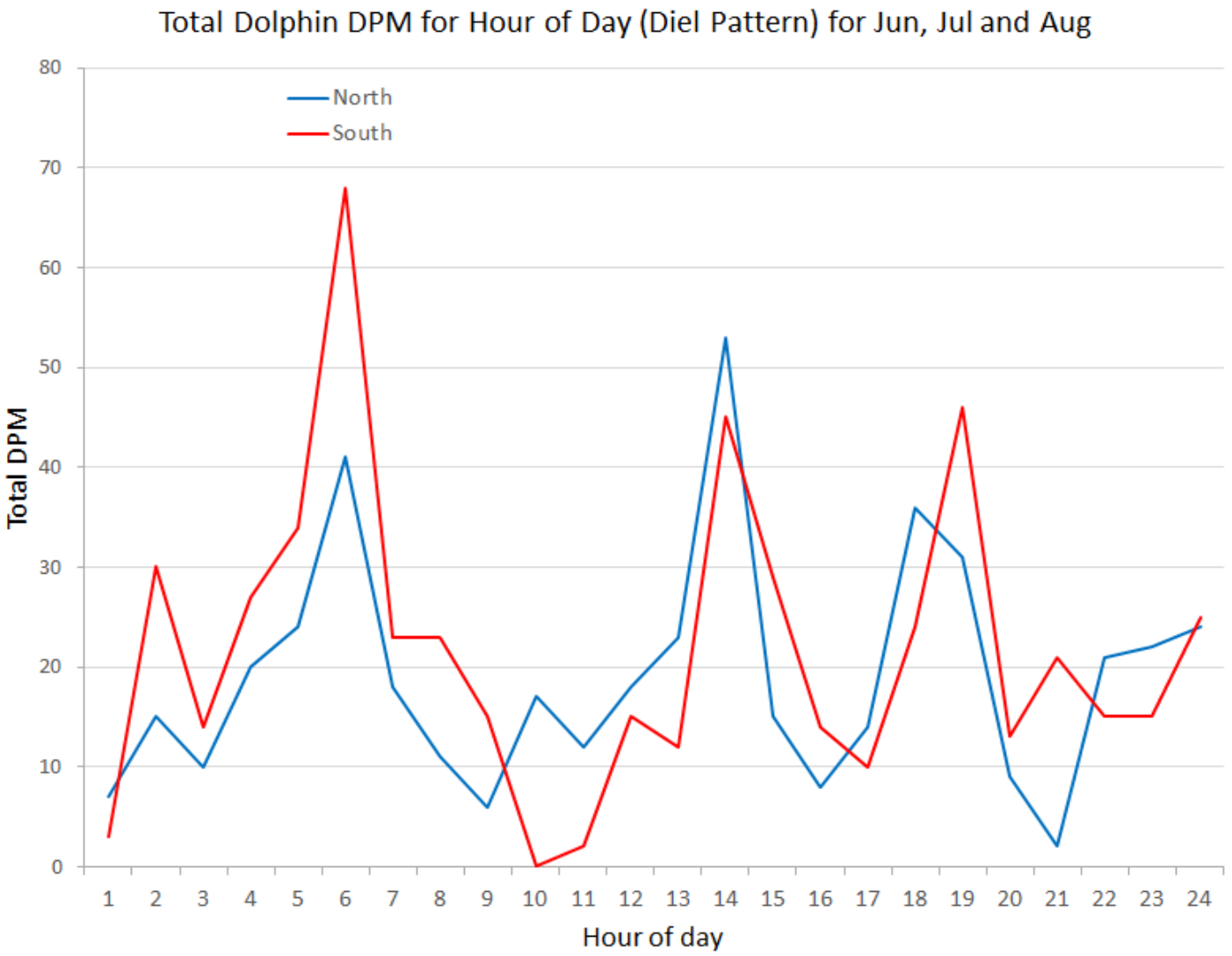

Figure 4-47.3. Total Dolphin DPM for hour of day across summer months

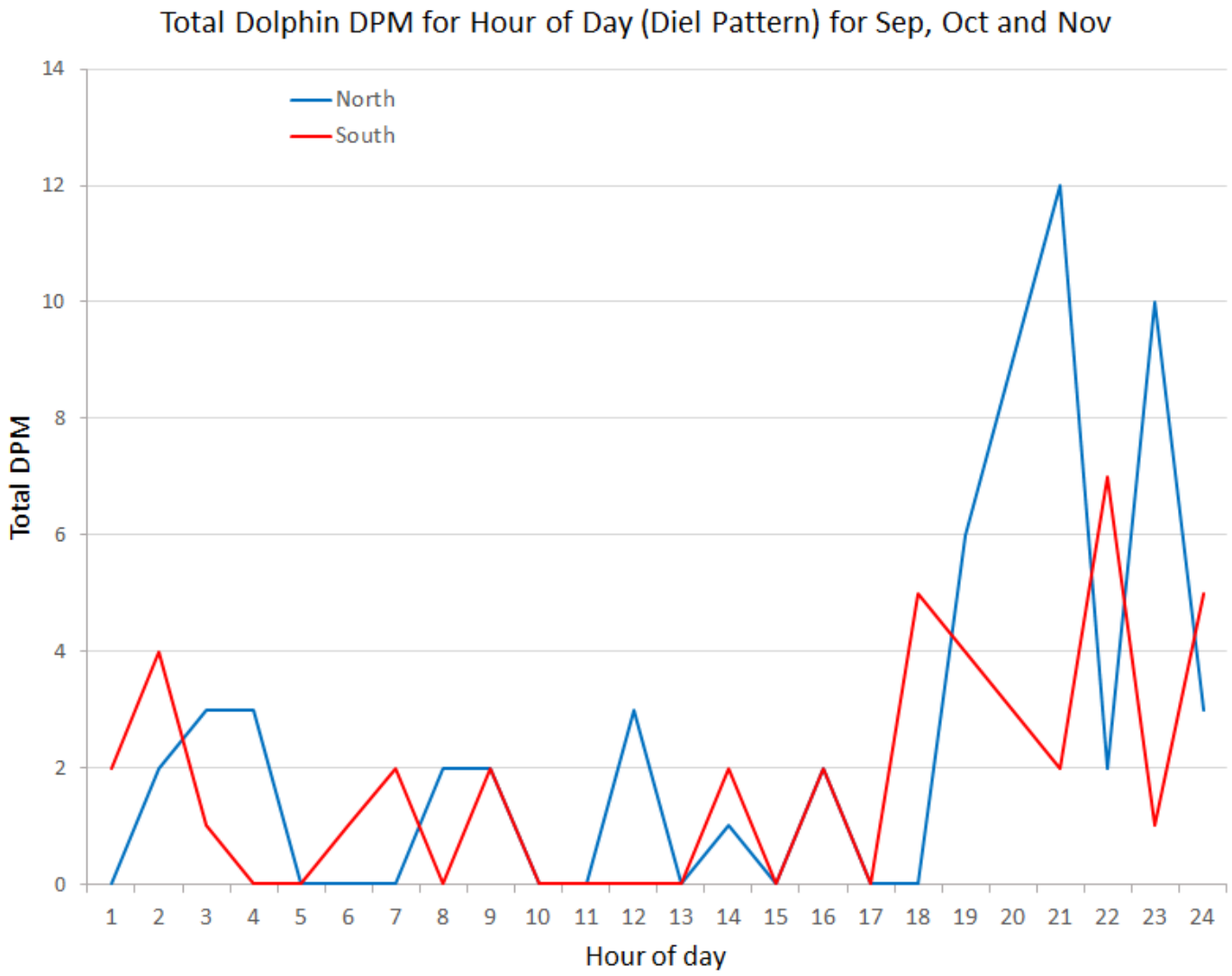

Figure 4-47.4. Total Dolphin DPM for hour of day across autumn months

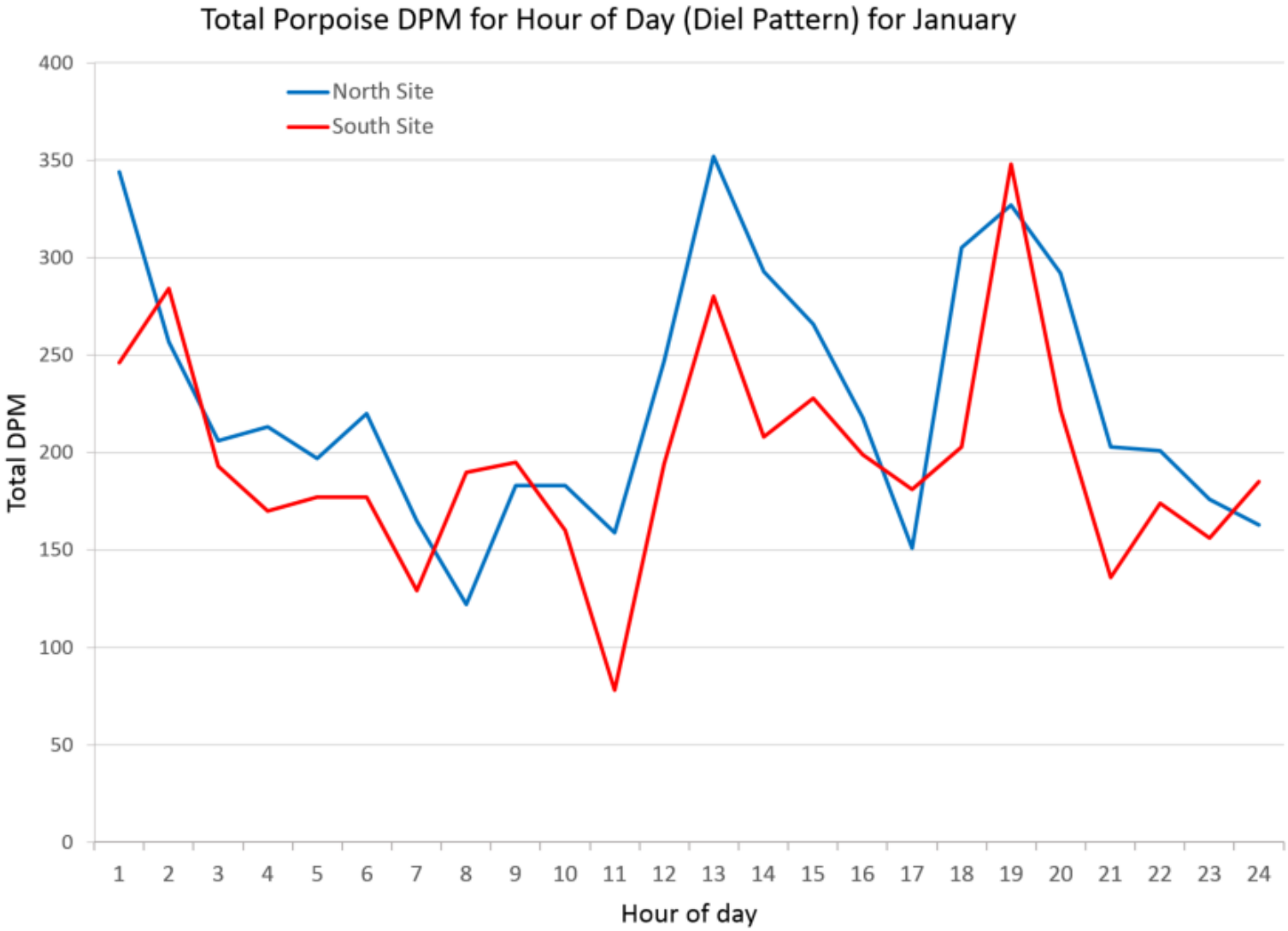

Figure 4-48.1. Total porpoise DPM for hour of day in January

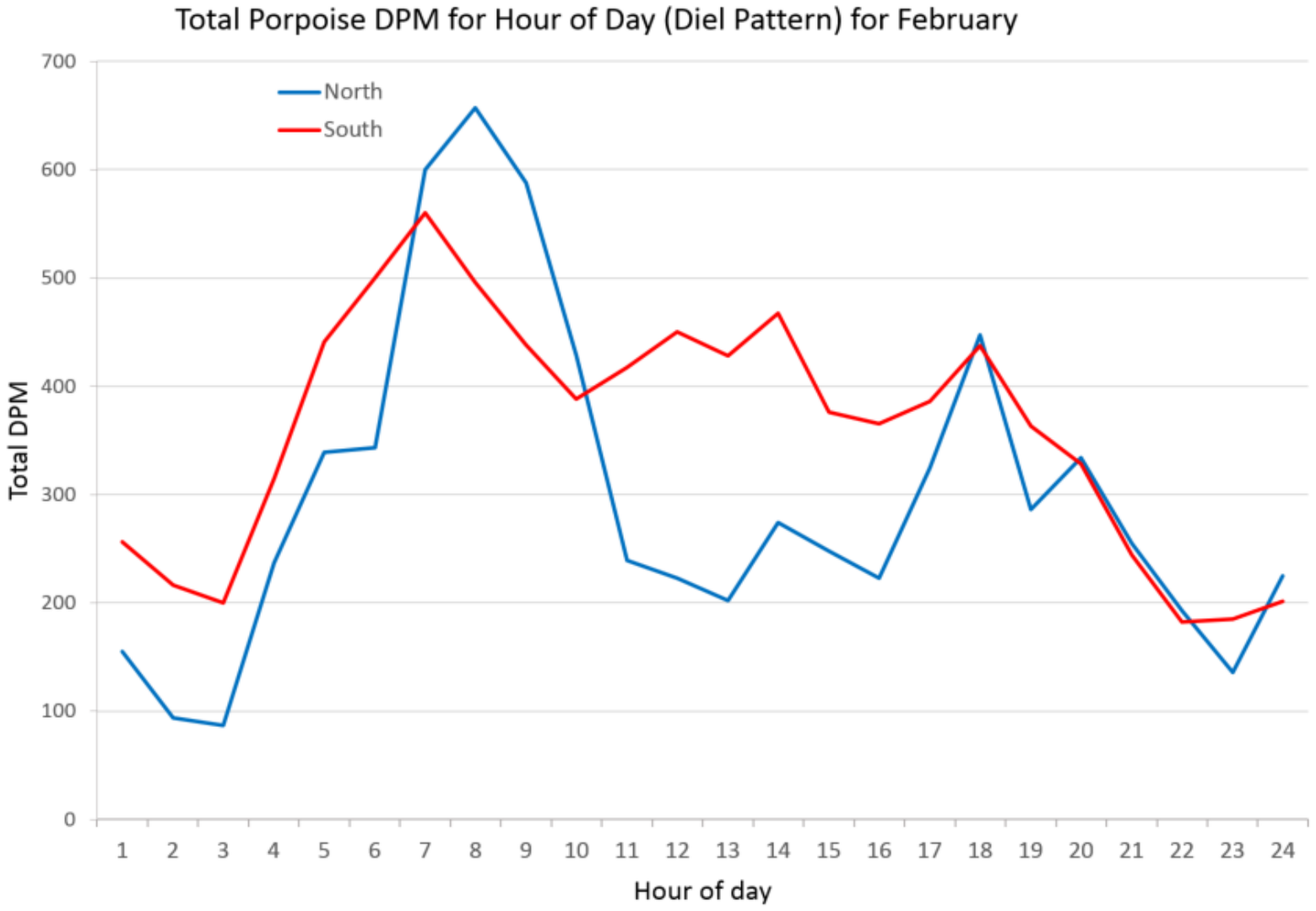

Figure 4-48.2. Total porpoise DPM for hour of day in February

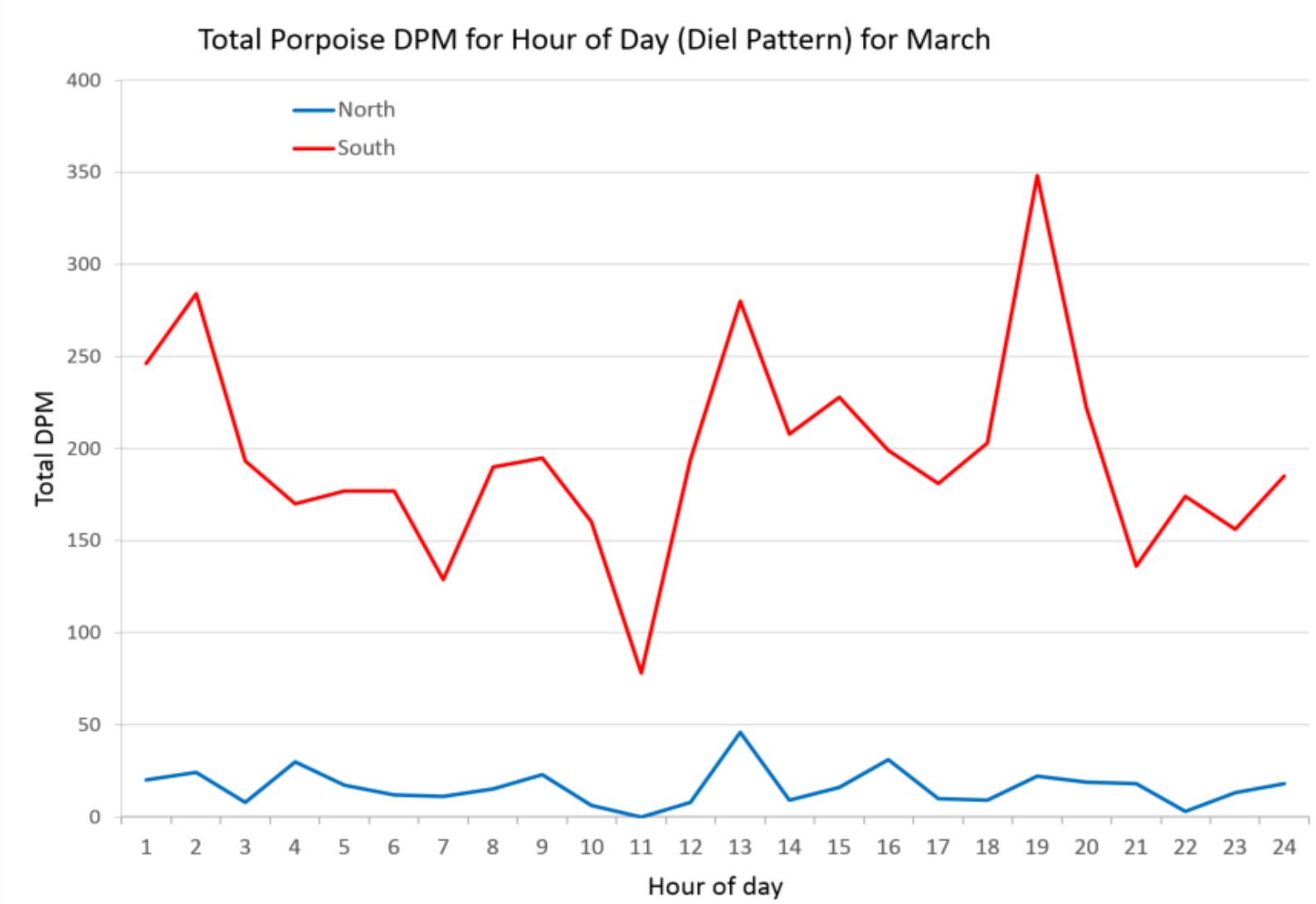

Figure 4-48.3. Total porpoise DPM for hour of day in March

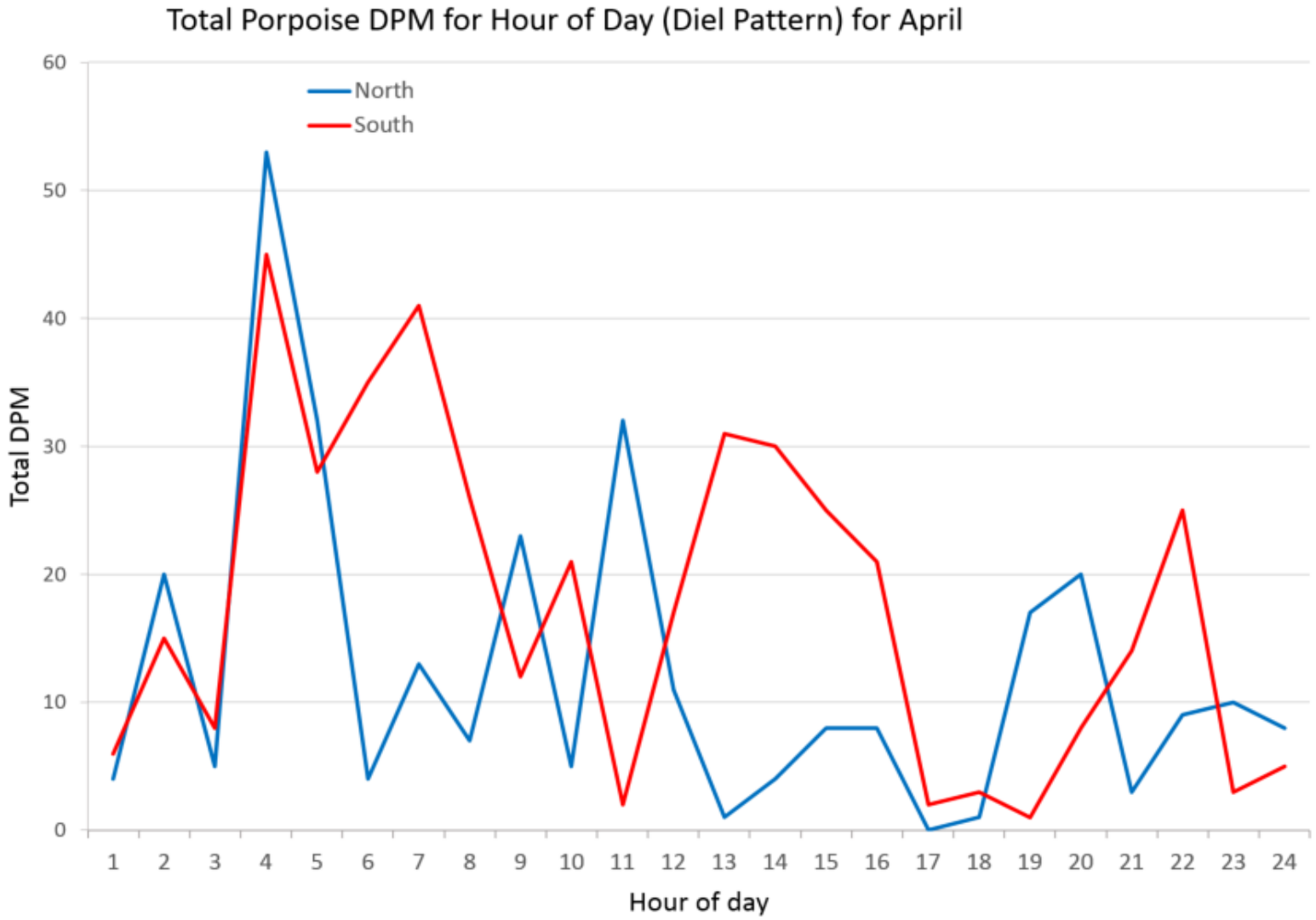

Figure 4-48.4. Total porpoise DPM for hour of day in April

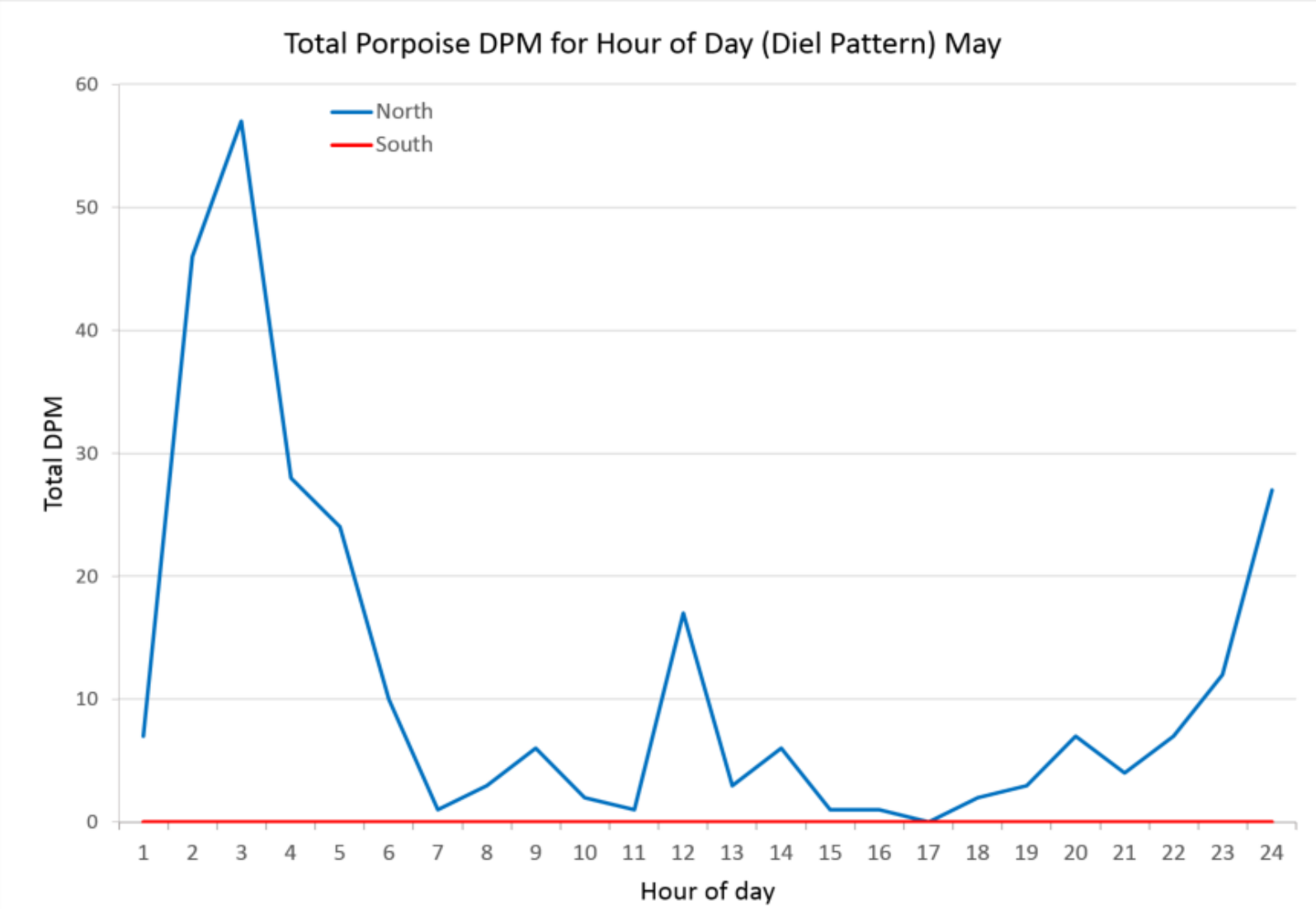

Figure 4-48.5. Total porpoise DPM for hour of day in May

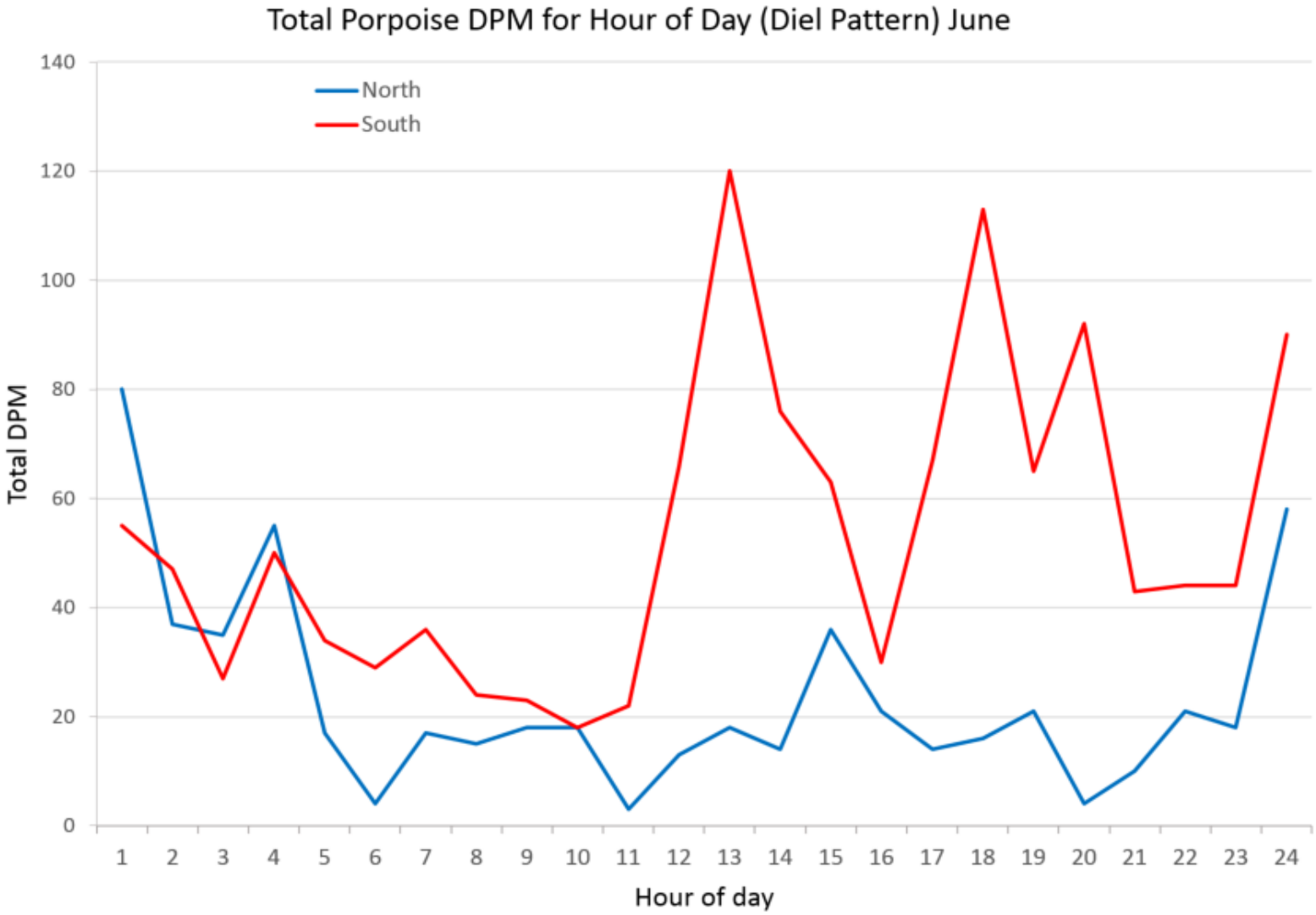

Figure 4-48.6. Total porpoise DPM for hour of day in June

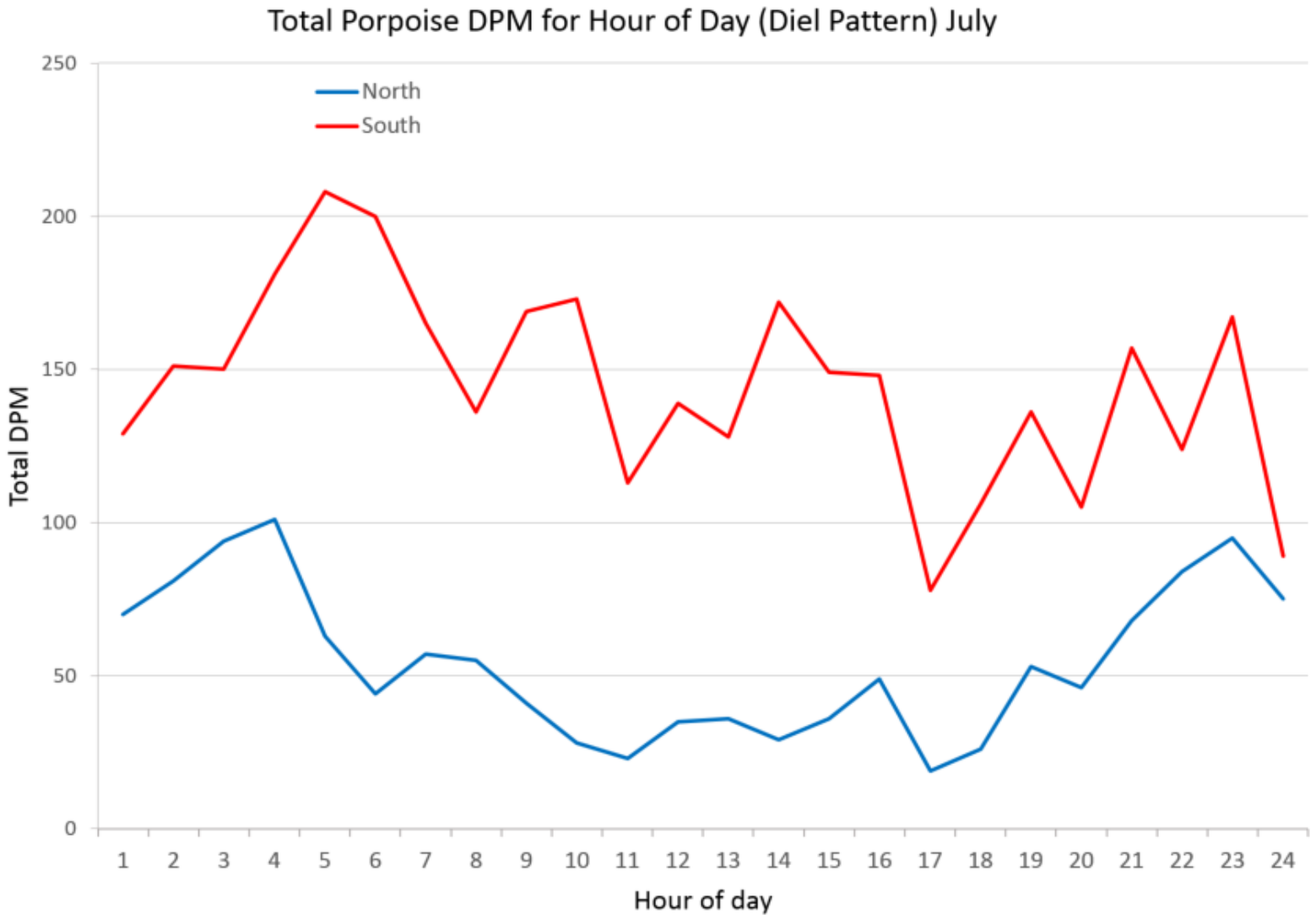

Figure 4-48.7. Total porpoise DPM for hour of day in July

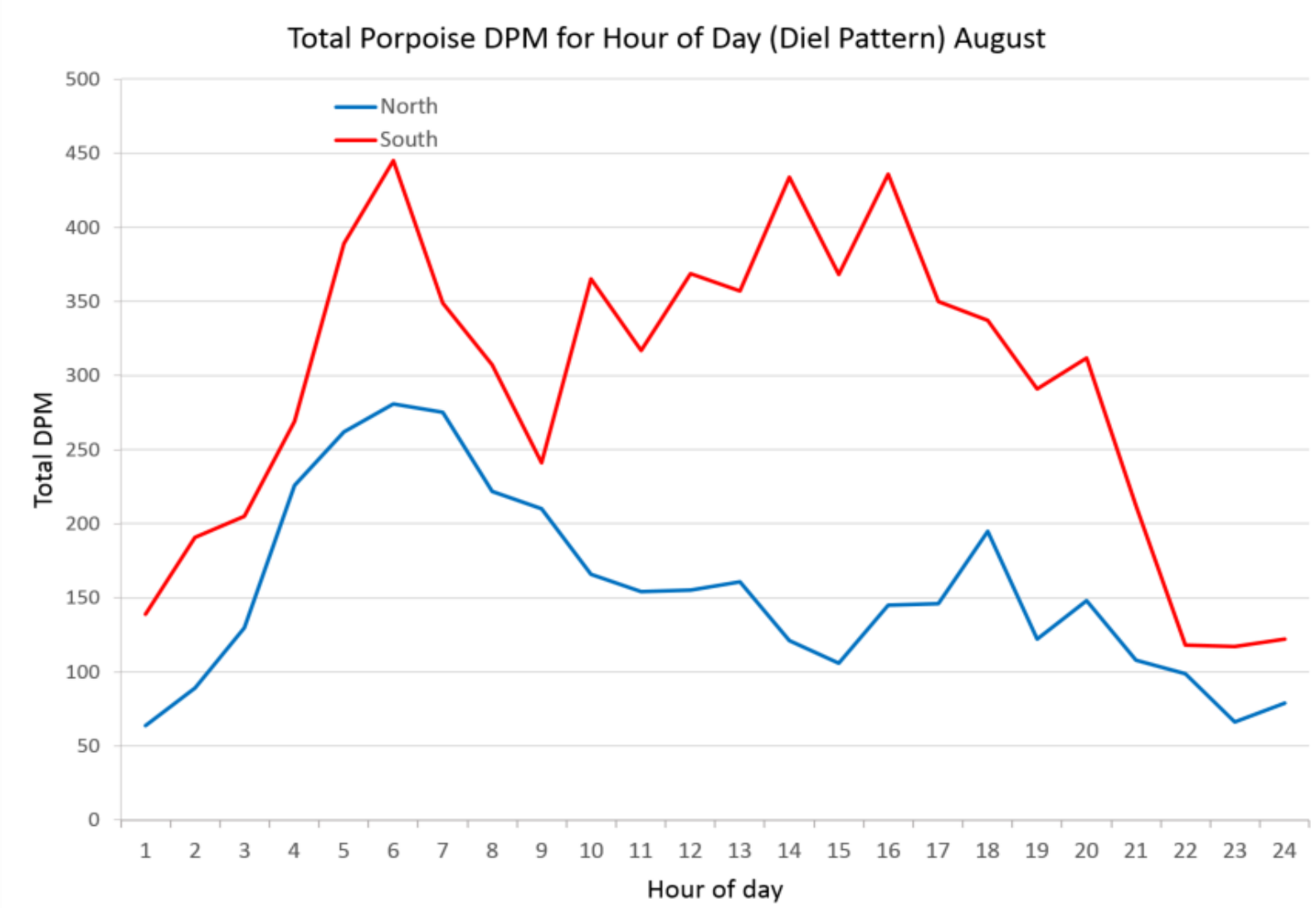

Figure 4-48.8. Total porpoise DPM for hour of day in August

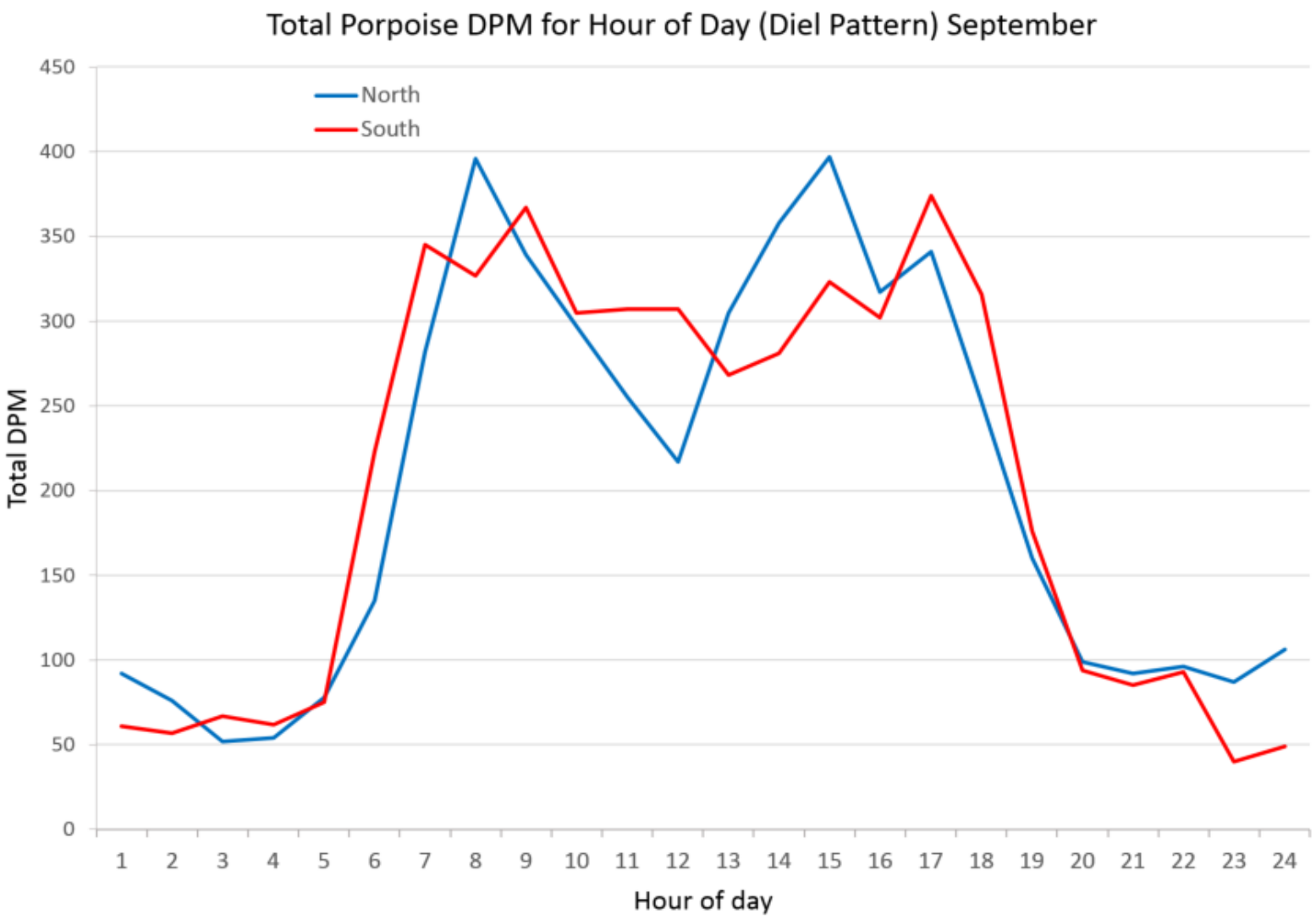

Figure 4-48.9. Total porpoise DPM for hour of day in September

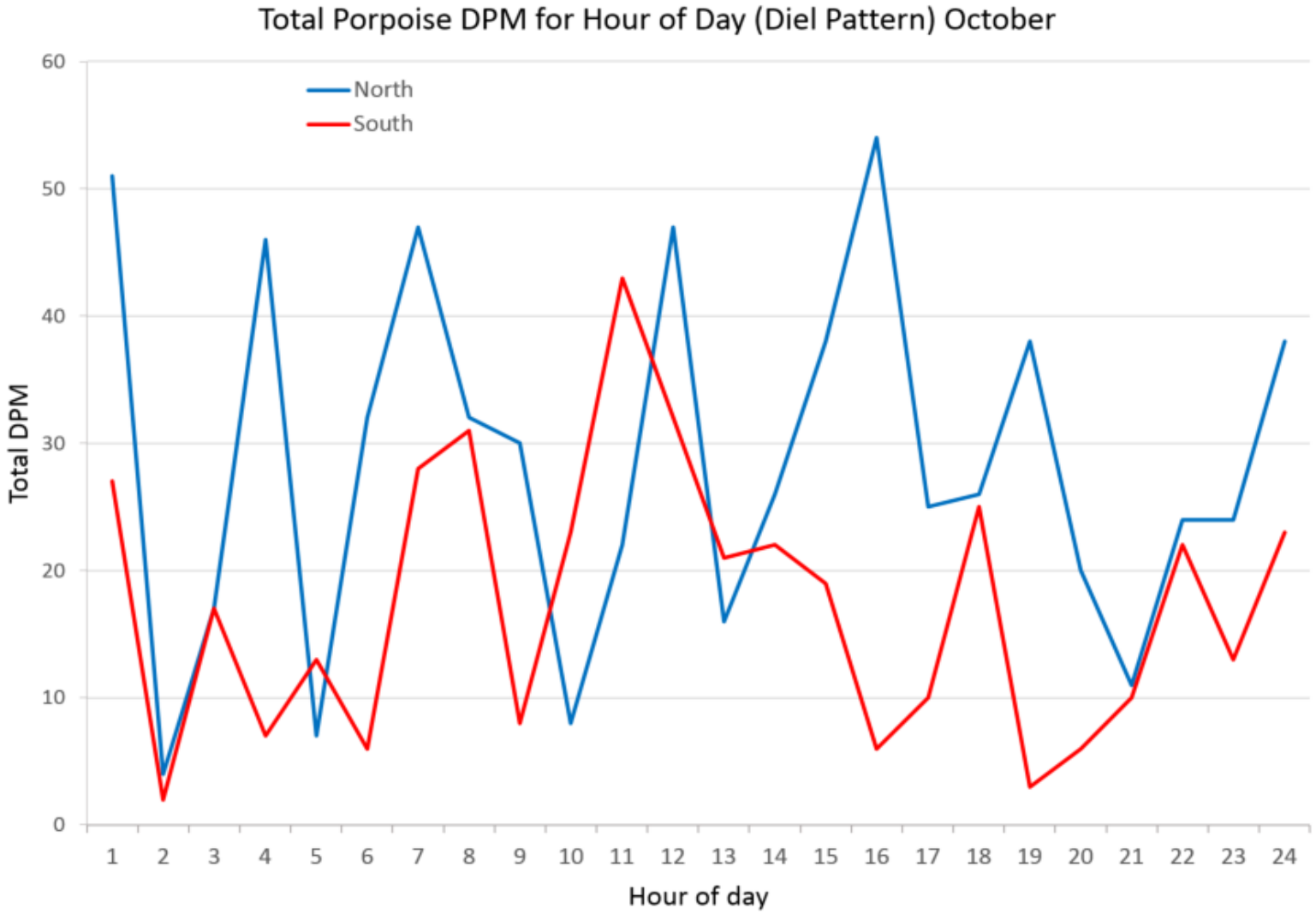

Figure 4-48.10. Total porpoise DPM for hour of day in October

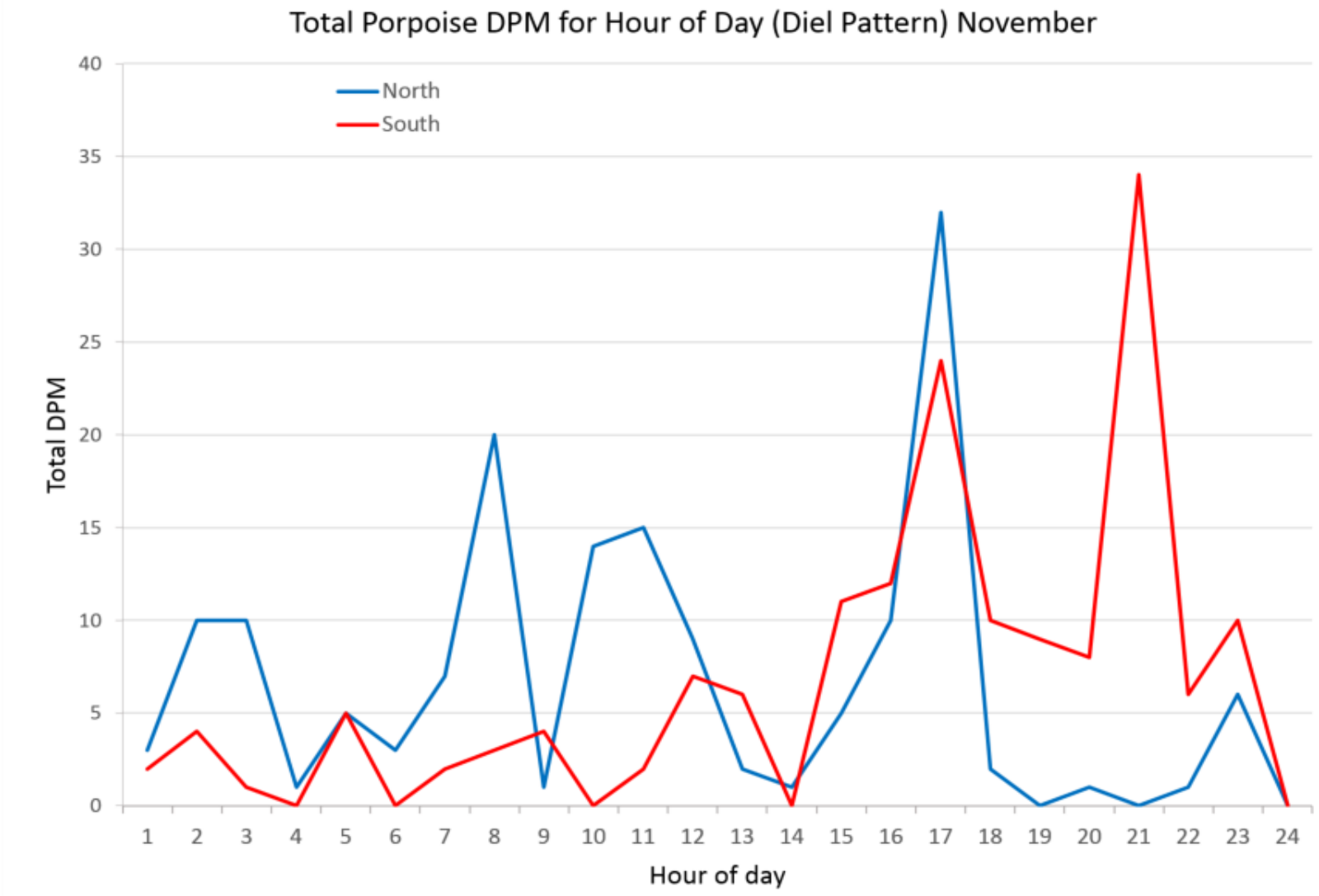

Figure 4-48.11. Total porpoise DPM for hour of day in November

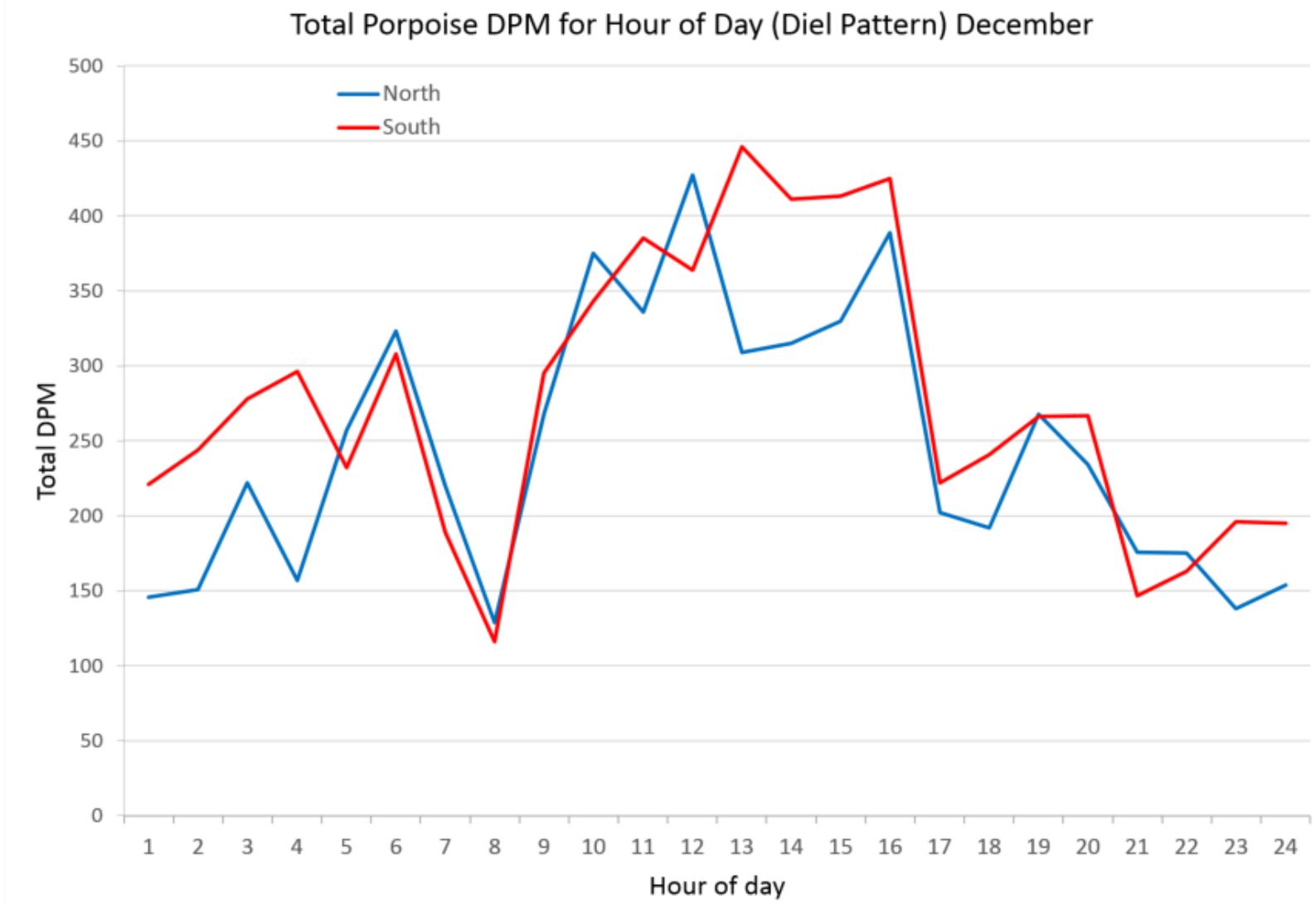

Figure 4-48.12. Total porpoise DPM for hour of day in December

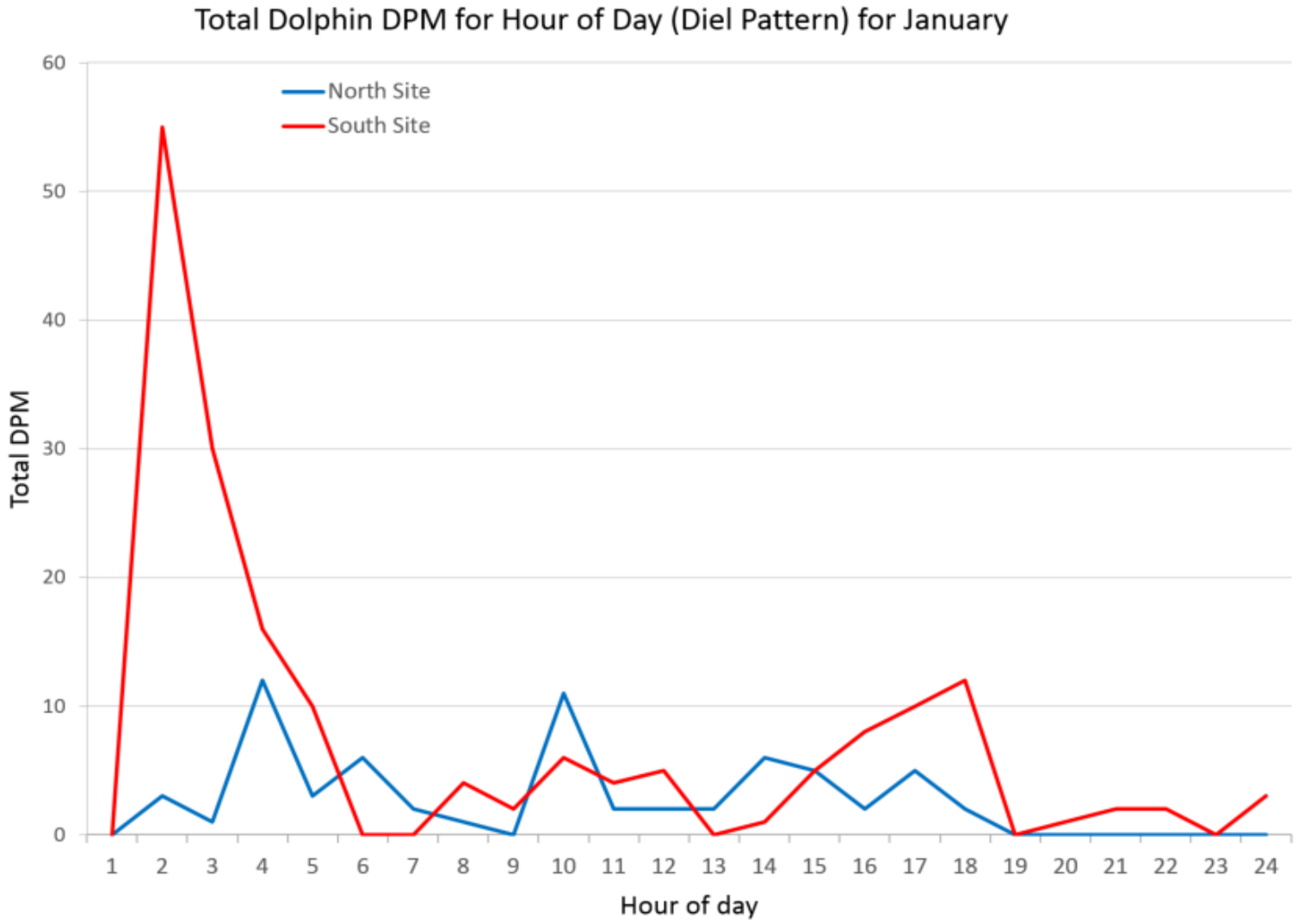

Figure 4-49.1. Total dolphin DPM for hour of day in January

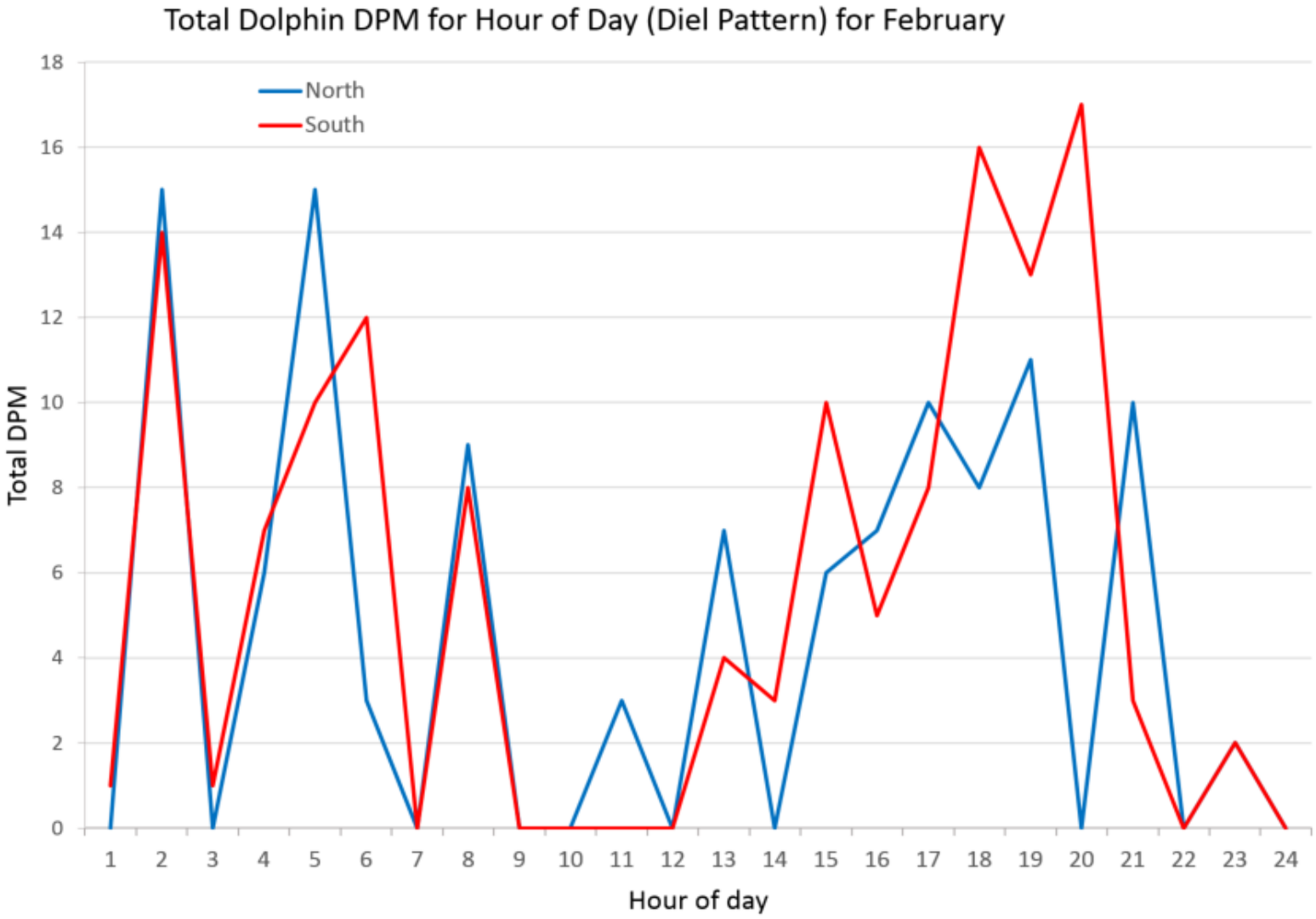

Figure 4-49.2. Total dolphin DPM for hour of day in February

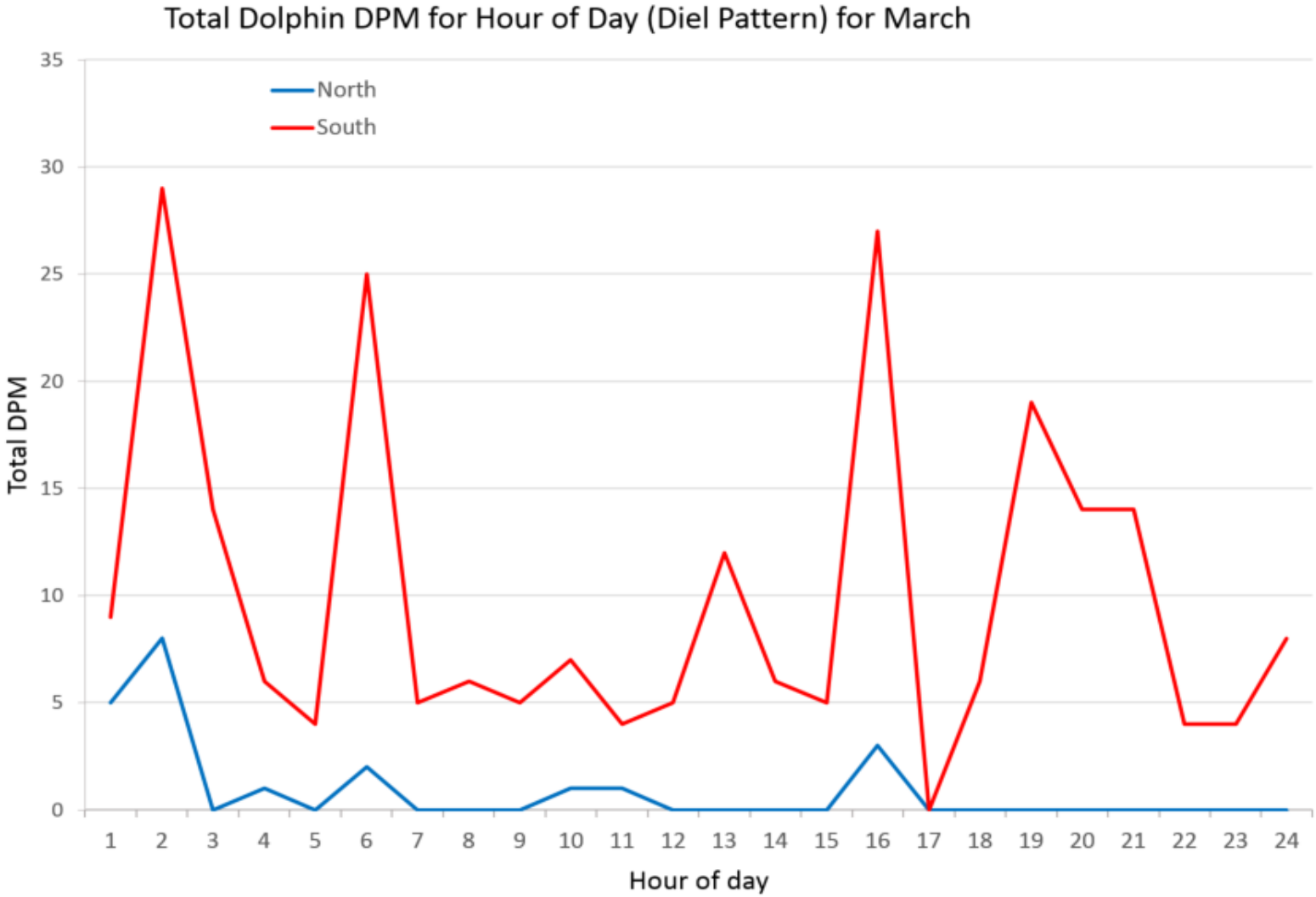

Figure 4-49.3. Total dolphin DPM for hour of day in March

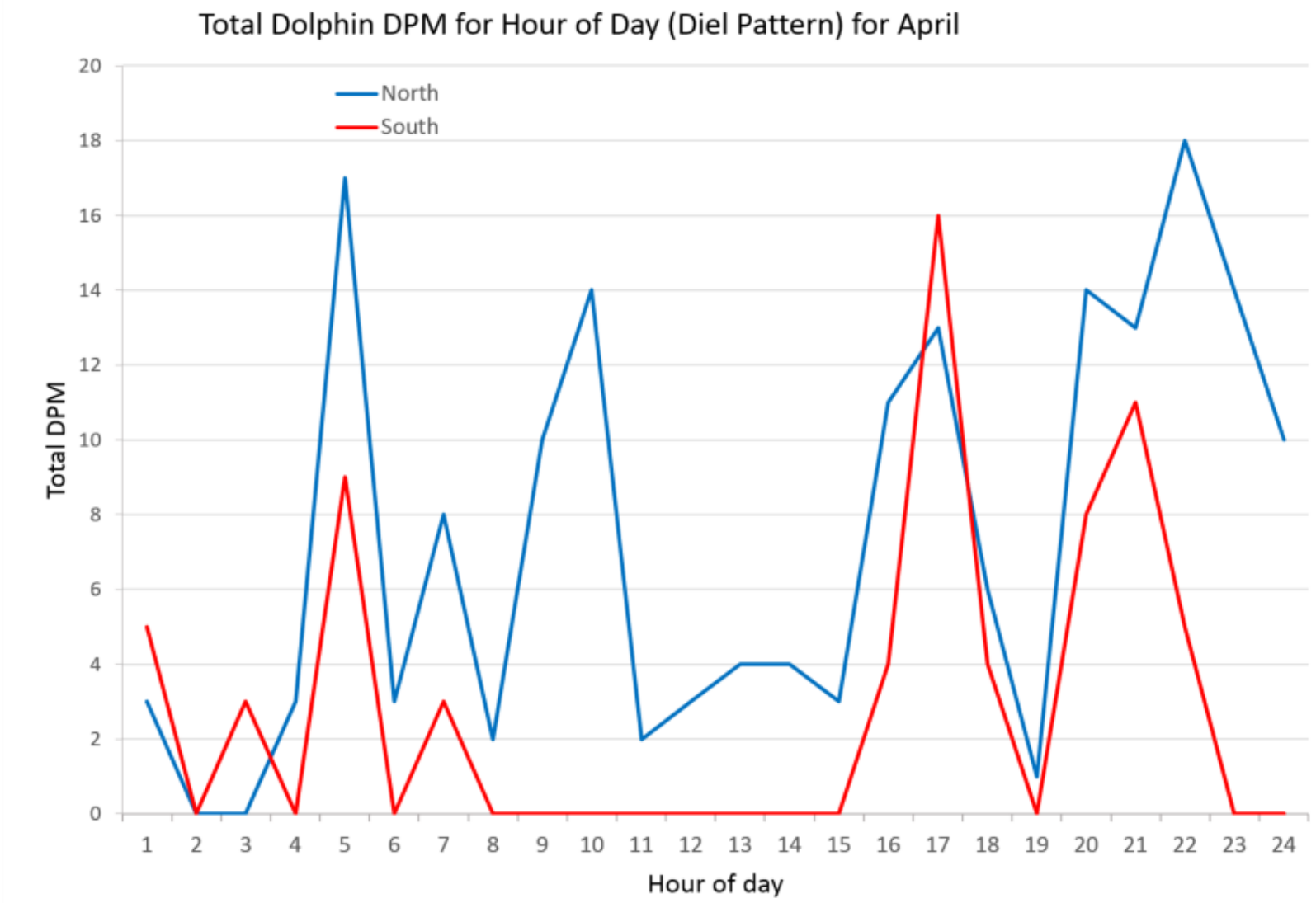

Figure 4-49.4. Total dolphin DPM for hour of day in April

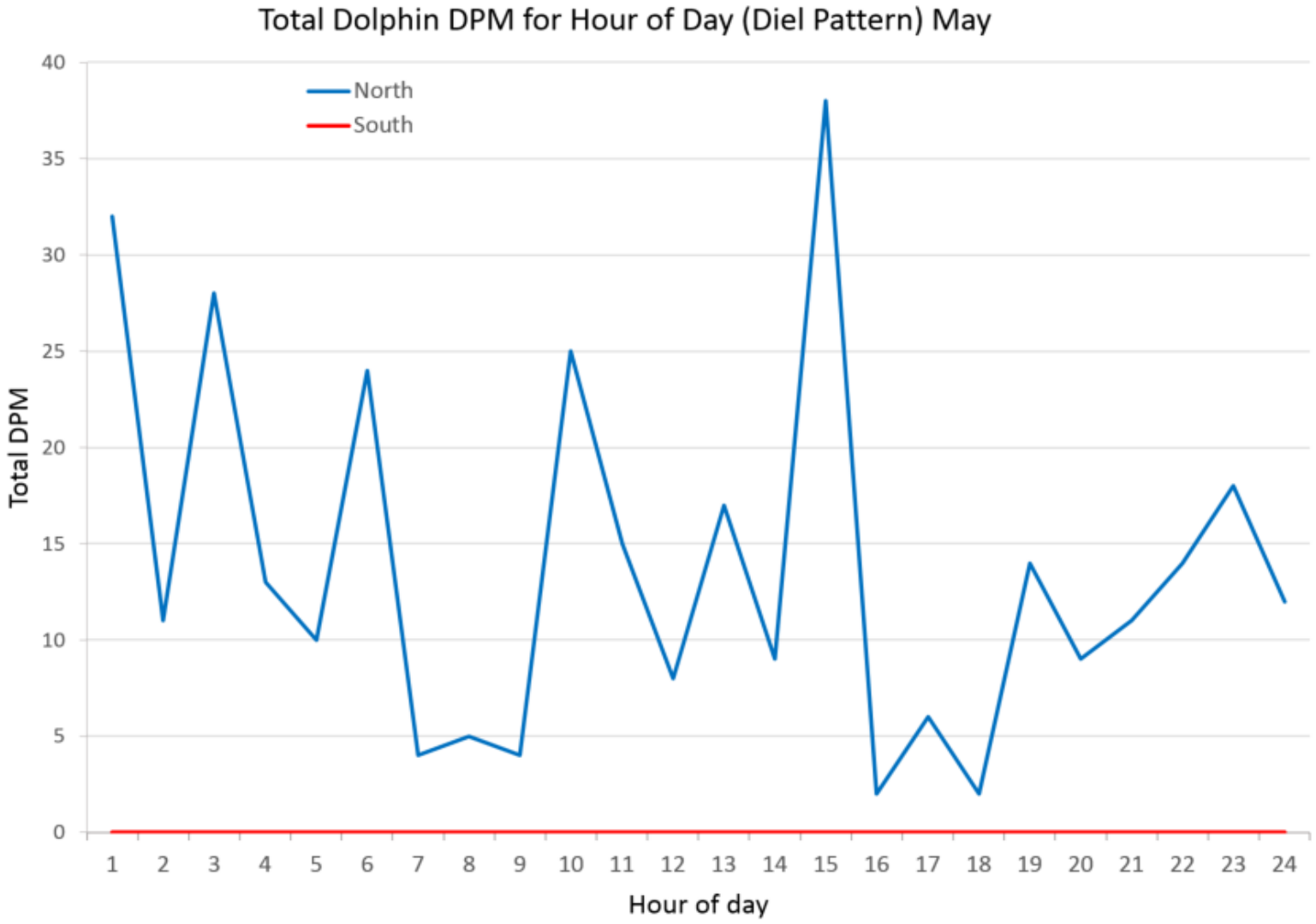

Figure 4-49.5. Total dolphin DPM for hour of day in May

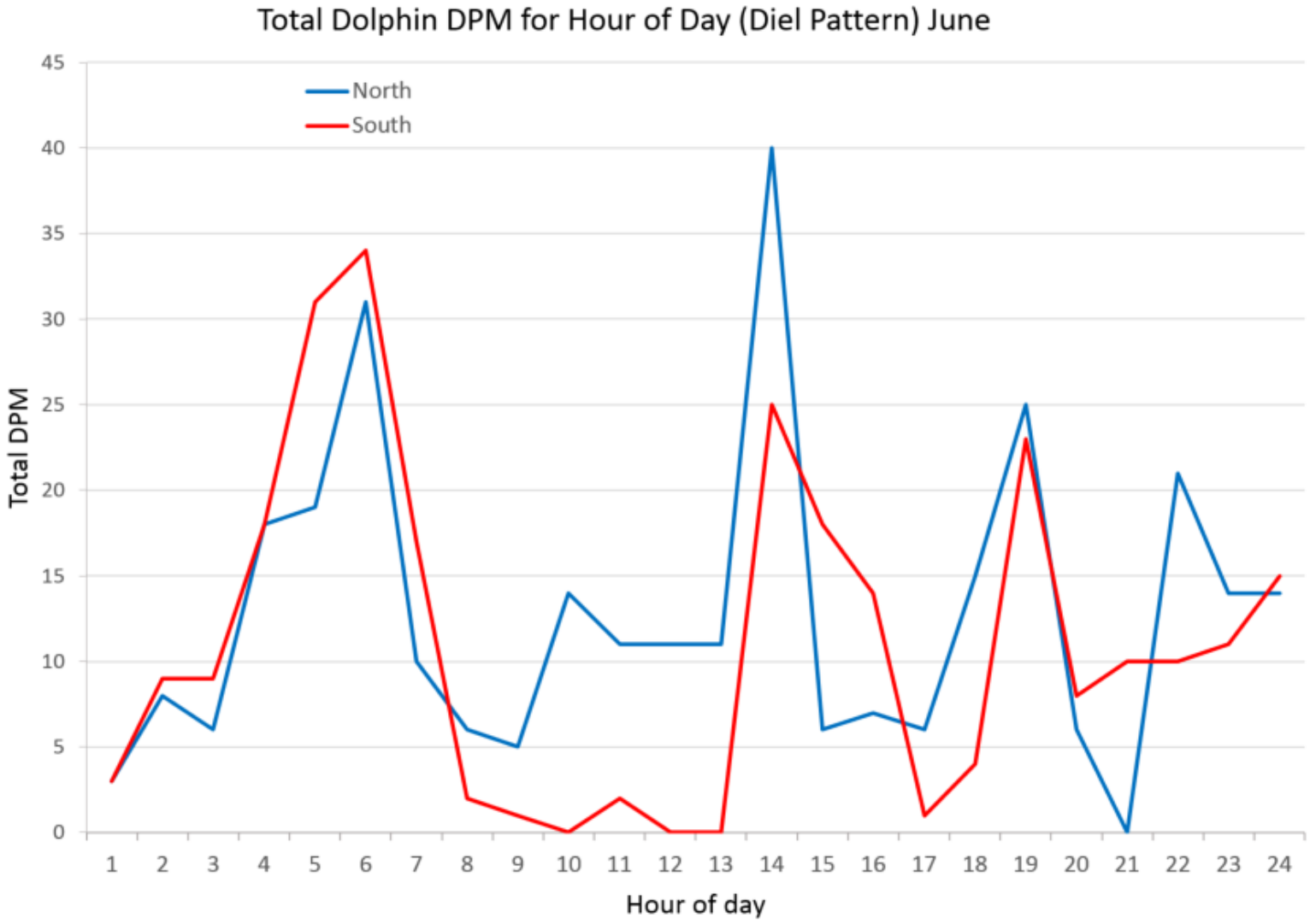

Figure 4-49.6. Total dolphin DPM for hour of day in June

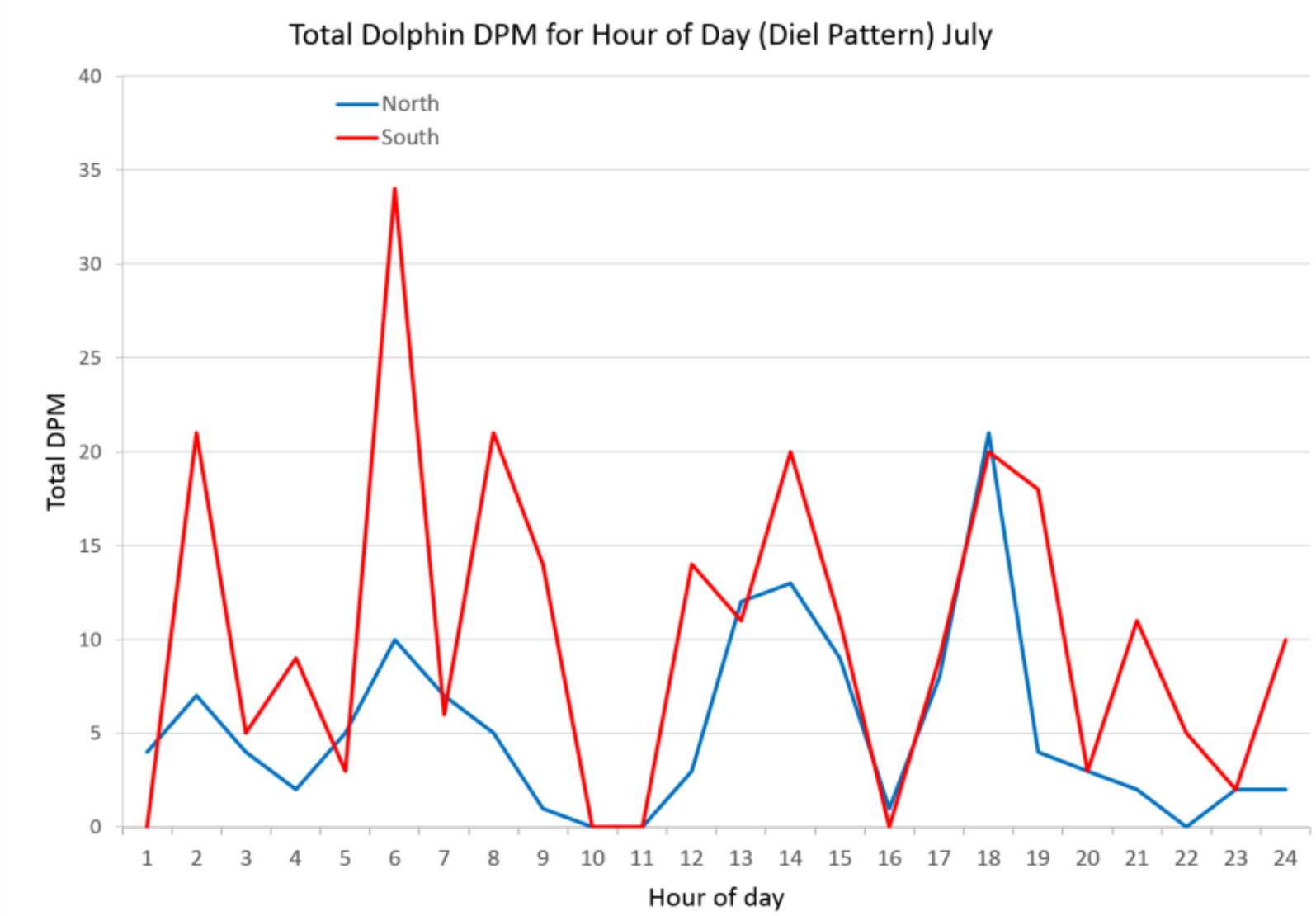

Figure 4-49.7. Total dolphin DPM for hour of day in July

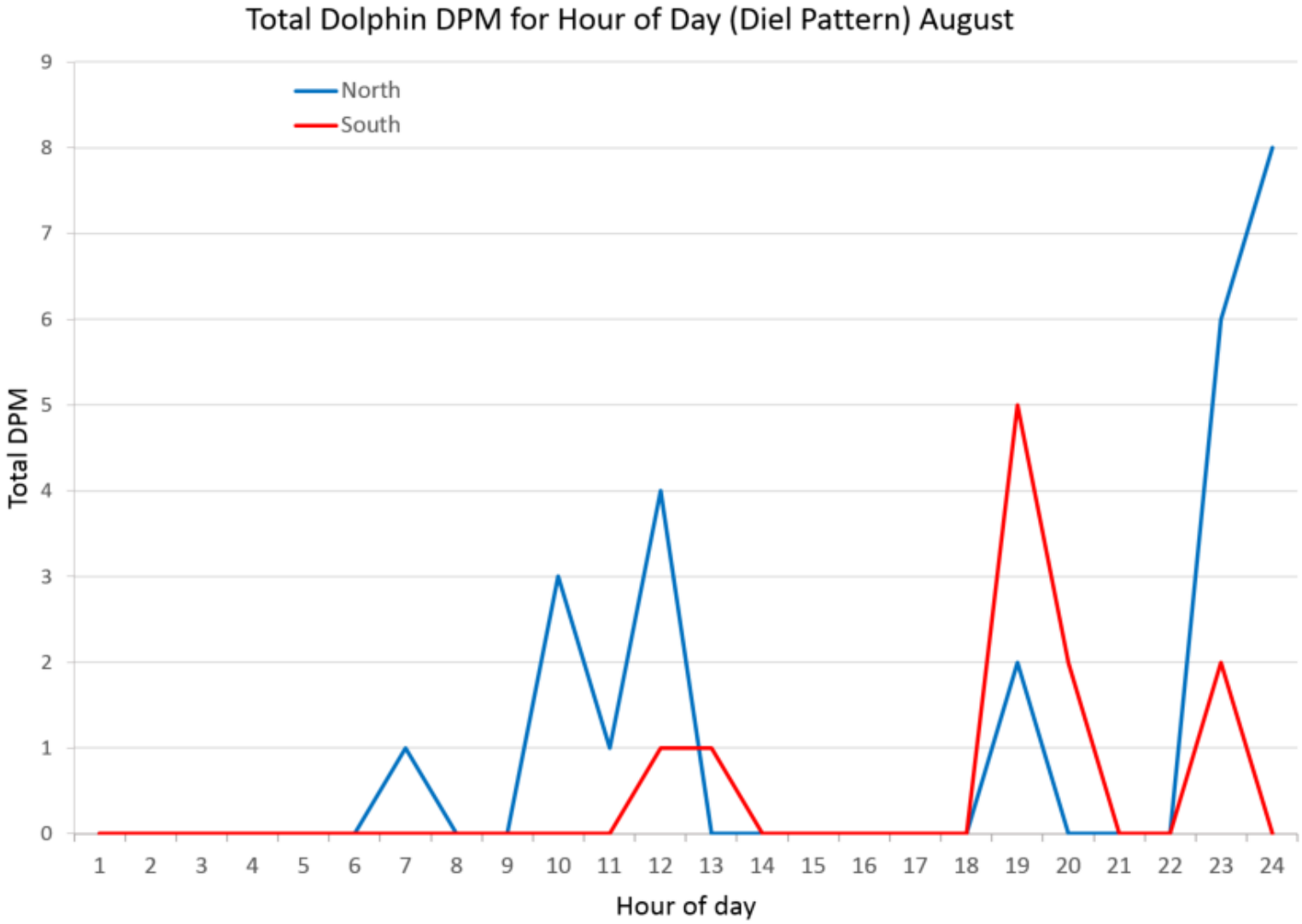

Figure 4-49.8. Total dolphin DPM for hour of day in August

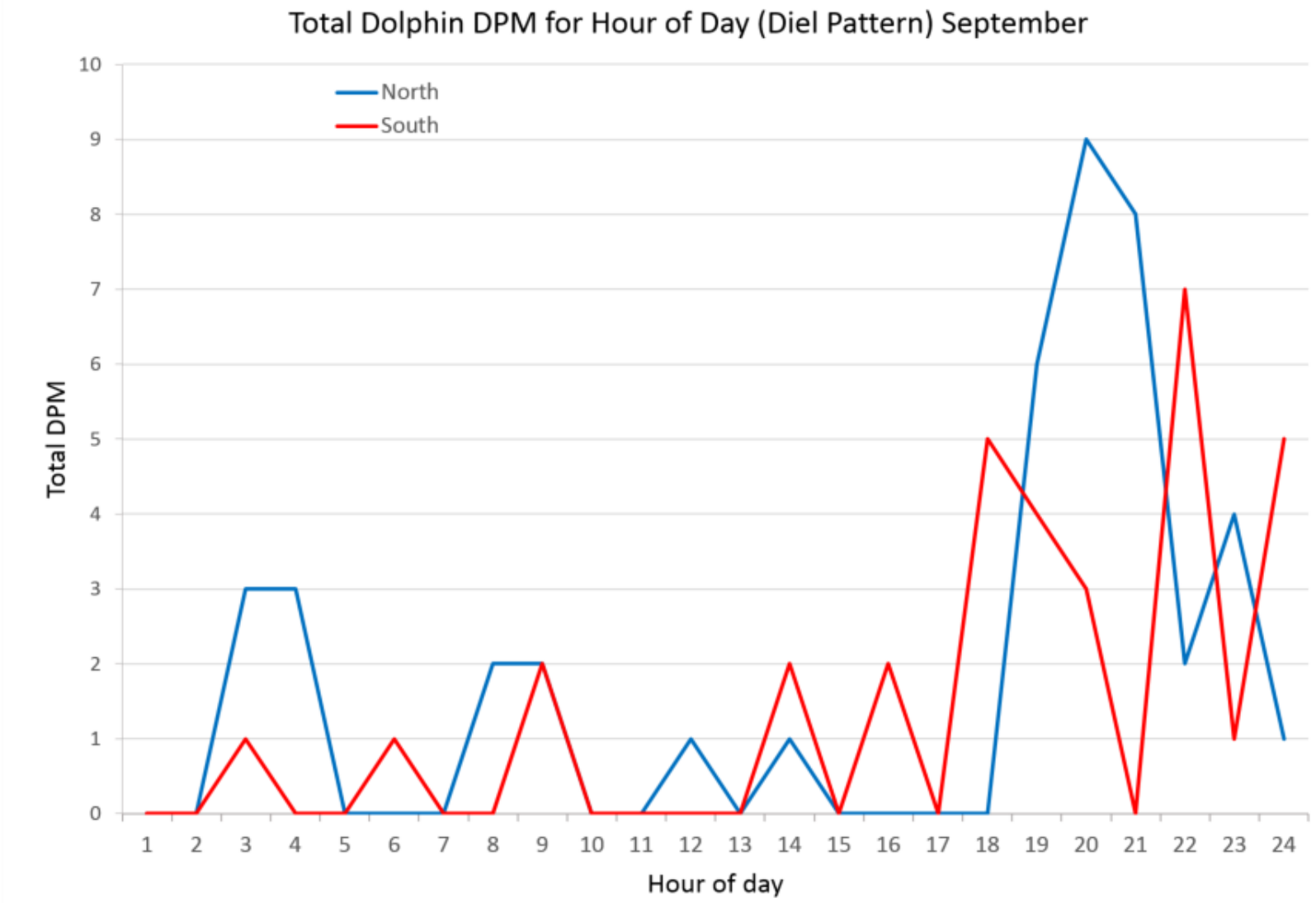

Figure 4-49.9. Total dolphin DPM for hour of day in September

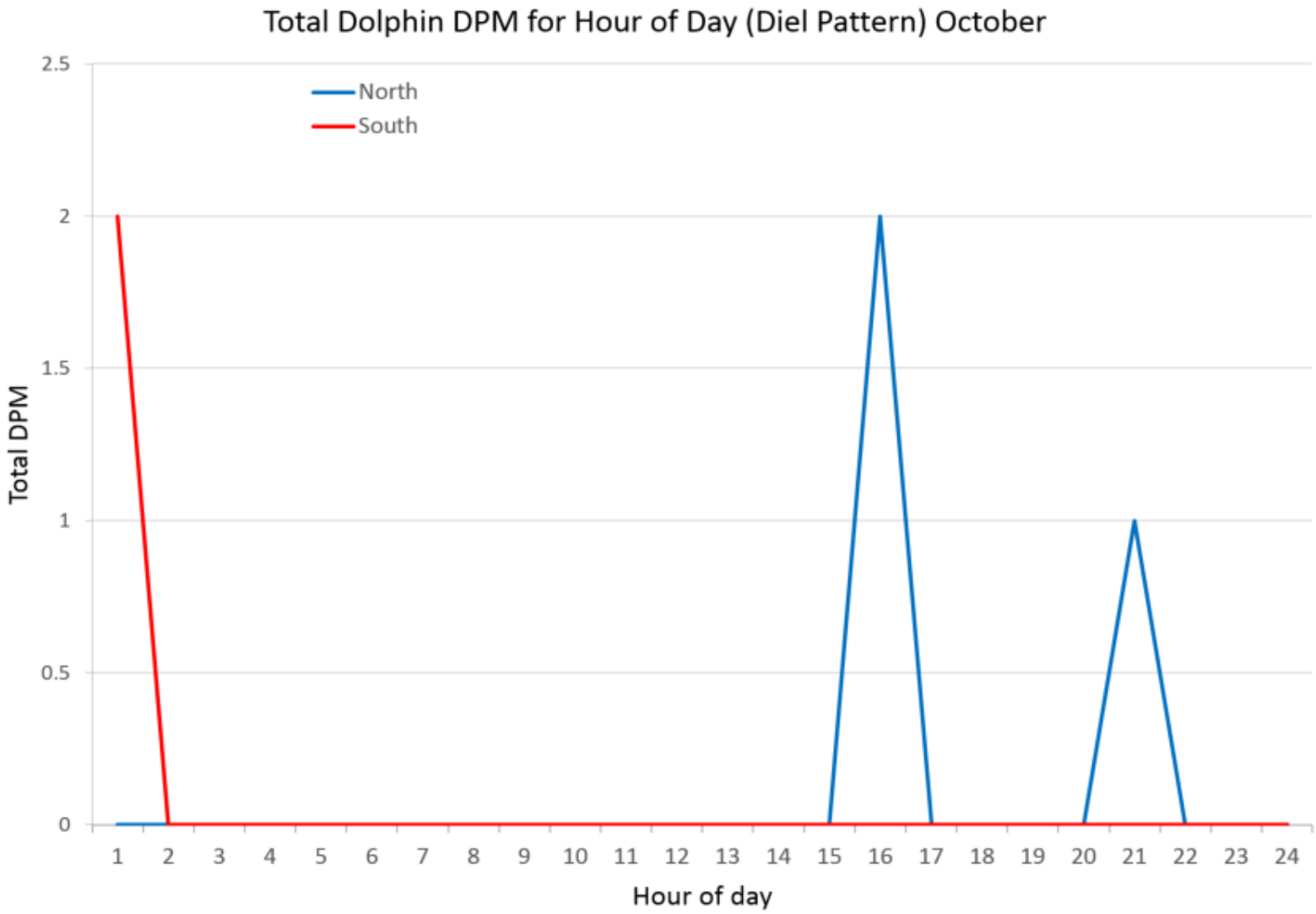

Figure 4-49.10. Total dolphin DPM for hour of day in October

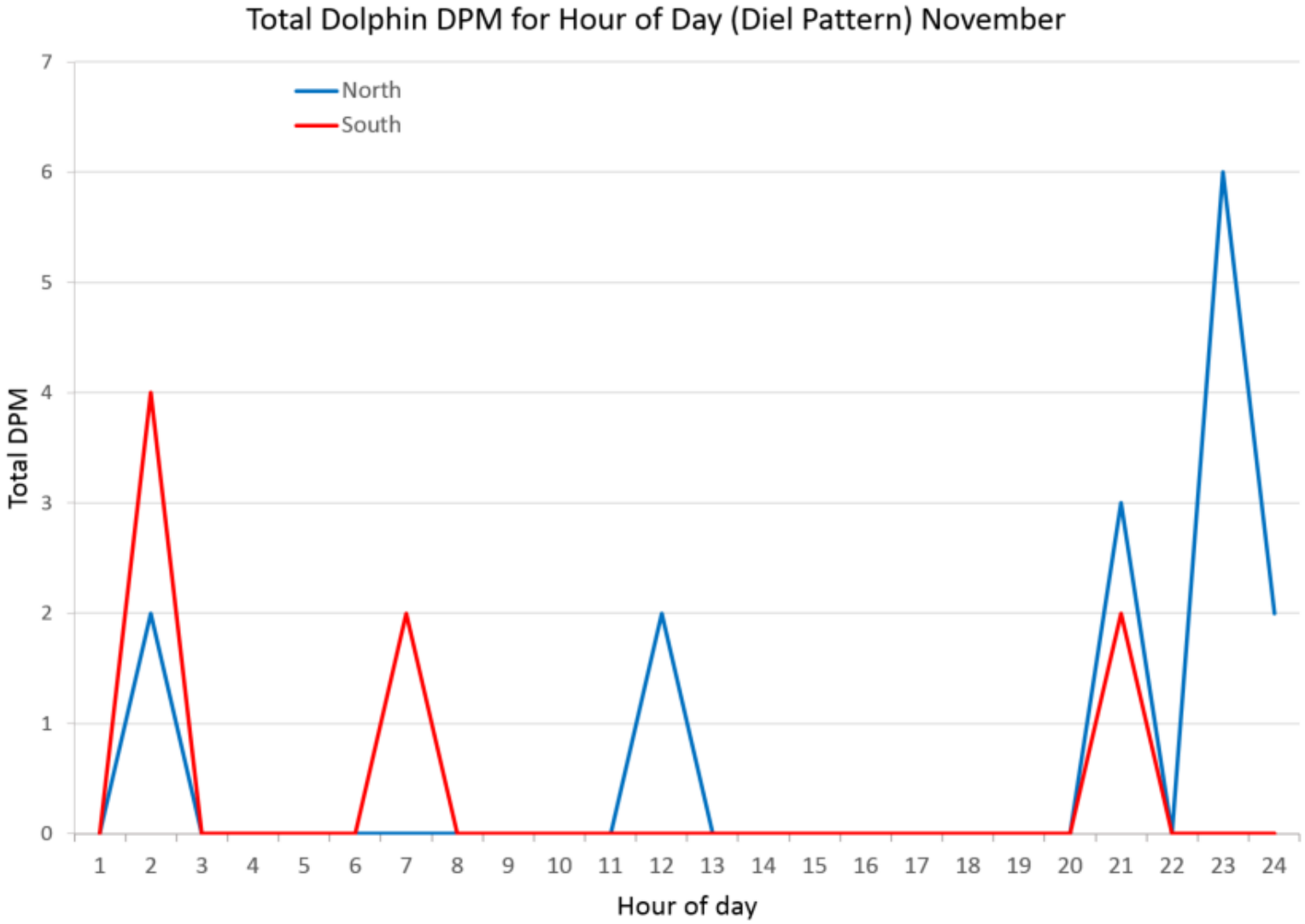

Figure 4-49.11. Total dolphin DPM for hour of day in November

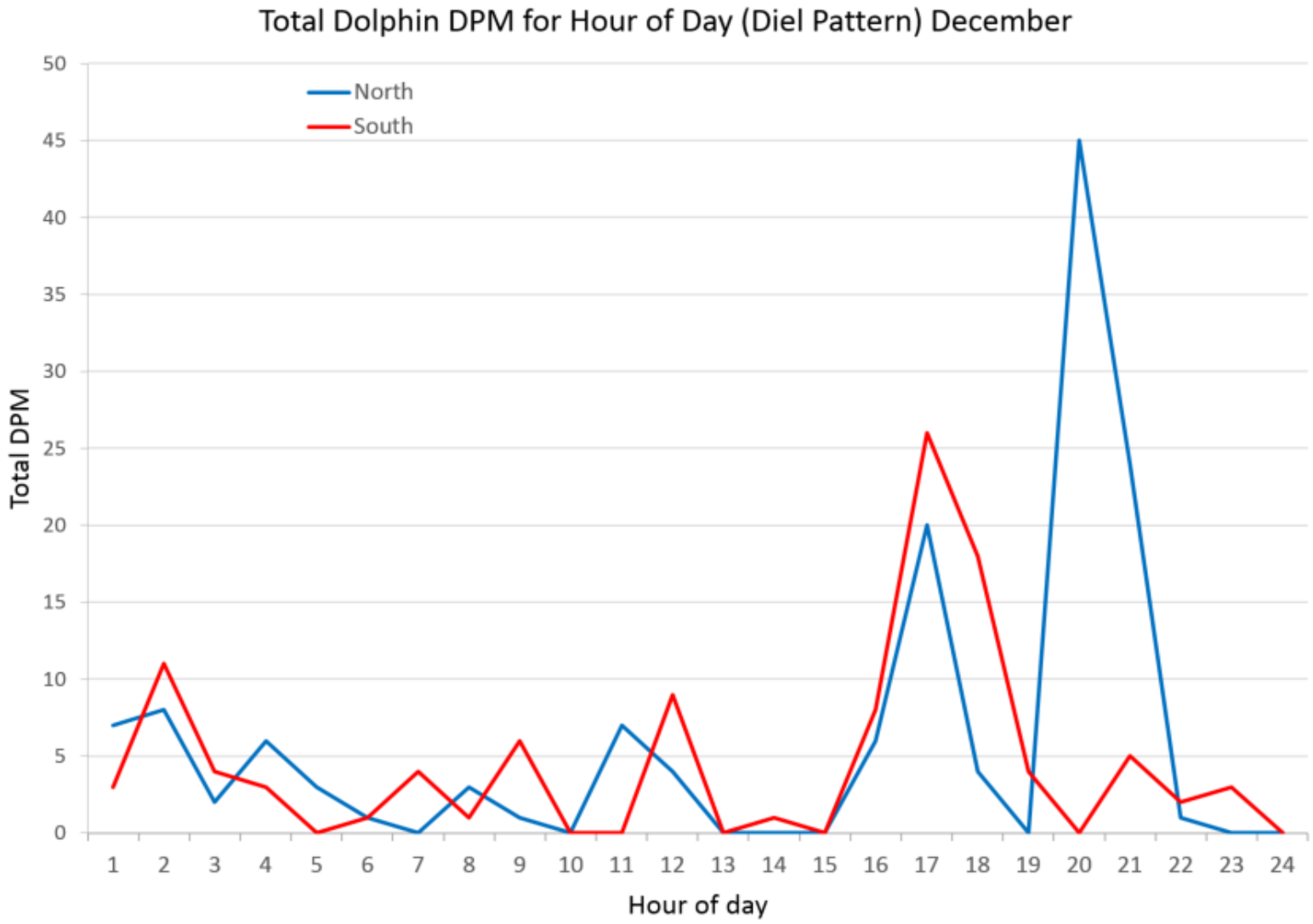

Figure 4-49.12. Total dolphin DPM for hour of day in December

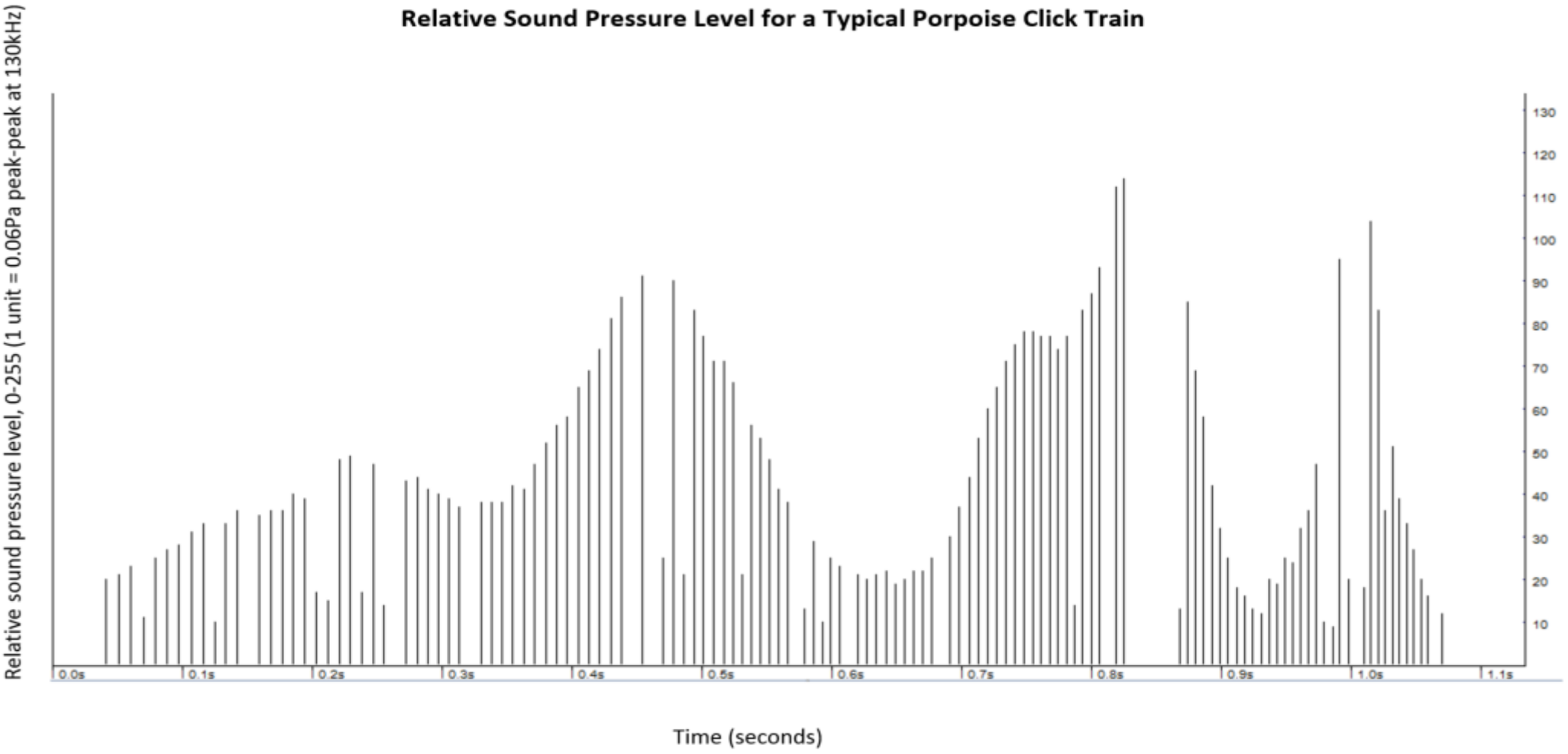

Figure 4-50: SPL Chart of a Typical Porpoise Click Train

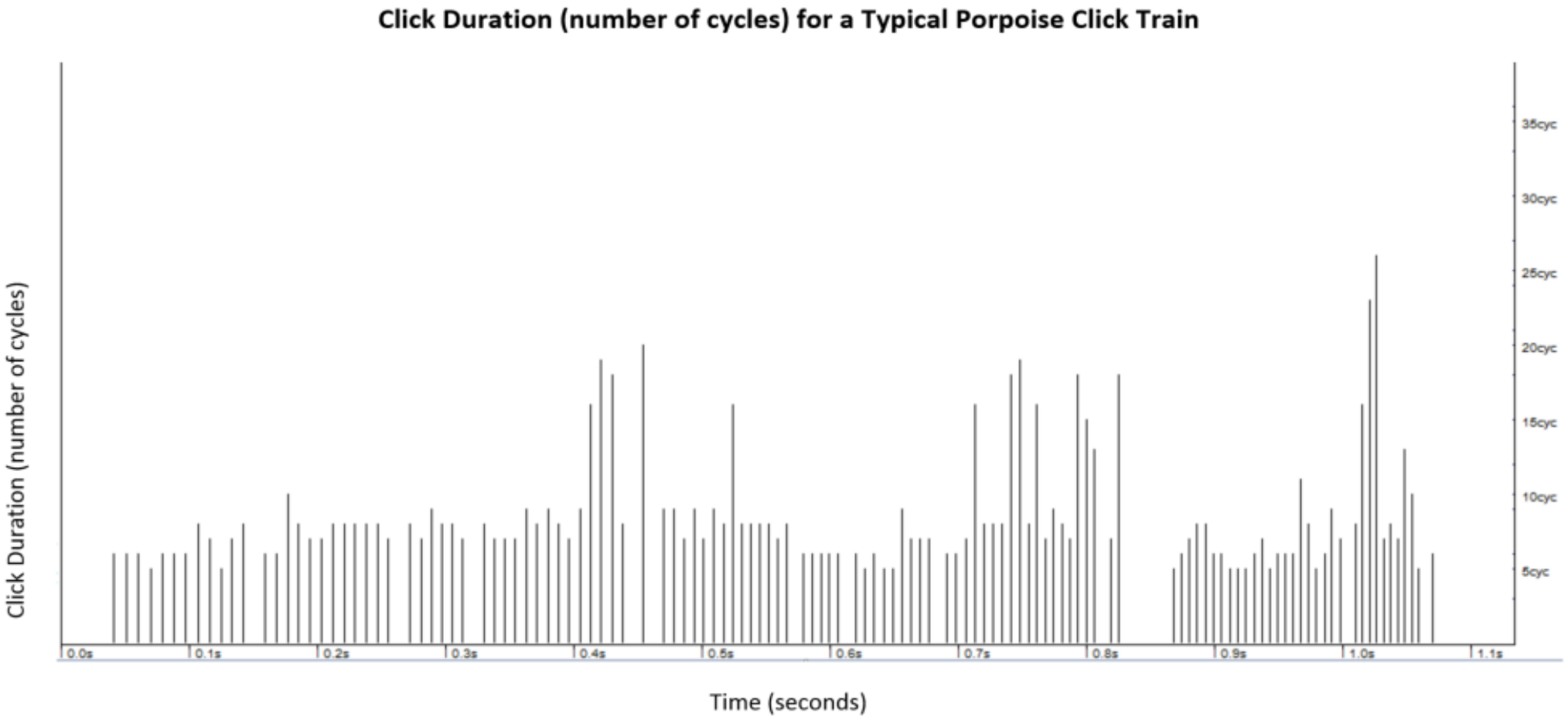

Figure 4-51: Duration (No. of Cycles) of a Typical Porpoise Click Train

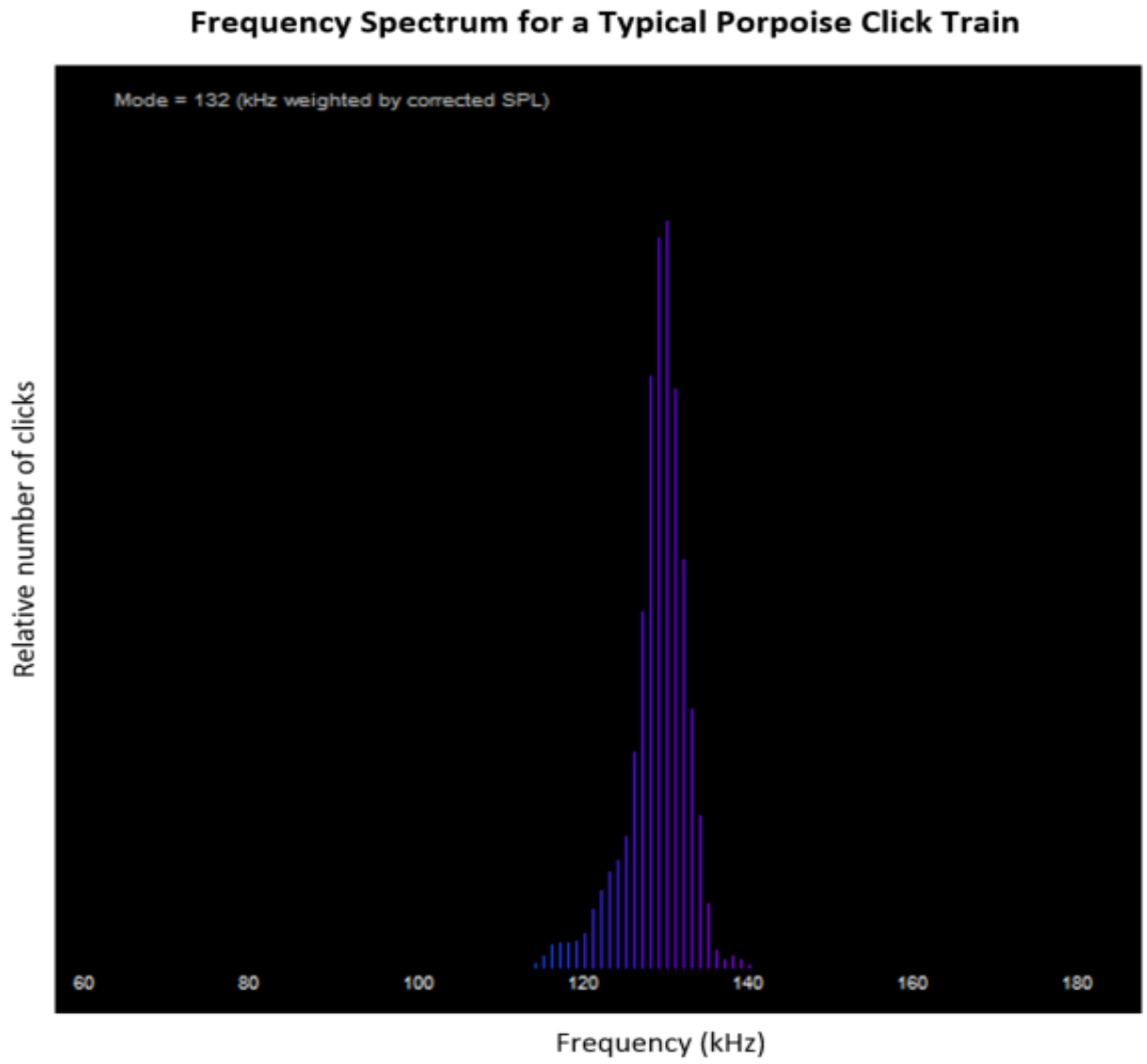

Figure 4-52: Frequency Spectrum of a Typical Porpoise Click Train

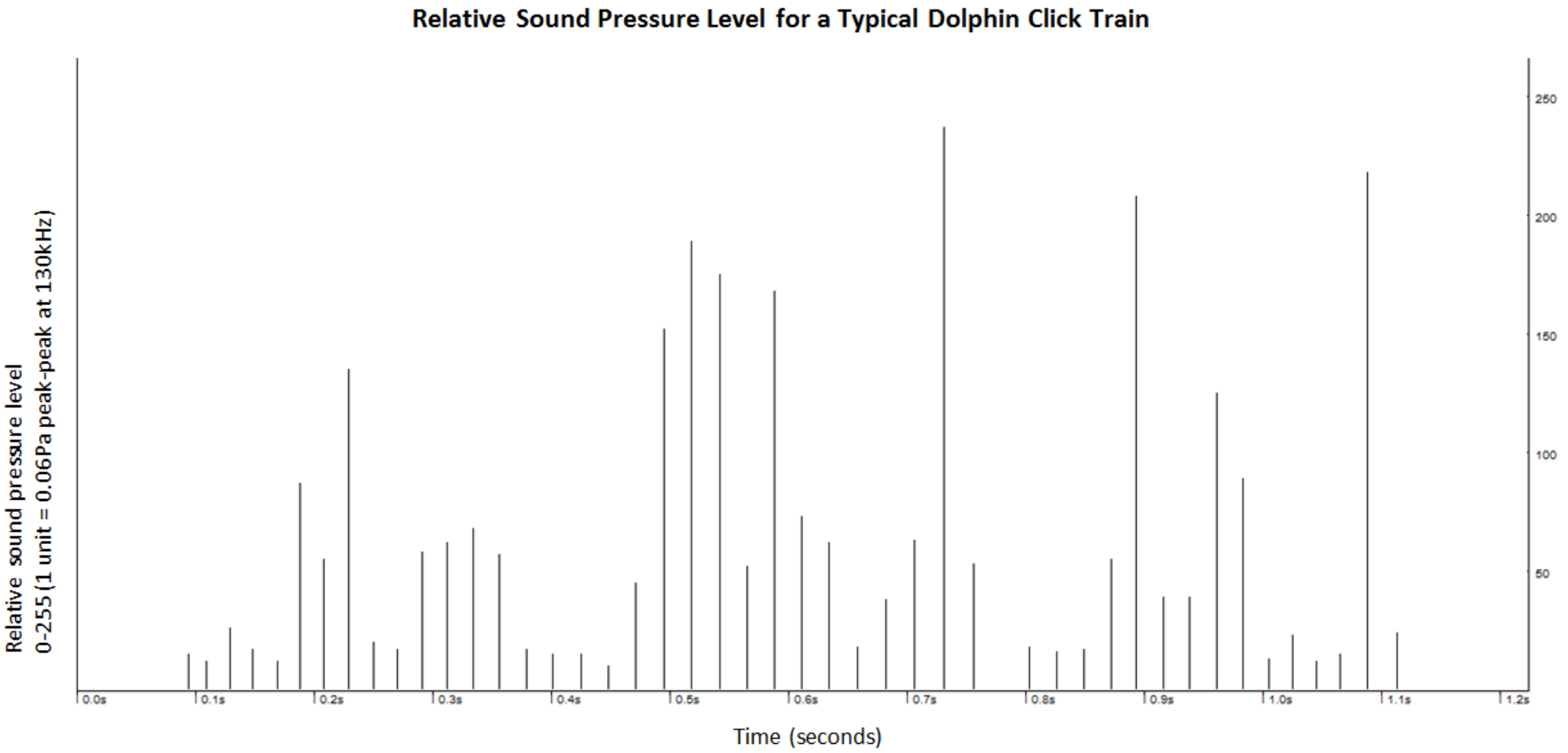

Figure 4-53: SPL Chart of a Typical Dolphin Train, Characterised by a Wide Frequency Spectrum and Multipath Clicks

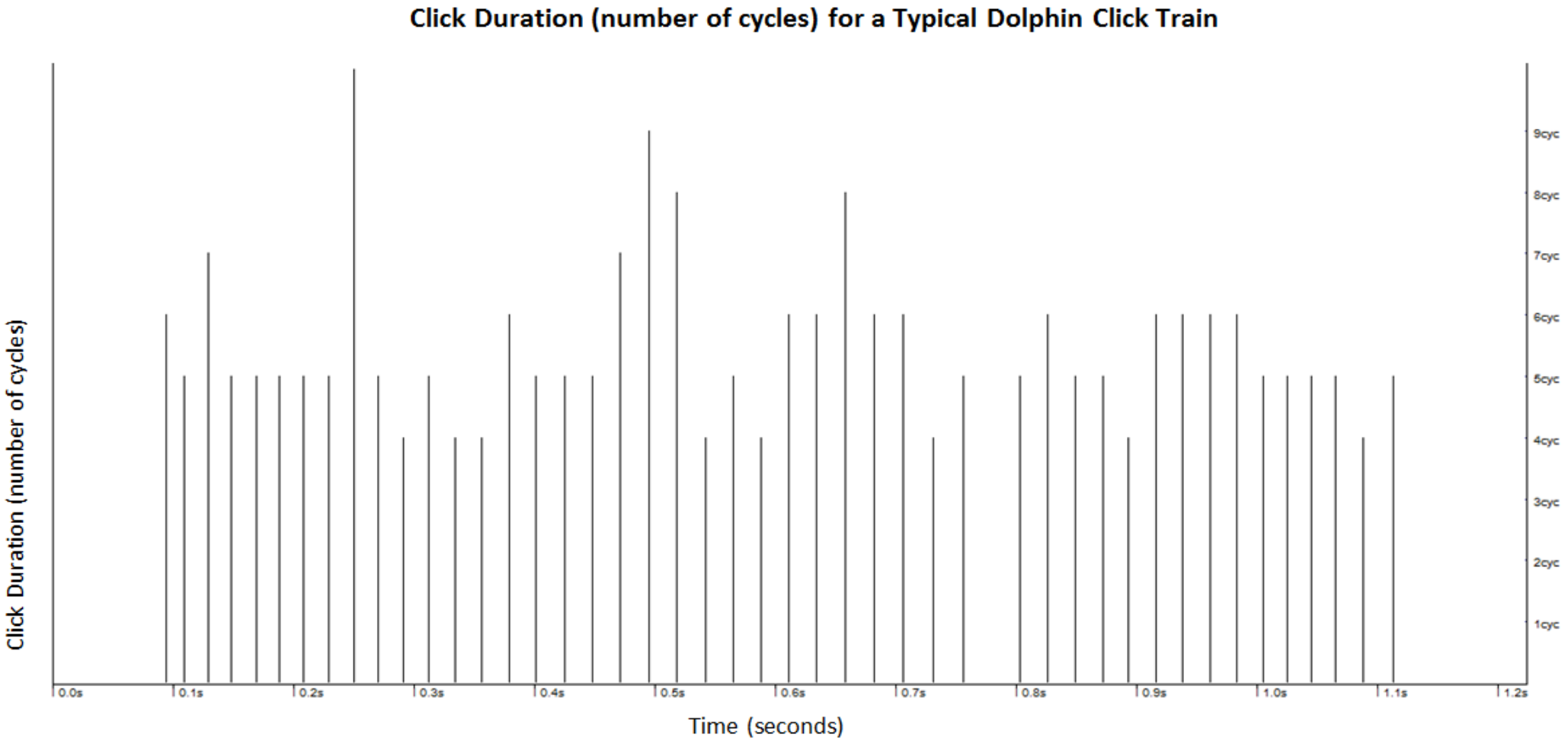

Figure 4-54: Duration (No. of Cycles) of a Typical Dolphin Click Train

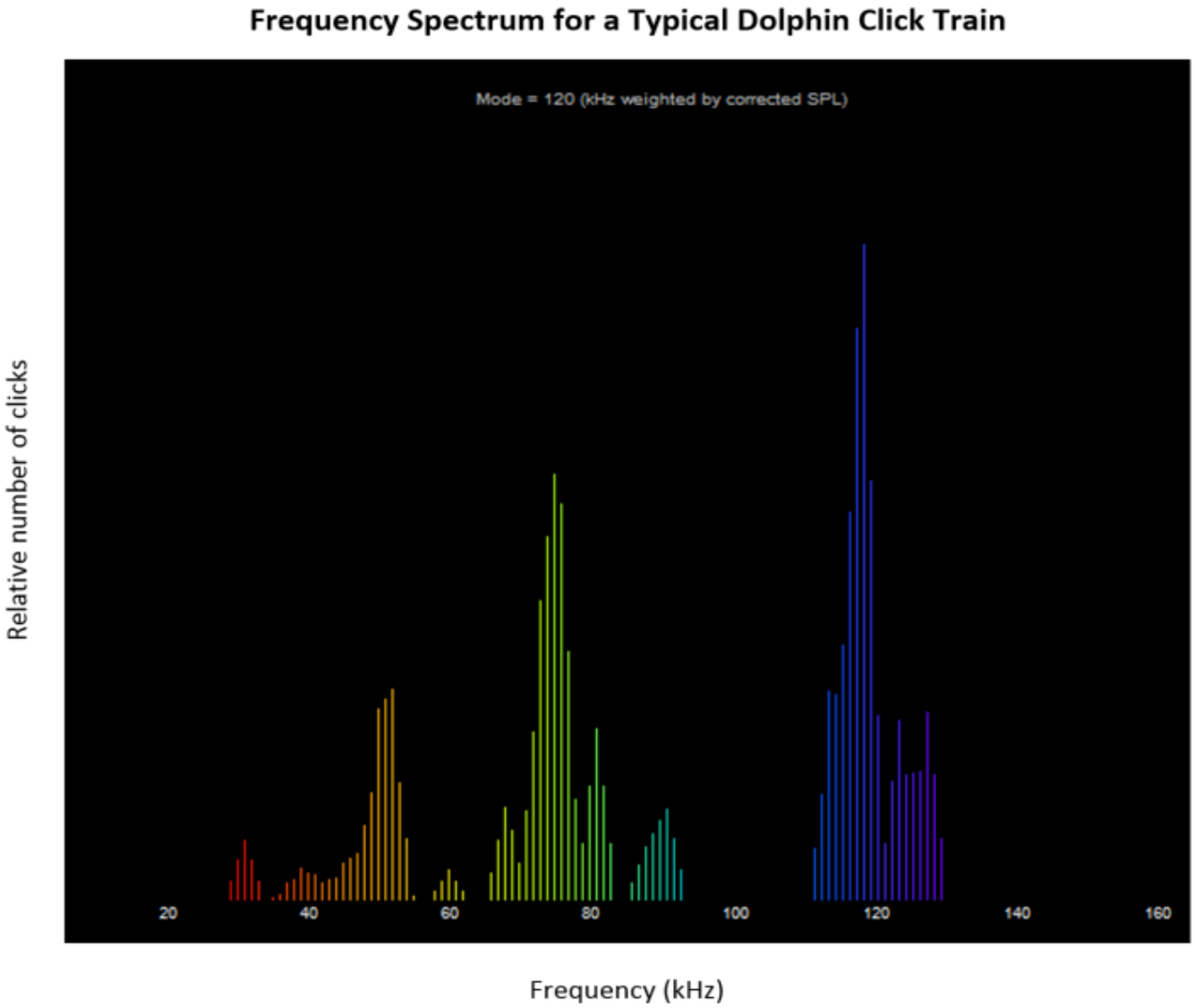

Figure 4-55: Frequency Spectrum of a Typical Dolphin Click Train

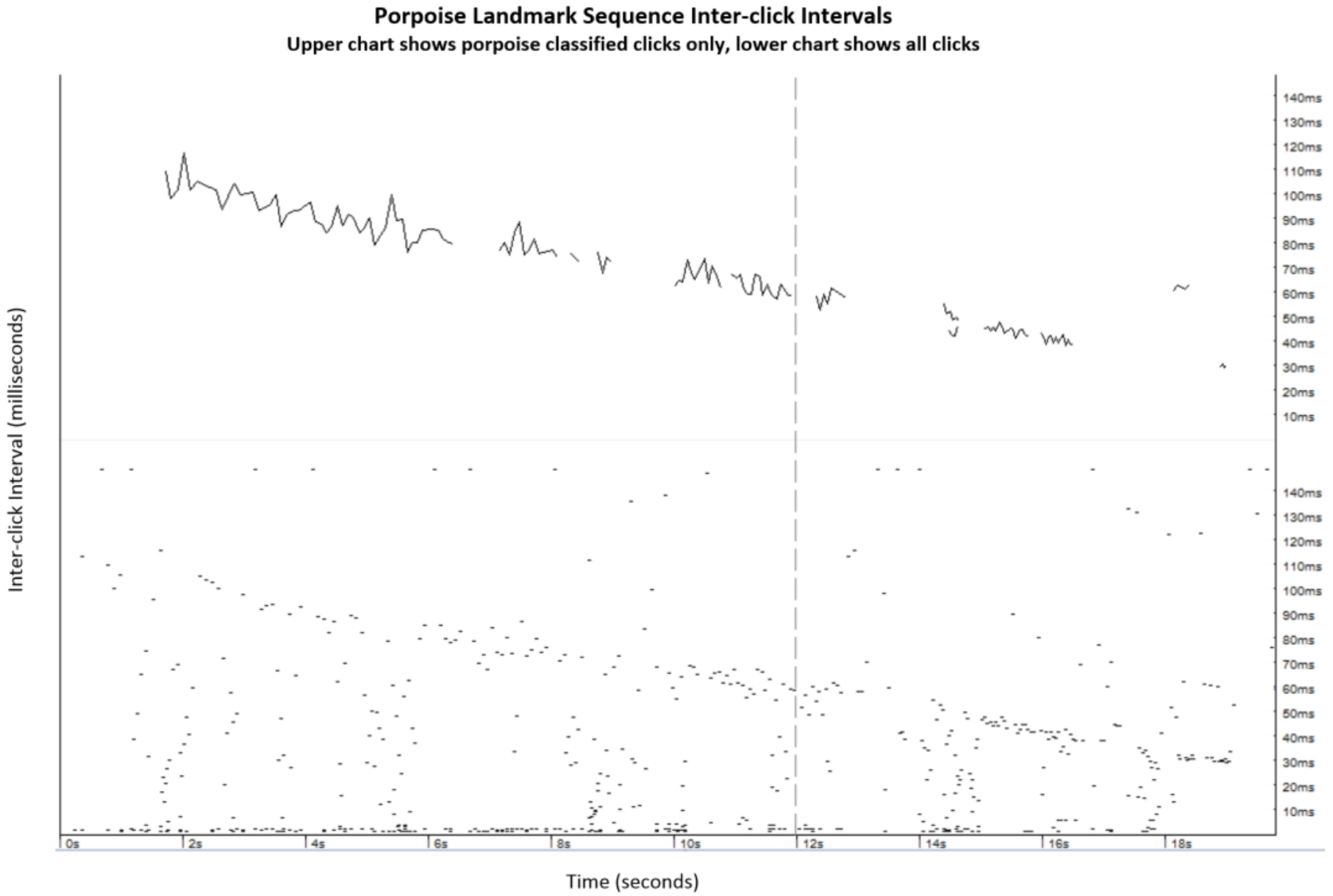

Figure 4-56: An Example of a Porpoise Landmark Sequence from the North Site in Deployment 1

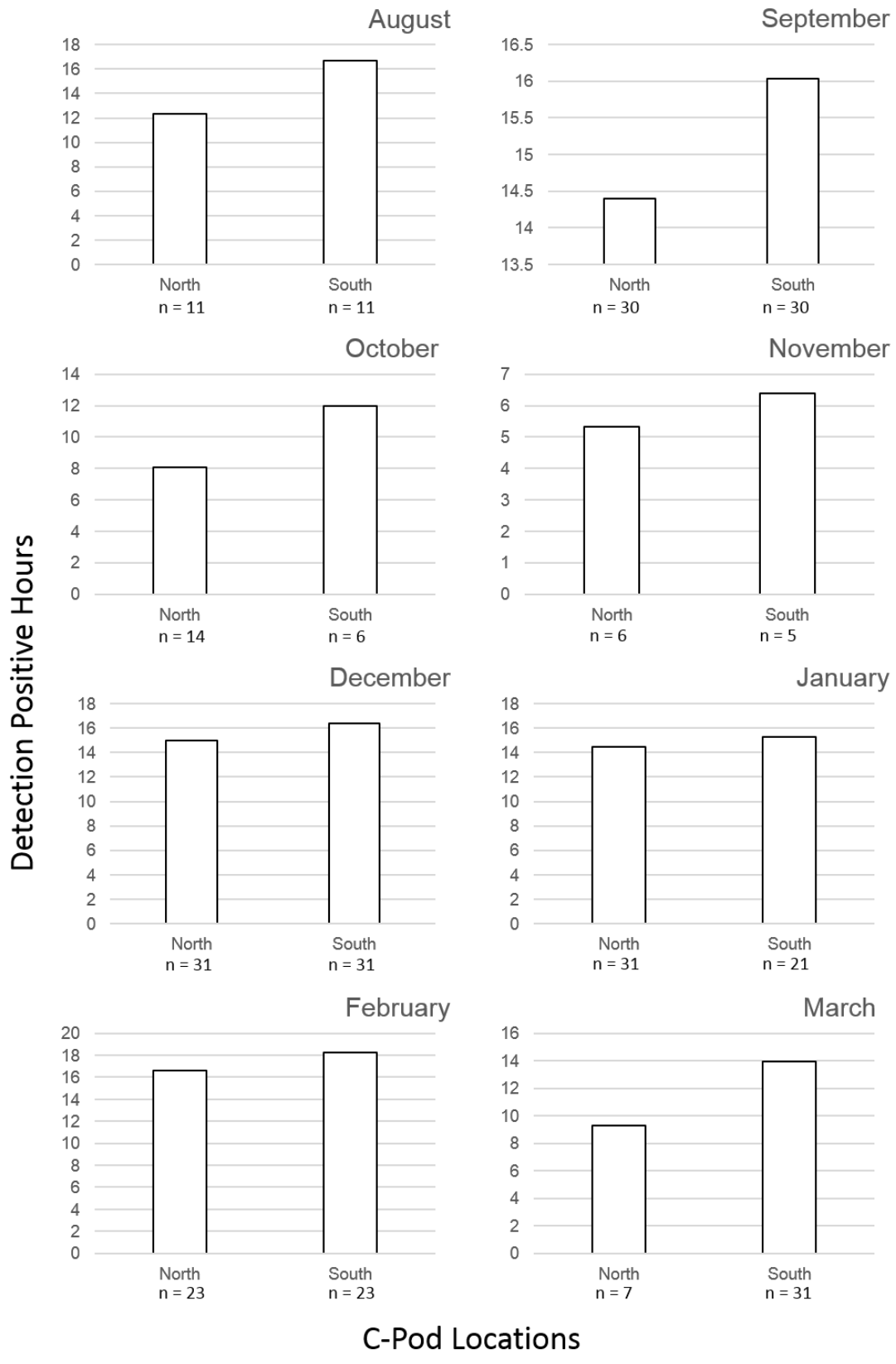

Figure 4-57: Mean Detection Positive Days per Month at the North and South C-POD Locations. Error bars represent the standard error of the mean and n= the sample size (number of days data recorded)

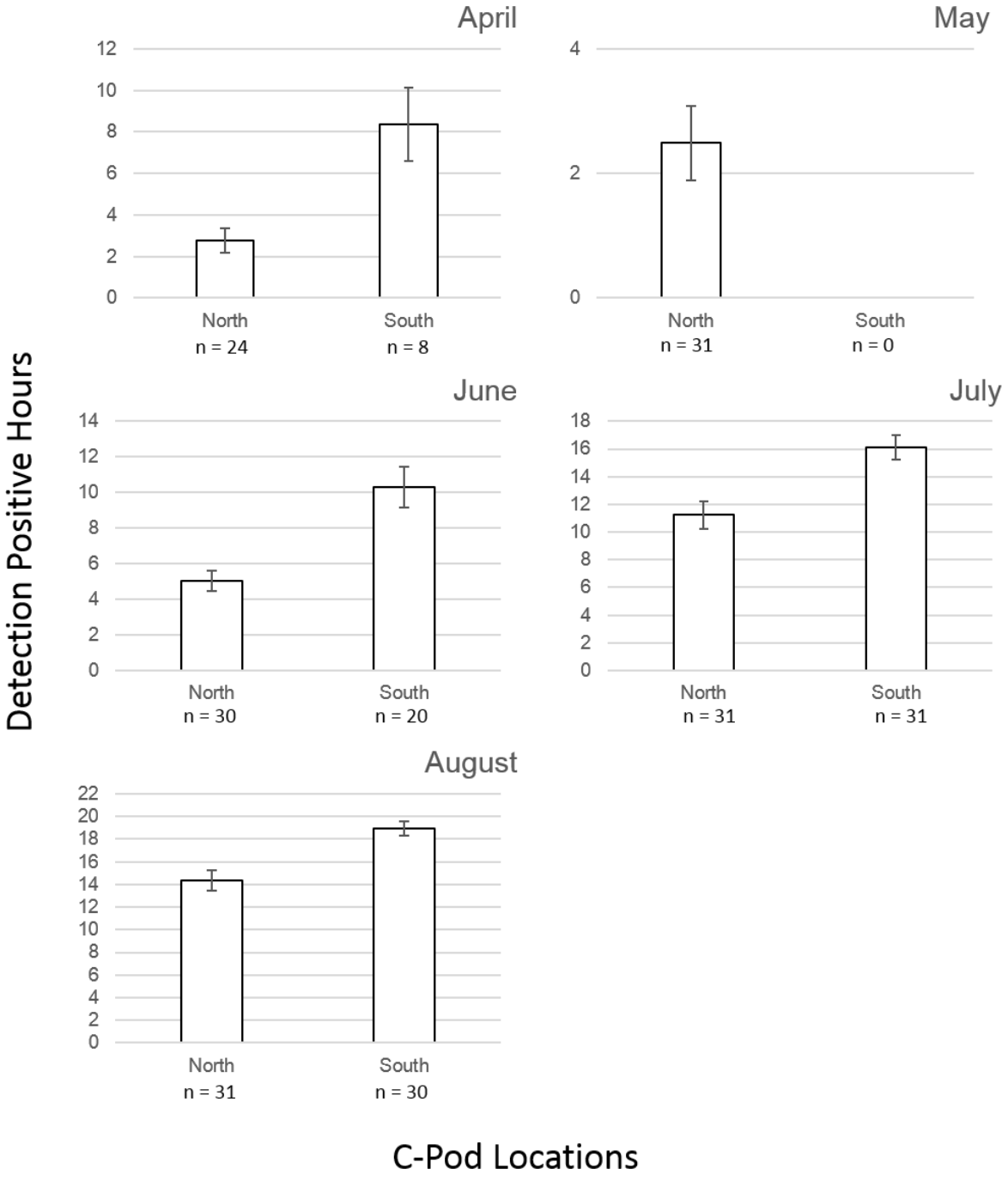

Figure 4-57: Mean Detection Positive Days per Month at the North and South C-POD Locations. Error bars represent the standard error of the mean and n= the sample size (number of days data recorded)