RAMBOLL

Ref.: HYDHZMBEEM00_0_7747L.19

7 November 2019

By Fax (3767 5922) and By Post

ARUP
Level 5, Festival Walk
80 Tat Chee Avenue
Kowloon Tong, Kowloon

Attention: Mr. Michael Chan / Mr. Mark Ching

Dear Sirs,

Re: Agreement No. CE 48/2011 (EP)
Environmental Project Office for the
HZMB Hong Kong Link Road, HZMB Hong Kong Boundary Crossing Facilities, and Tuen Mun-Chek Lap Kok Link – Investigation

Contract No. HY/2011/09 HZMB HKLR - Section between HKSAR Boundary and Scenic Hill
Final Report of Land-based Monitoring on North-South Movement of Chinese White Dolphins in West Lantau Waters After Bridge Construction

Reference is made to your letter providing a copy of the captioned report dated 31 October 2019 (letter ref.: 214487/(HY/2011/09)/M45/630/B30529).

Reference is also made to the "Proposal for Land-based Dolphin Behaviour and Movement Monitoring" (hereinafter referred to the "Methodology Proposal") dated 24 January 2013 prepared by the dolphin specialist.

We write to verify that the four Progress Reports the for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Sham Wat Station appended to the captioned report is in accordance with the Methodology Proposal prepared by the dolphin specialist.

Thank you very much for your attention and please feel free to contact the undersigned should you require further information.

Yours faithfully,
For and on behalf of
Ramboll Hong Kong Limited

Ray Yan
Independent Environmental Checker
HZMB HKLR

c.c.	HyD	Mr. Cheng Pan	(By Fax: 3188 6614)
	HyD	Mr. David Chan	(By Fax: 3188 6614)
	EPD	Mr. Alfred Lo	(By Fax: 2960 1760)
	AFCD	Dr. Y.M. Mak	(By Fax: 2377 4427)
	ARUP	Mr. Eric Chan	(By Fax: 2268 3970)

Internal: DY, YH, HW, ENPO Site

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Your ref -
Our ref 214487/(HY/2011/09)/M45/630/B 30529

BY HAND

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For the attention of Mr Y. H. HUI

31 October 2019

Dear Sir

Contract No. HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill

Final Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins in West Lantau Waters After Bridge Construction (September 2016 – August 2018)

I attach the report for the two-year post-construction Land-based Monitoring on North-South Movement of Chinese White Dolphins in West Lantau Waters after bridge construction (September 2016 – August 2018) with ETL's certification letters for IEC's review and verification.

The bored piling work and pier construction were completed in May 2016. In the approved monitoring proposal, the impact frequency was 30 consecutive days with an additional 64 days (twice per month) of monitoring, and these were completed in August 2016. Therefore, the "*after bridge construction*" monitoring was started in September 2016. Accordingly, in the report, the monitoring conducted since September 2016 shall be referred to "post-construction" (equivalent to "*after bridge construction*") in terms of its terminology.

Please note that the terms "baseline" (equivalent to "*before bridge construction*"), "construction" (equivalent to "*during bridge construction*") and "post-construction" (equivalent to "*after bridge construction*") are referred in the monitoring reports.

Should you have any queries, please do not hesitate to contact my ARE, Mr Dennis Yu, on 3767 5847.

Yours faithfully

Michael Chan
CRE / Supervising Officer's Representative

cc HyD/MW(SD) - Mr Y C Lam
IEC - Mr Ray Yan
Arup - Mr Eric Chan

Response required : Yes, please
Date required : ASAP
Attachments : Yes (92 x A4)

WYY/mw

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Our Ref: MA12014/DCVJV/it190111_1st

Dragages-China Habour-VSL Joint Venture

Site Office: Tung Chung Waterfront Road,
adjacent to Tung Chung New Development Pier,
New Territories, Hong Kong

By Mail
11 January 2019

Attn.: Mr. W K Poon (Project Director)

Dear Sir,

Contract No. HY/2011/09
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill
- Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (September 2016 – February 2017)

I refer to the revised Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (September 2016 – February 2017) dated September 27, 2017 for the captioned Contract prepared by Samuel Hung of Hong Kong Cetacean Research Project.

I hereby agree and certify that the above report is true and correct to the best of my knowledge.

If you need any further information, please call me at 2151 2089 or 9161 7287.

Yours faithfully,
WELLAB Limited

Dr. Priscilla Choy
Environmental Team Leader

CONTRACT HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill

Revised Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (September 2016 – February 2017)

By Samuel Hung, Ph.D.
Hong Kong Cetacean Research Project (HKCRP)

September 27, 2017

1. INTRODUCTION

The Hong Kong Link Road (HKLR) comprises a 9.4 km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1-km tunnel section to the reclamation formed along the east coast of the Airport Island, and a 1.6-km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). Dragages – China Harbour – VSL JV (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2011/09 – Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill".

According to the HKLR EM&A Manual, a number of environmental monitoring and audit works related to Chinese White Dolphins (a.k.a. Indo-Pacific humpback dolphins, *Sousa chinensis*) are to be conducted during baseline, construction and post-construction phases, including land-based dolphin behaviour and movement monitoring. In September 2016, a continuation of the construction phase monitoring on the north-south movement is commissioned by the Contractor, and this progress report for the land-based monitoring on north-south movement of Chinese White Dolphins across the Hong Kong Link Road presents the methodology and results during the first six months of monitoring from September 2016 to February 2017, at a location hereafter termed as Sham Wat Station.

2. METHODS

2.1. Monitoring Station

Based on the requirements under the EM&A Manual as described in the EM&A proposal for this work, the Sham Wat Station is located along the northwest coast of Lantau Island (GPS position: 22°16.10' N. and 113°52.32' E, Figure 1). The station was selected based on its height above sea level (minimum requirement of over 20 metres; Würsig et al. 1991), close proximity to shore, and relatively unobstructed views of the HKLR alignment to the west of the airport extending toward the HKSAR Boundary (Figure 2).

The height of the Sham Wat Station established by the HKCRP team is 55.70 metres high at mean low water, 66 metres from shore. The station is only a few hundred metres to the closest point of the HKLR alignment (Figure 2), which is ideal to examine the north-south movements of Chinese White Dolphins in relation to the HKLR alignment.

2.2. Monitoring Period and Definition of Baseline/Construction Phases

Before the present construction phase monitoring study, thirty days of shore-based theodolite tracking works were conducted for each of the baseline and initial construction phases according to the EM&A manual requirements (Table 1). An additional 64 days of shore-based monitoring (twice per month, with 5-6 hours on each survey day) were also conducted throughout the construction period specifically to examine the impact of bridge construction on north-south movement of Chinese White Dolphins across the bridge alignment. Such monitoring commenced after the 30 days of construction phase monitoring in relation to bored piling impact assessment was completed in July 2013, and ended in August 2016. In addition, shore-based theodolite tracking at Sham Wat Station was also conducted as part of the AFCD long-term marine mammal monitoring programme since 2011, and such data was integrated with the HKLR baseline monitoring data to increase the overall sample size for analysis on the north-south movements of dolphins (Table 1).

For the examination of north-south movement of Chinese white dolphins across the HKLR alignment, the baseline phase was defined as the time period from April 2011 (i.e. the start of AFCD monitoring at Sham Wat) up to June 2013. Even though bored piling works associated with HKLR construction commenced on March 18th and continued until April 13th of 2013, only minor work procedures with lower level of disturbance (such as installation of permanent casing and excavation for bored pile) took place at two pier sites (P48 and P52). Presumably these works in less

than a month at the very initial stage of bored piling works have insignificant impact as obstruction on north-south movements of dolphins. And after this brief period of construction, the bored piling works were suspended for two months in May and June 2013 as part of the environmental permit condition to avoid the peak calving season of Chinese White Dolphins. Therefore, the period of March to June of 2013 was also included as part of the baseline period with very low level of construction activities occurred along the HKLR alignment (Table 1).

Table 1. Different monitoring periods during baseline/construction phases, with the current six-month monitoring period highlighted in **blue**

(* The initial construction phase in March – June 2013 was considered under baseline phase, as only minor work procedures with lower level of disturbance took place at just two pier sites)

	Survey Type	Time Period	Effort (# of hours)
Baseline Phase	HKCRP	Apr 2011 – Dec 2012	51.1
Baseline Phase (under bored piling monitoring program)	HKLR	Jan 2013	177.8
Initial Construction Phase* (under bored piling monitoring program)	HKLR	Mar-Apr 2013	179.3
	HKCRP	Apr-Jun 2013	30.9
Construction Phase	HKLR/HKCRP	Jul-Dec 2013	107.5
	HKLR/HKCRP	Jan-Dec 2014	134.8
	HKLR	Jan-Dec 2015	128.8
	HKLR	Jan-Aug 2016	84.1
	HKLR	Sep 2016 – Feb 2017	63.1

On the other hand, the construction phase for this monitoring on north-south movements was defined as the time period starting from July 2013, when marine bored piling activities construction works have intensified significantly until almost all piling works were completed in March 2015, and with subsequent monitoring works ended in August 2016. The additional six months of monitoring starting in September 2016 under the present study is also included as part of the construction phase as well (Table 1).

2.3. Monitoring Methodology

The methodology of the present monitoring programme generally followed the one established under the Piwetz et al. (2012) study that was part of the AFCD long-

term marine mammal monitoring programme (Hung 2012). On each survey day from Sham Wat Station, observers searched continuously for Chinese white dolphins using unaided eyes and 7x50 handheld binoculars. A theodolite tracking session was initiated when an individual dolphin or group of dolphins was located, and focal follow methods were used to track the dolphins (Lundquist 2012, Lundquist et al. 2012a and 2012b, Piwetz et al. 2012).

Within a group, a focal individual was selected for the purposes of tracking behaviour and movement of the group, based on its distinctive feature such as colouration or severe injury mark. The focal individual or group were then tracked continuously via the theodolite, with positions recorded whenever a known or unknown dolphin surfaced. If an individual could not be positively distinguished from other members, the group would be tracked by recording positions based on a central point within the group when the dolphins surfaced. Tracking continued until animals were lost from view, moved beyond the range of reliable visibility (generally >3 km but up to >5 km under excellent conditions), or when environmental conditions obstructed visibility (e.g. intense haze).

Positions of dolphins, boats and construction activities were measured using a Sokkisha DT5 digital theodolite with ± 5-sec precision and 30-power magnification connected to a laptop computer running the program *Pythagoras* Version 1.2 (Gailey and Ortega-Ortiz 2002). This program calculates a real-time conversion of horizontal and vertical angles collected by the theodolite into geographic positions of latitude and longitude each time a fix is initiated. *Pythagoras* also displays positions, movements, and distances in real-time. When possible, the position of the focal dolphin was recorded at every surfacing with use of *Pythagoras*.

2.4. Data Analysis

First, the dolphin encounter rates (number of encounters per 100 hours of observation) were calculated before and during HKLR construction. The comparison between different periods of baseline and construction phases would allow determination of whether the observed level of occurrence was different during construction than it was prior to construction, which could be affected by the bored piling works and presence of bridge piers as obstruction along the HKLR alignment.

To investigate whether the north-south movement of Chinese white dolphins between North and West Lantau waters have been affected by the presence of the Hong Kong Link Road, in particular the spacing between bridge pile cap piers, the

number of dolphin groups that moved across the bridge alignment (either from north to south, or from south to north) was examined before and during the construction of the bridge, and compared between the two phases. The proportions of dolphin tracks that crossed the bridge alignment before and during construction were compared, and if a significantly greater percentage of dolphin tracks was recorded crossing the bridge alignment in the baseline phase than in the construction phase, the obstruction of the bridge as a barrier to dolphin movement would become evident.

3. RESULTS AND DISCUSSION

3.1. Summary of Theodolite Tracking Effort

For the present six-month study under the construction phase monitoring, 63.1 hours of shore-based theodolite tracking effort was conducted on 12 days (Appendix I). During these 12 days of land-based monitoring work, dolphins were successfully tracked from shore on six days, with a total of 10 dolphin groups being sighted (Appendix I). All ten groups were successfully tracked, with a total of 271 fixes obtained among these 10 tracks. In addition, 1,651 fixes were obtained from other vessels in the study area, including 256 fixes on fishing boats, 183 fixes on high-speed ferries, and 1,212 fixes on other vessels including construction vessels (Appendix I).

3.2. Dolphin encounter rates

Encounter rates of dolphins (number of dolphin sightings per 100 hours of tracking effort) were calculated for the baseline phase, and different periods of the construction phase (including the six-month period from the present study), and are presented in Table 2.

Table 2. Dolphin encounter rates (number of dolphin sightings per 100 hour of theodolite tracking effort) during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins

	Time Period	Effort (# of hours)	# of Dolphin Sightings	Encounter Rate
Baseline Phase	Apr 2011-Jan 2013	228.9	99	43.3
	Mar-Jun 2013	210.2	38	18.1
	Overall	***439.1***	***137***	***31.2***
Construction Phase	Jul-Dec 2013	107.5	70	65.1
	Jan-Dec 2014	134.8	42	31.2
	Jan-Dec 2015	128.8	23	17.9
	Jan-Aug 2016	84.1	15	17.8
	Sep 2016-Feb 2017	63.1	10	15.8
	Overall	***518.3***	***160***	***30.9***

During the baseline phase, there was a noticeable drop in dolphin encounter rate from 43.3 for the period without any construction activities (i.e. up to January 2013), to 18.1 at the very initial stage of construction works with just a few sites with some bored piling activities (i.e. March to June 2013) (Table 2). In the subsequent months (July-December 2013) when the construction works resumed after a two-month suspension to satisfy the environmental permit condition, dolphin encounter rate rosed back to a higher level (65.1). However, the encounter rate quickly reduced to a lower level in 2015, and remained fairly low in 2016-17 (Table 2). In fact, dolphin occurrence during the six-month period of the present study was the lowest among all seven periods.

3.3. North-south movement and distribution of tracks

The ten tracks collected during the six-month from the present study were analyzed for north-south movements of dolphins across the bridge alignment. These tracks contained 271 individual lat-long locations, which were analyzed to determine whether they were north of the alignment south of the alignment or within the alignment. The different proportions were also compared to the ones from different phases before and during HKLR construction works.

Among the ten tracks, 90% were wholly on the south side of the bridge alignment, 0% entirely on the north side, and 10% passed across the alignment (Table 3; and see tracks in Appendix II).

Table 3. Percentages of dolphin tracks to the south side and north side of HKLR alignment as well as across the alignment during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins

	Time Period	# of Tracks	South Side of HKLR	North Side of HKLR	Across HKLR Alignment
Baseline Phase	Apr 2011-Jan 2013	84	70%	13%	17%
	Mar-Jun 2013	28	68%	4%	28%
	Overall	***112***	***70%***	***11%***	***20%***
Construction Phase	Jul-Dec 2013	45	71%	2%	27%
	Jan-Dec 2014	38	84%	11%	5%
	Jan-Dec 2015	21	71%	0%	29%
	Jan-Aug 2016	9	89%	0%	11%
	Sep 2016-Feb 2017	10	90%	0%	10%
	Overall	***123***	***78%***	***4%***	***18%***

The percentages of tracks across the alignment were examined across different periods of baseline and construction phases (Table 3). During the baseline period up to June 2013, 20% of tracks passed across the alignment, and in the subsequent months from July to December 2013, such percentage remained similar, with 27% of tracks passed across the alignment. However, such percentage have dropped dramatically to only 5% in 2014, when bored piling works were the most intense, and the spacing between bridge piers became progressively narrower with multiple work fronts. In 2015, the percentage of tracks across the alignment rebounded to a much higher level (29%), but the total number of tracks and encounter rate of dolphins were both lower than the ones in 2014. The percentage of tracks across the alignment dropped to a much lower level during the first eight months of 2016 (11%), and it remained low for the six month period from September 2016 to February 2017 under the present study (10%) (Table 3). It appeared that the level of north-south movements have greatly diminished since the completion of bored piling works with no sign of recovery.

4. CONCLUSION

Intensive effort of shore-based theodolite tracking at Sham Wat Station was conducted before and during the construction of HKLR with bored piling works. The results from the tracking sessions revealed that when the bored piling works became most intense and the spacing between bridge piers became narrower, the dolphins have diminished their use in the vicinity of the bridge alignment, and their north-south movements were also affected with seldom crossings underneath the bridge alignment.

The low level of north-south movements of Chinese white dolphins across the HKLR alignment in recent years could possibly be attributed by two factors: 1) the physical presence of bridge piers and narrower spacing between them which could partially obstruct movements of dolphins; and 2) the on-going deterioration of habitat quality in North Lantau waters that makes it less attractive for dolphins to cross the alignment from West Lantau to North Lantau waters. It would be premature at this point to conclude which of the factors, or both factors, have influenced the observed declining level of north-south movements in recent years. Apparently, continuous monitoring of such movement through shore-based theodolite tracking from Sham Wat Station would be critical in order to determine whether the north-south movement would resume to the level of pre-construction phase, and the dolphins have partially or fully recovered from the impact of the HKLR construction.

5. REFERENCES

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Lundquist, D. 2012. Behaviour and movement patterns of dusky dolphins (*Lagenorhynchus obscurus*) off Kaikoura, New Zealand: Effects of tourism. Ph.D. Thesis, University of Otago. http://hdl.handle.net/10523/2125

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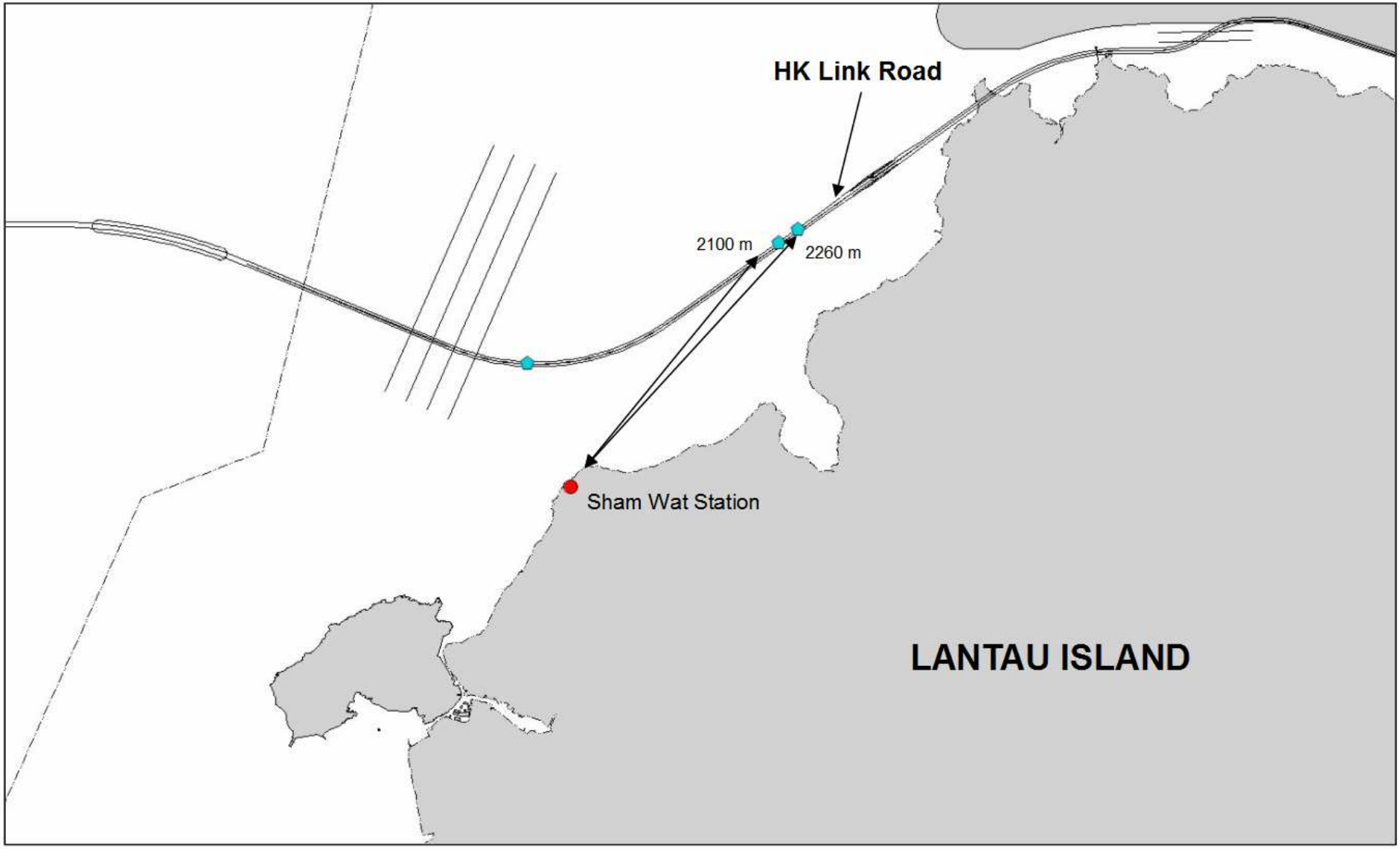


Figure 1. Location of Sham Wat Theodolite Tracking Station in northwestern Lantau with the first few bored piling locations

Figure 2. Panoramic View from the Sham Wat Theodolite Tracking Station (photos taken on 20/12/2012 (above) and 04/09/2015 (below))

Appendix I. Sham Wat Land-based Theodolite Tracking Database (April 2011 - February 2017)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
14/04/11	HKCRP	10:00	13:16	3:16	2-4	1-2	2	261	126	0	92	8	34
03/08/11	HKCRP	7:22	13:10	5:48	1-2	4	4	206	78	0	41	9	75
09/09/11	HKCRP	9:42	13:42	4:00	3	3	0	59	0	5	7	6	38
25/12/11	HKCRP	9:04	10:55	1:51	4	1.5	2	64	26	2	14	8	13
15/03/12	HKCRP	9:17	13:30	4:13	2	2	0	88	0	0	30	11	46
26/06/12	HKCRP	9:33	12:59	3:26	2	2	6	108	61	0	33	7	5
02/07/12	HKCRP	8:13	12:17	4:04	2	2	15	190	147	0	18	5	15
13/07/12	HKCRP	6:07	10:30	4:23	2	1	13	145	47	0	58	6	30
31/07/12	HKCRP	6:29	11:00	4:31	1	3	4	152	47	0	45	8	48
20/08/12	HKCRP	9:24	13:15	3:51	1-2	2.5	4	295	233	0	25	13	22
09/10/12	HKCRP	9:31	12:56	3:25	2	2-3.5	1	61	17	0	21	8	13
10/12/12	HKCRP	10:06	14:35	4:29	3	2.5	1	81	25	0	7	4	44
20/12/12	HKCRP	12:56	16:46	3:50	3-4	2-3	1	96	5	3	4	6	76
02/01/13	HKLR	9:20	14:50	5:30	2	2.5	3	156	33	0	22	13	87
03/01/13	HKLR	9:00	14:55	5:55	2-4	2.5	0	175	0	0	34	17	123
04/01/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	157	0	4	0	18	132
05/01/13	HKLR	10:10	15:40	5:30	3	2.5-3	0	215	0	0	30	7	176
06/01/13	HKLR	9:05	14:55	5:50	3-4	2.5-3	0	154	0	0	19	26	108
07/01/13	HKLR	8:57	14:57	6:00	3-4	3-3.5	0	100	0	0	7	14	78
08/01/13	HKLR	9:01	14:51	5:50	2-3	3-3.5	0	110	0	0	9	14	86
09/01/13	HKLR	8:55	13:58	5:03	3-5	2.5-3.5	0	68	0	0	5	7	55
10/01/13	HKLR	9:01	15:31	6:30	2-3	3-3.5	0	95	0	0	6	12	75
11/01/13	HKLR	9:15	15:45	6:30	2-4	2.5-3.5	1	204	19	0	41	23	118
12/01/13	HKLR	9:09	15:09	6:00	2-3	4	1	94	12	0	7	10	64
13/01/13	HKLR	8:54	14:54	6:00	2-4	2.5-4	2	112	16	3	26	20	47
14/01/13	HKLR	8:50	14:50	6:00	2	2.5	0	275	0	0	49	18	206
15/01/13	HKLR	9:27	15:27	6:00	2-4	1.5-3	0	180	0	0	44	16	118
16/01/13	HKLR	9:00	15:00	6:00	2	3-4	0	85	0	0	8	10	64
17/01/13	HKLR	8:55	14:55	6:00	2-3	2-3.5	4	349	184	0	12	13	138
18/01/13	HKLR	8:55	15:00	6:05	2-3	2.5-3.5	0	213	0	0	48	14	146
19/01/13	HKLR	9:10	15:10	6:00	2	2.5	1	247	52	0	55	23	115
20/01/13	HKLR	8:56	14:56	6:00	2-3	2	0	163	0	0	8	27	127
21/01/13	HKLR	8:50	15:10	6:20	1-2	2-3.5	0	248	0	0	18	24	202
22/01/13	HKLR	8:50	15:20	6:30	2-3.5	1	3	253	152	0	6	17	74

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
23/01/13	HKLR	8:28	14:58	6:30	1	3.5-4	0	115	0	0	5	15	92
24/01/13	HKLR	8:23	15:38	7:15	1	3-4	3	412	328	0	5	18	57
25/01/13	HKLR	9:07	15:00	5:53	2-4	2.5-3	0	132	0	0	9	17	105
26/01/13	HKLR	8:55	15:25	6:30	2	2.5-3	9	433	240	0	46	17	128
27/01/13	HKLR	9:11	15:41	6:30	1-3	3.5	4	162	44	0	0	40	78
28/01/13	HKLR	8:55	15:30	6:35	2-3	2-2.5	4	295	96	0	34	12	151
29/01/13	HKLR	8:30	15:00	6:30	1-2	2	7	476	169	0	91	15	200
30/01/13	HKLR	8:18	14:48	6:30	3-4	1.5	4	264	128	0	9	11	112
06/03/13	HKLR	9:07	15:10	6:03	1-2	1.5-2	0	254	0	0	55	11	185
07/03/13	HKLR	8:56	14:57	6:01	1	2.5	1	231	4	0	18	12	196
09/03/13	HKLR	8:55	15:00	6:05	1-3	2	0	258	0	0	47	20	188
10/03/13	HKLR	8:53	14:54	6:01	1-2	1.5-2.5	2	219	42	0	36	36	104
11/03/13	HKLR	9:00	15:01	6:01	2-4	2.5	2	339	31	0	46	15	246
12/03/13	HKLR	8:59	14:59	6:00	2-4	2.5	2	369	37	0	54	17	259
13/03/13	HKLR	9:15	15:15	6:00	1-2	2.5-3	3	386	67	0	57	13	245
14/03/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	363	0	0	39	16	306
15/03/13	HKLR	9:05	15:05	6:00	2	2.5	0	353	0	0	132	15	205
16/03/13	HKLR	8:55	15:00	6:05	2-3	2-2.5	0	326	0	0	94	16	215
17/03/13	HKLR	8:53	14:53	6:00	2-3	2.5	1	382	59	0	49	43	230
18/03/13	HKLR	9:05	15:05	6:00	2	2.5	1	325	1	0	80	16	227
19/03/13	HKLR	9:03	14:27	5:24	2	2	2	389	38	0	72	15	263
20/03/13	HKLR	9:00	15:00	6:00	2	1.5	2	481	70	0	60	11	339
21/03/13	HKLR	9:03	15:03	6:00	2-4	2.5-3	0	261	0	0	18	18	224
22/03/13	HKLR	8:59	14:59	6:00	2	3	1	368	2	0	22	17	325
23/03/13	HKLR	9:00	15:15	6:15	2	2	1	444	6	0	69	16	352
24/03/13	HKLR	9:06	13:43	4:37	1	3	0	254	0	0	49	31	173
25/03/13	HKLR	9:00	15:00	6:00	3-5	2.5-3.5	1	250	7	0	34	13	194
27/03/13	HKLR	9:56	15:35	5:39	2-4	1.5-3	0	273	0	0	48	11	212
28/03/13	HKLR	9:00	11:34	2:34	1-3	2	0	207	0	0	42	7	157
30/03/13	HKLR	9:15	15:07	5:52	3-6	2-2.5	0	276	0	0	66	20	157
01/04/13	HKLR	9:07	15:20	6:13	2	2.5-3	0	432	0	0	90	35	304
02/04/13	HKLR	9:02	13:09	4:07	1-2	3-4	1	250	13	0	65	10	161
04/04/13	HKLR	9:02	15:32	6:30	3-4	2.5-3	2	330	80	0	31	35	182
05/04/13	HKLR	9:53	15:23	5:30	3-4	2.5	0	277	0	0	50	13	212

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
07/04/13	HKLR	9:00	15:00	6:00	2-3	2	0	299	0	0	32	40	226
08/04/13	HKLR	9:05	15:05	6:00	2	2.5	0	233	0	0	17	15	200
09/04/13	HKLR	9:00	15:30	6:30	2-3	2-3	0	193	0	0	16	11	164
10/04/13	HKLR	9:00	15:00	6:00	2	2-2.5	0	315	0	0	27	17	270
11/04/13	HKLR	9:00	14:50	5:50	2	2.5	0	94	0	0	21	0	70
23/04/13	HKCRP	9:36	14:25	4:49	2-3	1.5-3	0	203	0	0	34	11	157
29/04/13	HKCRP	9:03	13:28	4:25	2-3	2.5-3	2	227	60	0	11	12	142
08/05/13	HKCRP	9:03	13:30	4:27	3-4	2.5	0	183	0	0	12	10	160
15/05/13	HKCRP	9:12	13:28	4:16	1-3	1.5	1	193	1	0	21	13	157
30/05/13	HKCRP	10:14	14:16	4:02	1-3	1	4	333	214	0	0	3	115
13/06/13	HKCRP	9:06	13:36	4:30	3	2.5	4	230	107	0	19	8	95
26/06/13	HKCRP	9:04	13:31	4:27	3-5	1	5	271	73	0	9	7	181
04/07/13	HKCRP	9:27	14:03	4:36	2	1.5-2	2	336	28	0	7	8	292
08/07/13	HKLR	9:01	15:01	6:00	1	1	1	371	119	0	36	13	202
09/07/13	HKLR	9:04	15:04	6:00	2-3	1-2	4	389	117	1	40	14	216
10/07/13	HKLR	10:57	17:00	6:03	2	1	5	422	120	2	50	8	241
11/07/13	HKLR	9:08	15:01	5:53	1	1	5	456	211	0	54	5	185
12/07/13	HKLR	9:06	15:06	6:00	2	2.5	15	430	235	11	33	21	129
13/07/13	HKLR	9:06	15:01	5:55	1-3	2.5	7	378	211	0	16	26	122
15/07/13	HKLR	9:06	15:08	6:02	1-3	2-3	2	188	50	0	4	11	103
17/07/13	HKLR	9:02	13:54	4:52	2	2-2.5	1	330	127	6	0	11	185
18/07/13	HKLR	9:14	15:06	5:52	2	1.5-2	0	251	0	0	0	14	236
19/07/13	HKLR	9:10	15:04	5:54	2-3	1-1.5	3	268	39	7	0	12	207
23/07/13	HKLR	9:02	15:02	6:00	2	1.5	7	334	126	0	3	9	195
24/07/13	HKLR	12:30	16:02	3:32	2	1-1.5	1	158	64	0	0	4	88
29/07/13	HKLR	8:56	14:59	6:03	2	1	6	275	117	0	0	6	151
26/08/13	HKCRP	9:06	14:10	5:04	2	1.5-2.5	4	456	167	0	9	16	262
29/08/13	HKCRP	9:11	13:15	4:04	1-2	1	3	215	59	0	10	9	135
28/09/13	HKLR	8:59	15:01	6:02	2-4	3	1	590	10	0	3	14	565
30/09/13	HKLR	10:28	15:33	5:05	2-3	3.5	0	163	0	0	2	1	159
04/12/13	HKCRP	8:58	13:01	4:03	2-3	3-3.5	1	385	1	0	20	7	355
19/12/13	HKCRP	9:03	13:33	4:30	3-4	2-2.5	2	320	20	0	0	5	293
16/01/14	HKCRP	9:03	13:38	4:35	2	3	0	385	0	0	4	11	367
22/01/14	HKLR	9:05	14:33	5:28	2	2.5	1	418	3	0	0	12	402

Appendix I. (cont'd)

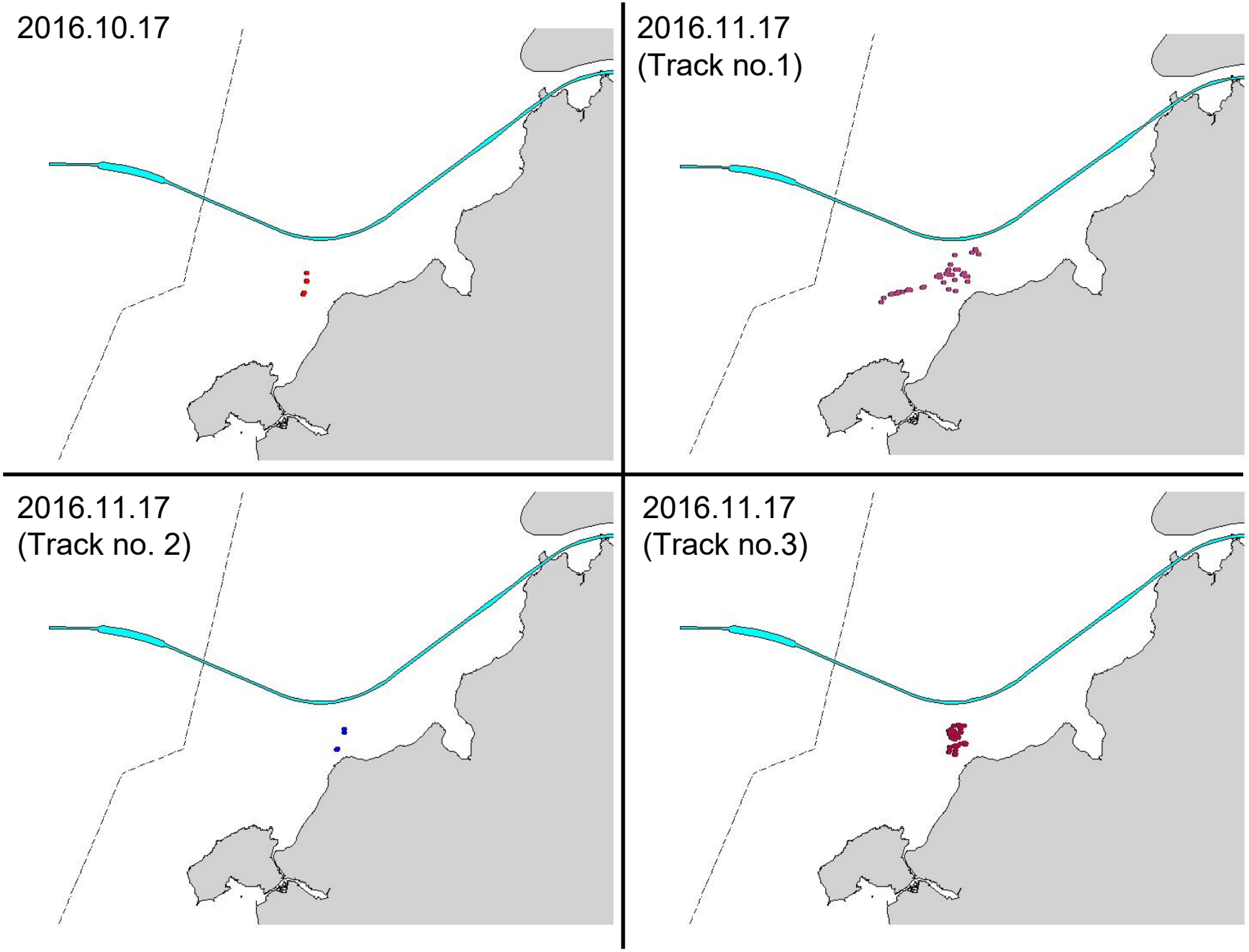
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
27/01/14	HKLR	8:54	14:59	6:05	1-3	2.5	3	517	212	0	4	13	287
06/02/14	HKCRP	9:19	14:18	4:59	2	1.5	0	308	0	0	23	12	271
17/02/14	HKCRP	9:21	13:24	4:03	2	2-3.5	1	276	55	0	2	9	209
14/03/14	HKLR	9:03	15:05	6:02	2-3	2.5	2	717	31	0	46	16	622
19/03/14	HKLR	9:16	14:30	5:14	1	2.5-3	4	543	113	0	49	13	480
16/04/14	HKLR	9:05	14:49	5:44	2-3	2.5-3	2	623	71	0	12	22	517
25/04/14	HKLR	9:08	14:47	5:39	2-4	2	0	405	0	0	10	18	375
19/05/14	HKLR	9:43	15:08	5:25	2-4	1	2	379	95	0	9	3	270
27/05/14	HKLR	9:04	14:32	5:28	1-3	1.5-2.5	1	254	5	0	0	12	234
03/06/14	HKLR	9:27	14:38	5:11	2-3	2	2	418	218	0	3	14	180
06/06/14	HKLR	9:18	15:00	5:42	2-3	1.5	1	359	34	0	0	13	310
11/07/14	HKLR	9:25	14:49	5:24	2	1.5	4	294	32	0	6	14	240
25/07/14	HKLR	9:33	14:54	5:21	2-3	2	2	416	31	4	0	5	374
22/08/14	HKLR	9:24	14:46	5:22	2	1	2	426	97	10	0	30	287
28/08/14	HKLR	9:24	14:56	5:32	2-3	2	1	408	21	15	0	10	362
01/09/14	HKLR	9:15	14:45	5:30	2-3	1-1.5	7	421	117	0	0	11	293
05/09/14	HKLR	9:09	14:33	5:24	2	2.5	1	420	1	5	0	20	392
20/10/14	HKLR	9:16	14:39	5:23	2	2	1	391	1	0	14	14	360
27/10/14	HKLR	9:09	14:38	5:29	1-2	3	3	476	93	0	21	15	345
10/11/14	HKLR	9:05	14:32	5:27	2-3	2-3.5	2	360	18	0	31	15	292
24/11/14	HKLR	9:09	14:38	5:29	2	1	0	482	0	0	31	12	438
05/12/14	HKLR	9:04	14:39	5:35	2	3	0	528	0	0	27	12	488
18/12/14	HKLR	9:00	14:15	5:15	2	2.5	0	407	0	0	7	11	388
02/01/15	HKLR	9:07	14:30	5:23	2	2.5-3	0	440	0	6	0	19	414
21/01/15	HKLR	9:14	13:16	4:02	1-2	3-3.5	0	301	0	10	6	13	270
17/02/15	HKLR	9:03	14:31	5:28	1	3.5-4	0	160	0	0	14	13	132
26/02/15	HKLR	8:59	14:33	5:34	2-3	2	1	298	64	0	15	11	207
09/03/15	HKLR	9:16	14:43	5:27	1	3.5-4	1	407	88	0	6	12	299
13/03/15	HKLR	9:04	14:40	5:36	2	1.5-2	1	446	21	0	16	12	396
14/04/15	HKLR	9:21	14:49	5:28	2	1	1	360	12	0	0	22	324
20/04/15	HKLR	9:14	14:32	5:18	2	3.5	0	268	0	0	20	8	237
11/05/15	HKLR	9:16	14:36	5:20	2	1.5	0	284	0	0	1	15	264
19/05/15	HKLR	9:04	14:05	5:01	2-3	2	0	173	0	0	0	10	161
03/06/15	HKLR	9:12	14:43	5:31	2-4	1	2	335	7	5	0	17	305

Appendix I. (cont'd)

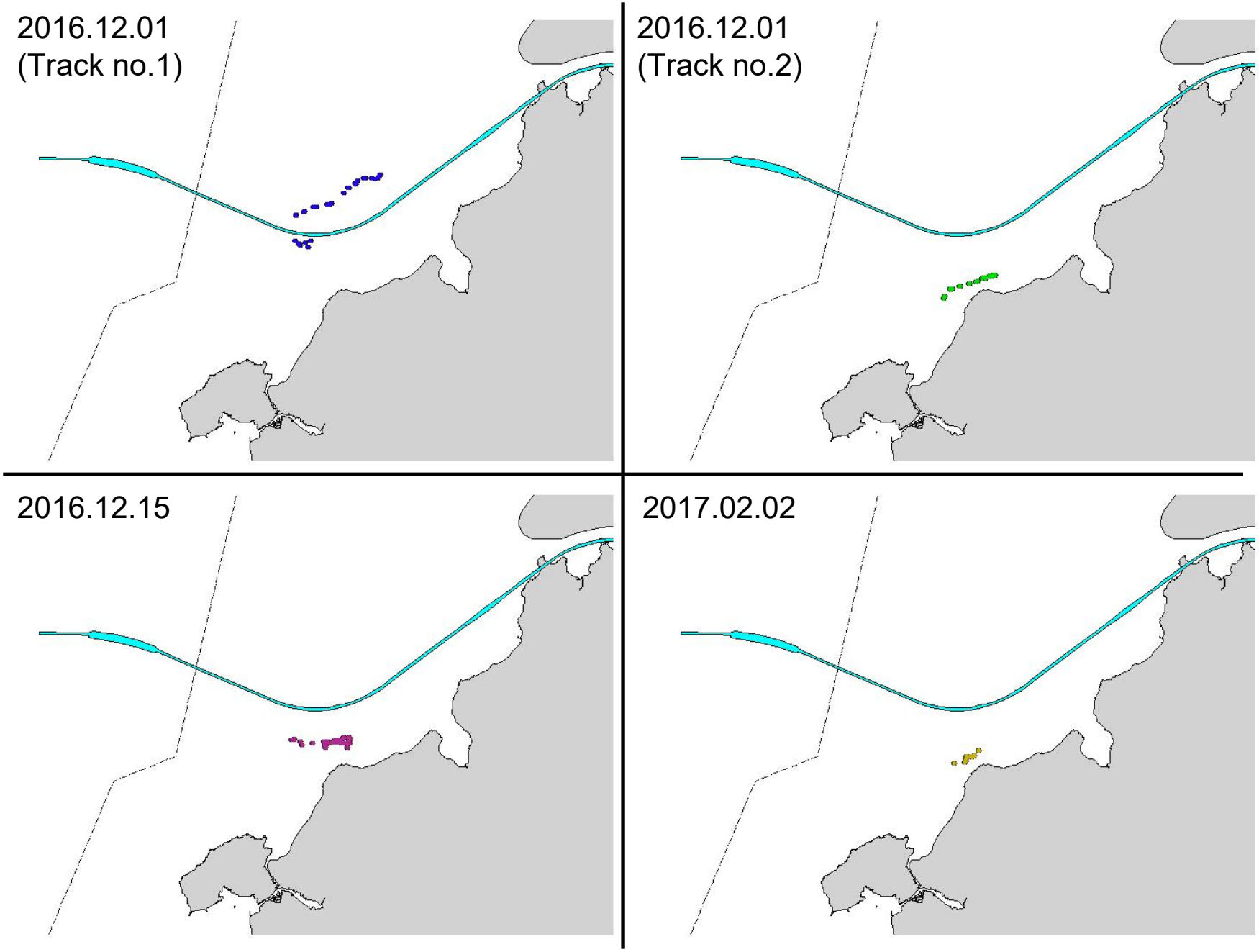
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
11/06/15	HKLR	9:05	14:30	5:25	2	2	0	274	0	0	0	12	259
06/07/15	HKLR	9:22	14:53	5:31	2	2-3	3	300	144	0	0	11	143
16/07/15	HKLR	9:28	14:44	5:16	2	2	2	334	173	0	0	23	136
13/08/15	HKLR	9:05	14:31	5:26	3	2	0	312	0	0	21	20	270
21/08/15	HKLR	9:02	14:16	5:14	2-3	2	1	276	27	30	3	11	203
04/09/15	HKLR	8:59	14:31	5:32	2	1.5	3	384	202	6	6	13	155
23/09/15	HKLR	9:02	14:30	5:28	2	1.5	1	252	10	9	0	8	223
02/10/15	HKLR	8:56	14:17	5:21	2	1.5	2	374	168	6	5	10	182
14/10/15	HKLR	8:58	14:28	5:30	2	3	1	218	83	0	0	9	124
04/11/15	HKLR	9:01	14:28	5:27	2	3	0	170	0	0	0	13	154
20/11/15	HKLR	9:02	14:31	5:29	2	2	1	219	1	6	17	20	173
01/12/15	HKLR	8:58	14:30	5:32	2	3	2	301	143	0	3	16	138
08/12/15	HKLR	8:53	14:24	5:31	2-3	2.5	1	254	68	0	3	7	173
07/01/16	HKLR	9:07	14:34	5:27	2	2	0	267	0	3	3	12	248
12/01/16	HKLR	9:03	14:24	5:21	2	2	2	227	21	0	9	10	186
05/02/16	HKLR	9:09	14:30	5:21	3-4	2.5	0	254	0	6	0	11	235
12/02/16	HKLR	8:56	14:29	5:33	2	3	2	247	89	5	5	17	130
02/03/16	HKLR	9:08	14:30	5:22	1	2.5	3	310	188	0	3	9	175
16/03/16	HKLR	9:25	14:34	5:09	1-2	3-3.5	1	225	1	0	5	11	207
21/04/16	HKLR	9:19	14:30	5:11	1-2	1.5-3.5	0	156	0	0	1	6	148
29/04/16	HKLR	8:57	14:20	5:23	2-3	2	0	251	0	0	0	19	230
09/05/16	HKLR	9:06	14:35	5:29	2	2	2	193	39	0	2	14	137
16/05/16	HKLR	9:11	14:42	5:31	3	1	0	166	0	0	0	11	151
02/06/16	HKLR	9:10	14:32	5:22	3-4	2.5	0	193	0	0	0	15	177
16/06/16	HKLR	9:27	14:31	5:04	2-3	2.5	1	213	3	0	0	12	196
07/07/16	HKLR	9:22	14:30	5:08	2-3	2	1	227	2	0	13	13	197
15/07/16	HKLR	9:24	14:30	5:06	2-4	4.5	1	185	11	5	2	18	147
11/08/16	HKLR	9:57	14:34	4:37	2	2-3	0	70	0	0	4	8	56
25/08/16	HKLR	9:15	14:15	5:00	2	2.5	2	203	41	0	4	13	144
30/09/16	HKLR	9:20	14:30	5:10	3	2.5-3.5	0	106	0	0	5	12	88
03/10/16	HKLR	9:27	14:45	5:18	2	1.5	0	148	0	0	20	23	102
17/10/16	HKLR	9:15	13:59	4:44	2-3	2.5	1	179	7	0	54	10	107
20/10/16	HKLR	9:14	14:31	5:17	2	3-3.5	0	190	0	0	26	17	146

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
08/11/16	HKLR	9:10	14:33	5:23	2	2.5-3.5	0	165	0	0	20	17	126
17/11/16	HKLR	9:01	14:30	5:29	2	2	3	152	94	0	4	11	40
01/12/16	HKLR	9:04	14:30	5:26	3	2.5	2	224	61	0	21	19	122
15/12/16	HKLR	9:17	14:31	5:14	3	2	1	204	50	0	56	12	85
09/01/17	HKLR	9:10	14:11	5:01	2	2.5-3	0	130	0	0	8	12	109
18/01/17	HKLR	9:13	14:15	5:02	2-3	2.5-4	0	79	0	0	7	15	55
02/02/17	HKLR	8:56	14:34	5:38	2	2.5	1	163	14	0	17	21	109
10/02/17	HKLR	9:07	14:32	5:25	2-3	3	2	201	45	0	18	14	123

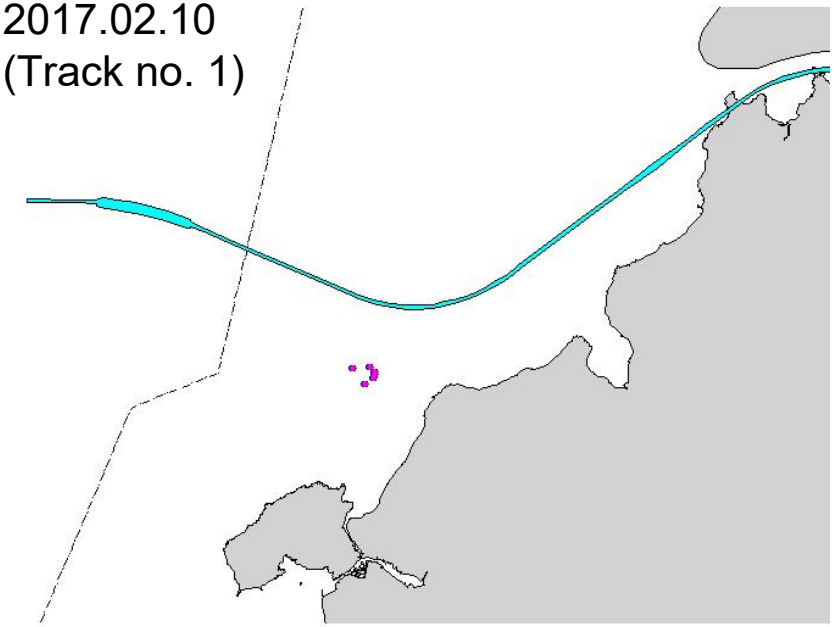


Appendix II. Ten tracks obtained during theodolite tracking sessions in Sep 2016 – Feb 2017

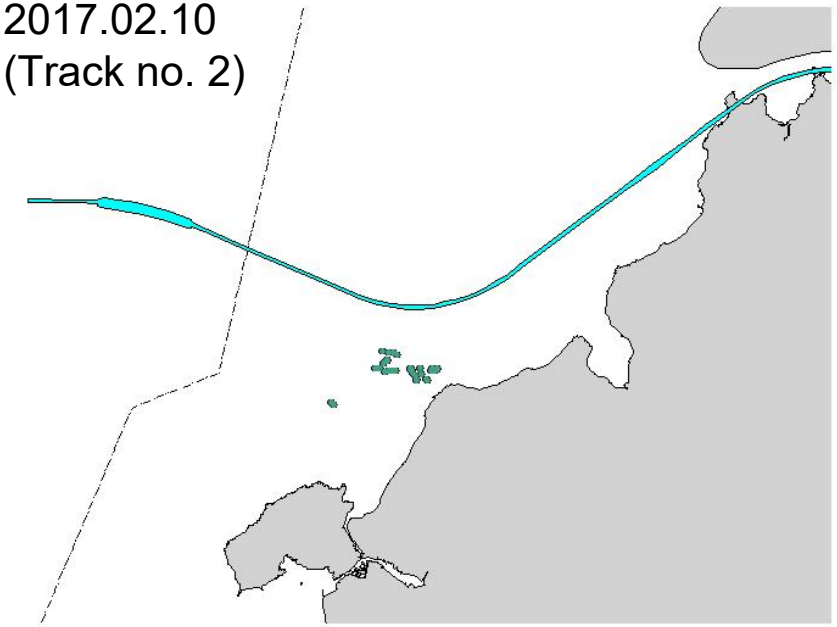


Appendix II. (cont'd)

2017.02.10
(Track no. 1)



2017.02.10
(Track no. 2)



Appendix II. (cont'd)

WELLAB 匯力
consulting . testing . research

Room 1701, Technology Park,
18 On Lai Street, Shatin, N.T, Hong Kong.
Tel: 2898 7388 Fax: 2898 7076
Website:http://www.wellab.com.hk
E-mail:wellab@wellab.com.hk

Our Ref: MA12014/DCVJV/it190111_2nd

Dragages-China Habour-VSL Joint Venture

Site Office: Tung Chung Waterfront Road,
adjacent to Tung Chung New Development Pier,
New Territories, Hong Kong

By Mail
11 January 2019

Attn.: Mr. W K Poon (Project Director)

Dear Sir,

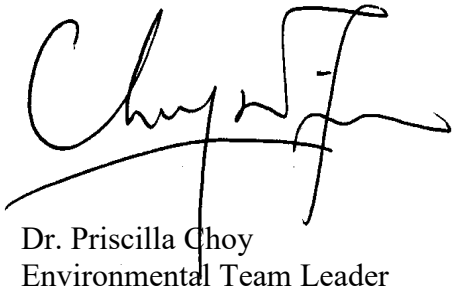
Contract No. HY/2011/09
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill
- Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (March - August 2017)

I refer to the revised Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (March - August 2017) dated October 5, 2017 for the captioned Contract prepared by Samuel Hung of Hong Kong Cetacean Research Project.

I hereby agree and certify that the above report is true and correct to the best of my knowledge.

If you need any further information, please call me at 2151 2089 or 9161 7287.

Yours faithfully,
WELLAB Limited



Dr. Priscilla Choy
Environmental Team Leader

CONTRACT HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill

Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (March – August 2017)

By Samuel Hung, Ph.D.
Hong Kong Cetacean Research Project (HKCRP)

October 5, 2017

1. INTRODUCTION

The Hong Kong Link Road (HKLR) comprises a 9.4 km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1-km tunnel section to the reclamation formed along the east coast of the Airport Island, and a 1.6-km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). Dragages – China Harbour – VSL JV (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2011/09 – Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill".

According to the HKLR EM&A Manual, a number of environmental monitoring and audit works related to Chinese White Dolphins (a.k.a. Indo-Pacific humpback dolphins, *Sousa chinensis*) are to be conducted during baseline, construction and post-construction phases, including land-based dolphin behaviour and movement monitoring. In September 2016, a continuation of the construction phase monitoring on the north-south movement is commissioned by the Contractor, and this progress report for the land-based monitoring on north-south movement of Chinese White Dolphins across the Hong Kong Link Road presents the methodology and results during the second half-yearly period of monitoring from March to August 2017, at a location hereafter termed as Sham Wat Station.

2. METHODS

2.1. Monitoring Station

Based on the requirements under the EM&A Manual as described in the EM&A proposal for this work, the Sham Wat Station is located along the northwest coast of Lantau Island (GPS position: 22°16.10' N. and 113°52.32' E, Figure 1). The station was selected based on its height above sea level (minimum requirement of over 20 metres; Würsig et al. 1991), close proximity to shore, and relatively unobstructed views of the HKLR alignment to the west of the airport extending toward the HKSAR Boundary (Figure 2).

The height of the Sham Wat Station established by the HKCRP team is 55.70 metres high at mean low water, 66 metres from shore. The station is only a few hundred metres to the closest point of the HKLR alignment (Figure 2), which is ideal to examine the north-south movements of Chinese White Dolphins in relation to the HKLR alignment.

2.2. Monitoring Period and Definition of Baseline/Construction Phases

Before the present construction phase monitoring study, thirty days of shore-based theodolite tracking works were conducted for each of the baseline and initial construction phases according to the EM&A manual requirements (Table 1). An additional 64 days of shore-based monitoring (twice per month, with 5-6 hours on each survey day) were also conducted throughout the construction period specifically to examine the impact of bridge construction on north-south movement of Chinese White Dolphins across the bridge alignment. Such monitoring commenced after the 30 days of construction phase monitoring in relation to bored piling impact assessment was completed in July 2013, and ended in August 2016. Thereafter, a continuation of the construction phase monitoring was commenced in September 2016 for the present study.

It should be noted that some shore-based theodolite tracking at Sham Wat Station was also conducted as part of the AFCD long-term marine mammal monitoring programme since 2011, and such data was also integrated with the HKLR baseline monitoring data to increase the overall sample size for analysis on the north-south movements of dolphins (Table 1).

Table 1. Different monitoring periods during baseline/construction phases, with the current six-month monitoring period highlighted in **blue**

(* The initial construction phase in March – June 2013 was considered under baseline phase, as only minor work procedures with lower level of disturbance took place at just two pier sites)

	Survey Type	Time Period	Effort (# of hours)
Baseline Phase	HKCRP	Apr 2011 – Dec 2012	51.1
Baseline Phase (under bored piling monitoring program)	HKLR	Jan 2013	177.8
Initial Construction Phase* (under bored piling monitoring program)	HKLR	Mar-Apr 2013	179.3
	HKCRP	Apr-Jun 2013	30.9
Construction Phase	HKLR/HKCRP	Jul-Dec 2013	107.5
	HKLR/HKCRP	Jan-Dec 2014	134.8
	HKLR	Jan-Dec 2015	128.8
	HKLR	Jan-Aug 2016	84.1
	HKLR	Sep 2016–Feb 2017	63.1
	HKLR	Mar-Aug 2017	64.1

For the examination of north-south movement of Chinese white dolphins across the HKLR alignment, the baseline phase was defined as the time period from April 2011 (i.e. the start of AFCD monitoring at Sham Wat) up to June 2013. Even though bored piling works associated with HKLR construction commenced on March 18th and continued until April 13th of 2013, only minor work procedures with lower level of disturbance (such as installation of permanent casing and excavation for bored pile) took place at two pier sites (P48 and P52). Presumably these works in less than a month at the very initial stage of bored piling works have insignificant impact as obstruction on north-south movements of dolphins. And after this brief period of construction, the bored piling works were suspended for two months in May and June 2013 as part of the environmental permit condition to avoid the peak calving season of Chinese White Dolphins. Therefore, the period of March to June of 2013 was also included as part of the baseline period with very low level of construction activities occurred along the HKLR alignment (Table 1).

On the other hand, the construction phase for this monitoring on north-south movements was defined as the time period starting from July 2013, when marine

bored piling activities construction works have intensified significantly until almost all piling works were completed in March 2015, and with subsequent monitoring works ended in August 2016. The additional 12 months of monitoring starting in September 2016 under the present study is also included as part of the construction phase as well (Table 1).

2.3. Monitoring Methodology

The methodology of the present monitoring programme generally followed the one established under the Piwetz et al. (2012) study that was part of the AFCD long-term marine mammal monitoring programme (Hung 2012). On each survey day from Sham Wat Station, observers searched continuously for Chinese white dolphins using unaided eyes and 7x50 handheld binoculars. A theodolite tracking session was initiated when an individual dolphin or group of dolphins was located, and focal follow methods were used to track the dolphins (Lundquist 2012, Lundquist et al. 2012a and 2012b, Piwetz et al. 2012).

Within a group, a focal individual was selected for the purposes of tracking behaviour and movement of the group, based on its distinctive feature such as colouration or severe injury mark. The focal individual or group were then tracked continuously via the theodolite, with positions recorded whenever a known or unknown dolphin surfaced. If an individual could not be positively distinguished from other members, the group would be tracked by recording positions based on a central point within the group when the dolphins surfaced. Tracking continued until animals were lost from view, moved beyond the range of reliable visibility (generally >3 km but up to >5 km under excellent conditions), or when environmental conditions obstructed visibility (e.g. intense haze).

Positions of dolphins, boats and construction activities were measured using a Sokkisha DT5 digital theodolite with ± 5-sec precision and 30-power magnification connected to a laptop computer running the program *Pythagoras* Version 1.2 (Gailey and Ortega-Ortiz 2002). This program calculates a real-time conversion of horizontal and vertical angles collected by the theodolite into geographic positions of latitude and longitude each time a fix is initiated. *Pythagoras* also displays positions, movements, and distances in real-time. When possible, the position of the focal dolphin was recorded at every surfacing with use of *Pythagoras*.

2.4. Data Analysis

First, the dolphin encounter rates (number of encounters per 100 hours of

observation) were calculated before and during HKLR construction. The comparison between different periods of baseline and construction phases would allow determination of whether the observed level of occurrence was different during construction than it was prior to construction, which could be affected by the bored piling works and presence of bridge piers as obstruction along the HKLR alignment.

To investigate whether the north-south movement of Chinese white dolphins between North and West Lantau waters have been affected by the presence of the Hong Kong Link Road, in particular the spacing between bridge pile cap piers, the number of dolphin groups that moved across the bridge alignment (either from north to south, or from south to north) was examined before and during the construction of the bridge, and compared between the two phases. The proportions of dolphin tracks that crossed the bridge alignment before and during construction were compared, and if a significantly greater percentage of dolphin tracks was recorded crossing the bridge alignment in the baseline phase than in the construction phase, the obstruction of the bridge as a barrier to dolphin movement would become evident.

3. RESULTS AND DISCUSSION

3.1. Summary of Theodolite Tracking Effort

For the present six-month study (i.e. March to August 2017) under the construction phase monitoring, 64.1 hours of shore-based theodolite tracking effort was conducted on 12 survey days (Appendix I). During these 12 days of land-based monitoring sessions, dolphins were successfully tracked from shore on six days, with a total of nine dolphin groups being sighted (Appendix I). All nine groups were successfully tracked, and 291 fixes of dolphin positions were obtained among these nine tracks. In addition, 1,159 fixes were obtained from the positions of other vessels in the study area, including 118 fixes on fishing boats, 117 fixes on high-speed ferries, 33 fixes on dolphin-watching boats, and 891 fixes on other vessels including construction vessels (Appendix I).

3.2. Dolphin encounter rates

Encounter rates of dolphins (number of dolphin sightings per 100 hours of tracking effort) were calculated for the baseline phase and different periods of the construction phase (including the six-month period from the present study), and are presented in Table 2.

Table 2. Dolphin encounter rates (number of dolphin sightings per 100 hour of theodolite tracking effort) during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins, with the current six-month monitoring period highlighted in **blue**

	Time Period	Effort (# of hours)	# of Dolphin Sightings	Encounter Rate
Baseline Phase	Apr 2011-Jan 2013	228.9	99	43.3
	Mar-Jun 2013	210.2	38	18.1
	Overall	***439.1***	***137***	***31.2***
Construction Phase	Jul-Dec 2013	107.5	70	65.1
	Jan-Dec 2014	134.8	42	31.2
	Jan-Dec 2015	128.8	23	17.9
	Jan-Aug 2016	84.1	15	17.8
	Sep 2016-Feb 2017	63.1	10	15.8
	Mar-Aug 2017	64.1	9	14.0
	Overall	***582.4***	***169***	***29.0***

During the baseline phase, there was a noticeable drop in dolphin encounter rate from 43.3 for the period without any construction activities (i.e. up to January 2013), to only 18.1 at the very initial stage of construction works with just a few sites with some bored piling activities (i.e. March to June 2013) (Table 2). In the subsequent months (July-December 2013) when the construction works resumed after a two-month suspension to satisfy the environmental permit condition, dolphin encounter rate rosed back to a higher level (65.1). However, the encounter rate quickly reduced to a much lower level in 2015, and remained fairly low in 2016 and 2017 (Table 2). In fact, dolphin occurrence during the second six-month period of the present study (i.e. March to August 2017) was the lowest among all eight periods, further dropping from the previous six-month period.

3.3. North-south movement and distribution of tracks

The nine tracks collected during the current six-month period were analyzed for north-south movements of dolphins across the bridge alignment. These tracks contained 291 individual lat-long locations, which were analyzed to determine whether they were entirely on the north or south side of the alignment, or crossing through the alignment. The different proportions were also compared to the ones from different phases before and during HKLR construction works.

Among the nine tracks, 89% (i.e. eight tracks) were wholly on the south side of the bridge alignment, 0% entirely on the north side, and 11% (i.e. one track) passed across the alignment (Table 3; also see tracks in Appendix II).

Table 3. Percentages of dolphin tracks to the south side and north side of HKLR alignment as well as across the alignment during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins, with the current six-month monitoring period highlighted in **blue**

	Time Period	# of Tracks	South Side of HKLR	North Side of HKLR	Across HKLR Alignment
Baseline Phase	Apr 2011-Jan 2013	84	70%	13%	17%
	Mar-Jun 2013	28	68%	4%	28%
	Overall	***112***	***70%***	***11%***	***20%***
Construction Phase	Jul-Dec 2013	45	71%	2%	27%
	Jan-Dec 2014	38	84%	11%	5%
	Jan-Dec 2015	21	71%	0%	29%
	Jan-Aug 2016	9	89%	0%	11%
	Sep 2016-Feb 2017	10	90%	0%	10%
	Mar-Aug 2017	9	89%	0%	11%
	Overall	***132***	***79%***	***4%***	***17%***

The percentages of tracks across the alignment were examined across different periods of baseline and construction phases (Table 3). During the baseline period up to June 2013, 20% of tracks passed across the alignment, and in the subsequent months from July to December 2013, such percentage remained similar, with 27% of tracks passed across the alignment. However, such percentage have dropped dramatically to only 5% in 2014, when bored piling works were the most intense, and the spacing between bridge piers became progressively narrower with multiple work fronts.

In 2015, the percentage of tracks across the alignment rebounded to a much higher level (29%), but the total number of tracks and encounter rate of dolphins were both much lower than the ones in 2014. The percentage of tracks across the alignment dropped to a much lower level during the first eight months of 2016 (11%), and it remained low for the two six-month periods afterward (i.e. 10% during September 2016 to February 2017; 11% during March to August 2017) under the present study (Table 3). It appeared that the level of north-south movements have

greatly diminished since the completion of bored piling works, and there has been no sign of recovery for dolphin crossings through the alignment.

4. CONCLUSION

Intensive effort of shore-based theodolite tracking at Sham Wat Station was conducted before and during the construction of HKLR with bored piling works. The results from the tracking sessions revealed that when the bored piling works became most intense and the spacing between bridge piers became narrower, the dolphins have diminished their use in the vicinity of the bridge alignment, and their north-south movements were also affected with seldom crossings underneath the bridge alignment.

The low level of north-south movements of Chinese white dolphins across the HKLR alignment in recent years could possibly be attributed by two factors: 1) the physical presence of bridge piers and narrower spacing between them which could partially obstruct movements of dolphins; and 2) the on-going deterioration of habitat quality in North Lantau waters that makes it less attractive for dolphins to cross the alignment from West Lantau to North Lantau waters. It would be premature at this point to conclude which of the factors, or both factors, have influenced the observed declining level of north-south movements in recent years. Apparently, continuous monitoring of such movement through shore-based theodolite tracking from Sham Wat Station would be critical in order to determine whether the north-south movement would resume to the level of pre-construction phase, and the dolphins have partially or fully recovered from the impact of the HKLR construction.

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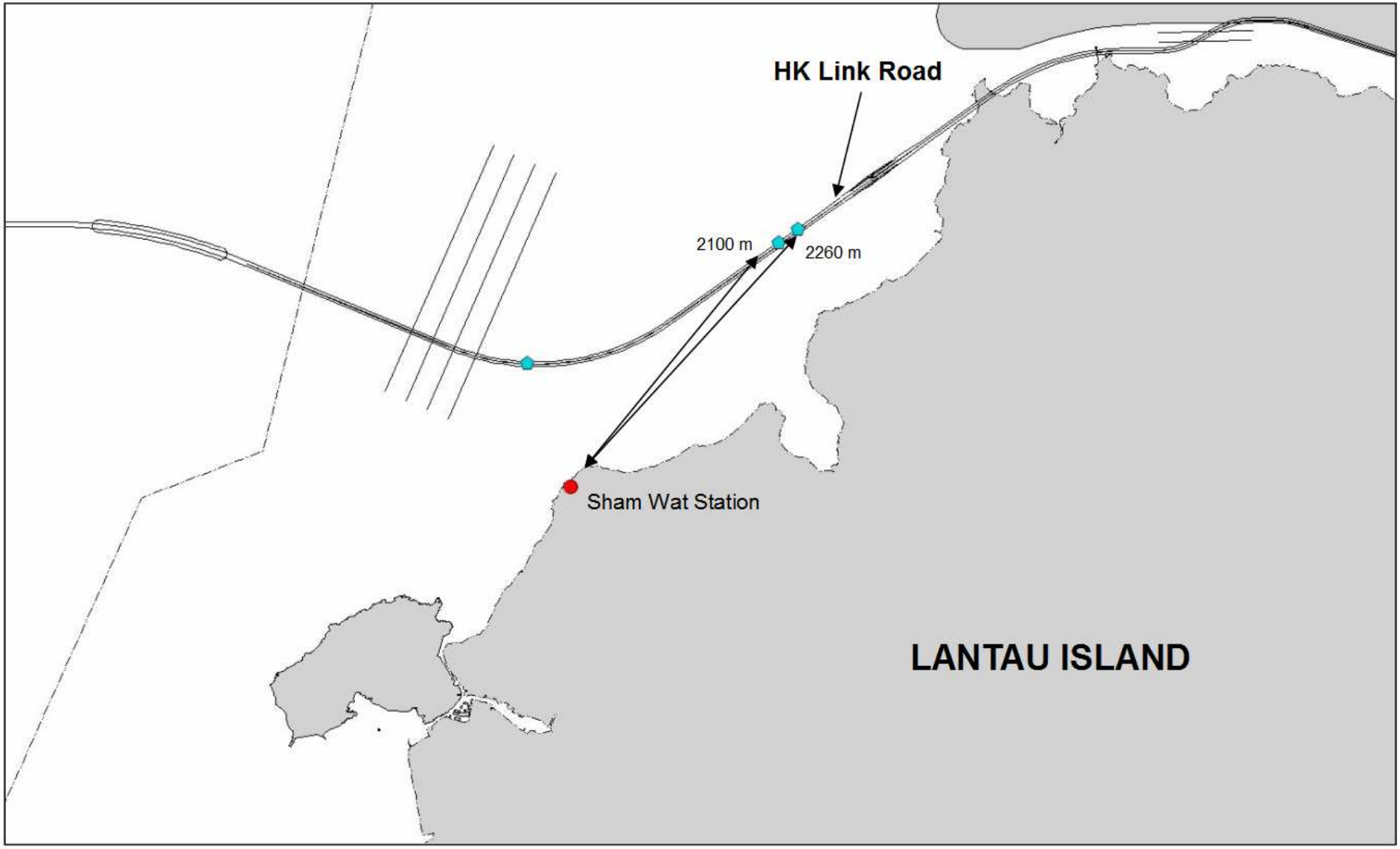


Figure 1. Location of Sham Wat Theodolite Tracking Station in northwestern Lantau with the first few bored piling locations

Figure 2. Panoramic View from the Sham Wat Theodolite Tracking Station (photos taken in 2012 (above) and 2015 (middle & below))

Appendix I. Sham Wat Land-based Theodolite Tracking Database (April 2011 - August 2017)

(note: the current six-month monitoring period is highlighted in **blue**)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
14/04/11	HKCRP	10:00	13:16	3:16	2-4	1-2	2	261	126	0	92	8	34
03/08/11	HKCRP	7:22	13:10	5:48	1-2	4	4	206	78	0	41	9	75
09/09/11	HKCRP	9:42	13:42	4:00	3	3	0	59	0	5	7	6	38
25/12/11	HKCRP	9:04	10:55	1:51	4	1.5	2	64	26	2	14	8	13
15/03/12	HKCRP	9:17	13:30	4:13	2	2	0	88	0	0	30	11	46
26/06/12	HKCRP	9:33	12:59	3:26	2	2	6	108	61	0	33	7	5
02/07/12	HKCRP	8:13	12:17	4:04	2	2	15	190	147	0	18	5	15
13/07/12	HKCRP	6:07	10:30	4:23	2	1	13	145	47	0	58	6	30
31/07/12	HKCRP	6:29	11:00	4:31	1	3	4	152	47	0	45	8	48
20/08/12	HKCRP	9:24	13:15	3:51	1-2	2.5	4	295	233	0	25	13	22
09/10/12	HKCRP	9:31	12:56	3:25	2	2-3.5	1	61	17	0	21	8	13
10/12/12	HKCRP	10:06	14:35	4:29	3	2.5	1	81	25	0	7	4	44
20/12/12	HKCRP	12:56	16:46	3:50	3-4	2-3	1	96	5	3	4	6	76
02/01/13	HKLR	9:20	14:50	5:30	2	2.5	3	156	33	0	22	13	87
03/01/13	HKLR	9:00	14:55	5:55	2-4	2.5	0	175	0	0	34	17	123
04/01/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	157	0	4	0	18	132
05/01/13	HKLR	10:10	15:40	5:30	3	2.5-3	0	215	0	0	30	7	176
06/01/13	HKLR	9:05	14:55	5:50	3-4	2.5-3	0	154	0	0	19	26	108
07/01/13	HKLR	8:57	14:57	6:00	3-4	3-3.5	0	100	0	0	7	14	78
08/01/13	HKLR	9:01	14:51	5:50	2-3	3-3.5	0	110	0	0	9	14	86
09/01/13	HKLR	8:55	13:58	5:03	3-5	2.5-3.5	0	68	0	0	5	7	55
10/01/13	HKLR	9:01	15:31	6:30	2-3	3-3.5	0	95	0	0	6	12	75
11/01/13	HKLR	9:15	15:45	6:30	2-4	2.5-3.5	1	204	19	0	41	23	118
12/01/13	HKLR	9:09	15:09	6:00	2-3	4	1	94	12	0	7	10	64
13/01/13	HKLR	8:54	14:54	6:00	2-4	2.5-4	2	112	16	3	26	20	47
14/01/13	HKLR	8:50	14:50	6:00	2	2.5	0	275	0	0	49	18	206
15/01/13	HKLR	9:27	15:27	6:00	2-4	1.5-3	0	180	0	0	44	16	118
16/01/13	HKLR	9:00	15:00	6:00	2	3-4	0	85	0	0	8	10	64
17/01/13	HKLR	8:55	14:55	6:00	2-3	2-3.5	4	349	184	0	12	13	138
18/01/13	HKLR	8:55	15:00	6:05	2-3	2.5-3.5	0	213	0	0	48	14	146
19/01/13	HKLR	9:10	15:10	6:00	2	2.5	1	247	52	0	55	23	115
20/01/13	HKLR	8:56	14:56	6:00	2-3	2	0	163	0	0	8	27	127
21/01/13	HKLR	8:50	15:10	6:20	1-2	2-3.5	0	248	0	0	18	24	202
22/01/13	HKLR	8:50	15:20	6:30	2-3.5	1	3	253	152	0	6	17	74

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
23/01/13	HKLR	8:28	14:58	6:30	1	3.5-4	0	115	0	0	5	15	92
24/01/13	HKLR	8:23	15:38	7:15	1	3-4	3	412	328	0	5	18	57
25/01/13	HKLR	9:07	15:00	5:53	2-4	2.5-3	0	132	0	0	9	17	105
26/01/13	HKLR	8:55	15:25	6:30	2	2.5-3	9	433	240	0	46	17	128
27/01/13	HKLR	9:11	15:41	6:30	1-3	3.5	4	162	44	0	0	40	78
28/01/13	HKLR	8:55	15:30	6:35	2-3	2-2.5	4	295	96	0	34	12	151
29/01/13	HKLR	8:30	15:00	6:30	1-2	2	7	476	169	0	91	15	200
30/01/13	HKLR	8:18	14:48	6:30	3-4	1.5	4	264	128	0	9	11	112
06/03/13	HKLR	9:07	15:10	6:03	1-2	1.5-2	0	254	0	0	55	11	185
07/03/13	HKLR	8:56	14:57	6:01	1	2.5	1	231	4	0	18	12	196
09/03/13	HKLR	8:55	15:00	6:05	1-3	2	0	258	0	0	47	20	188
10/03/13	HKLR	8:53	14:54	6:01	1-2	1.5-2.5	2	219	42	0	36	36	104
11/03/13	HKLR	9:00	15:01	6:01	2-4	2.5	2	339	31	0	46	15	246
12/03/13	HKLR	8:59	14:59	6:00	2-4	2.5	2	369	37	0	54	17	259
13/03/13	HKLR	9:15	15:15	6:00	1-2	2.5-3	3	386	67	0	57	13	245
14/03/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	363	0	0	39	16	306
15/03/13	HKLR	9:05	15:05	6:00	2	2.5	0	353	0	0	132	15	205
16/03/13	HKLR	8:55	15:00	6:05	2-3	2-2.5	0	326	0	0	94	16	215
17/03/13	HKLR	8:53	14:53	6:00	2-3	2.5	1	382	59	0	49	43	230
18/03/13	HKLR	9:05	15:05	6:00	2	2.5	1	325	1	0	80	16	227
19/03/13	HKLR	9:03	14:27	5:24	2	2	2	389	38	0	72	15	263
20/03/13	HKLR	9:00	15:00	6:00	2	1.5	2	481	70	0	60	11	339
21/03/13	HKLR	9:03	15:03	6:00	2-4	2.5-3	0	261	0	0	18	18	224
22/03/13	HKLR	8:59	14:59	6:00	2	3	1	368	2	0	22	17	325
23/03/13	HKLR	9:00	15:15	6:15	2	2	1	444	6	0	69	16	352
24/03/13	HKLR	9:06	13:43	4:37	1	3	0	254	0	0	49	31	173
25/03/13	HKLR	9:00	15:00	6:00	3-5	2.5-3.5	1	250	7	0	34	13	194
27/03/13	HKLR	9:56	15:35	5:39	2-4	1.5-3	0	273	0	0	48	11	212
28/03/13	HKLR	9:00	11:34	2:34	1-3	2	0	207	0	0	42	7	157
30/03/13	HKLR	9:15	15:07	5:52	3-6	2-2.5	0	276	0	0	66	20	157
01/04/13	HKLR	9:07	15:20	6:13	2	2.5-3	0	432	0	0	90	35	304
02/04/13	HKLR	9:02	13:09	4:07	1-2	3-4	1	250	13	0	65	10	161
04/04/13	HKLR	9:02	15:32	6:30	3-4	2.5-3	2	330	80	0	31	35	182
05/04/13	HKLR	9:53	15:23	5:30	3-4	2.5	0	277	0	0	50	13	212

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
07/04/13	HKLR	9:00	15:00	6:00	2-3	2	0	299	0	0	32	40	226
08/04/13	HKLR	9:05	15:05	6:00	2	2.5	0	233	0	0	17	15	200
09/04/13	HKLR	9:00	15:30	6:30	2-3	2-3	0	193	0	0	16	11	164
10/04/13	HKLR	9:00	15:00	6:00	2	2-2.5	0	315	0	0	27	17	270
11/04/13	HKLR	9:00	14:50	5:50	2	2.5	0	94	0	0	21	0	70
23/04/13	HKCRP	9:36	14:25	4:49	2-3	1.5-3	0	203	0	0	34	11	157
29/04/13	HKCRP	9:03	13:28	4:25	2-3	2.5-3	2	227	60	0	11	12	142
08/05/13	HKCRP	9:03	13:30	4:27	3-4	2.5	0	183	0	0	12	10	160
15/05/13	HKCRP	9:12	13:28	4:16	1-3	1.5	1	193	1	0	21	13	157
30/05/13	HKCRP	10:14	14:16	4:02	1-3	1	4	333	214	0	0	3	115
13/06/13	HKCRP	9:06	13:36	4:30	3	2.5	4	230	107	0	19	8	95
26/06/13	HKCRP	9:04	13:31	4:27	3-5	1	5	271	73	0	9	7	181
04/07/13	HKCRP	9:27	14:03	4:36	2	1.5-2	2	336	28	0	7	8	292
08/07/13	HKLR	9:01	15:01	6:00	1	1	1	371	119	0	36	13	202
09/07/13	HKLR	9:04	15:04	6:00	2-3	1-2	4	389	117	1	40	14	216
10/07/13	HKLR	10:57	17:00	6:03	2	1	5	422	120	2	50	8	241
11/07/13	HKLR	9:08	15:01	5:53	1	1	5	456	211	0	54	5	185
12/07/13	HKLR	9:06	15:06	6:00	2	2.5	15	430	235	11	33	21	129
13/07/13	HKLR	9:06	15:01	5:55	1-3	2.5	7	378	211	0	16	26	122
15/07/13	HKLR	9:06	15:08	6:02	1-3	2-3	2	188	50	0	4	11	103
17/07/13	HKLR	9:02	13:54	4:52	2	2-2.5	1	330	127	6	0	11	185
18/07/13	HKLR	9:14	15:06	5:52	2	1.5-2	0	251	0	0	0	14	236
19/07/13	HKLR	9:10	15:04	5:54	2-3	1-1.5	3	268	39	7	0	12	207
23/07/13	HKLR	9:02	15:02	6:00	2	1.5	7	334	126	0	3	9	195
24/07/13	HKLR	12:30	16:02	3:32	2	1-1.5	1	158	64	0	0	4	88
29/07/13	HKLR	8:56	14:59	6:03	2	1	6	275	117	0	0	6	151
26/08/13	HKCRP	9:06	14:10	5:04	2	1.5-2.5	4	456	167	0	9	16	262
29/08/13	HKCRP	9:11	13:15	4:04	1-2	1	3	215	59	0	10	9	135
28/09/13	HKLR	8:59	15:01	6:02	2-4	3	1	590	10	0	3	14	565
30/09/13	HKLR	10:28	15:33	5:05	2-3	3.5	0	163	0	0	2	1	159
04/12/13	HKCRP	8:58	13:01	4:03	2-3	3-3.5	1	385	1	0	20	7	355
19/12/13	HKCRP	9:03	13:33	4:30	3-4	2-2.5	2	320	20	0	0	5	293
16/01/14	HKCRP	9:03	13:38	4:35	2	3	0	385	0	0	4	11	367
22/01/14	HKLR	9:05	14:33	5:28	2	2.5	1	418	3	0	0	12	402

Appendix I. (cont'd)

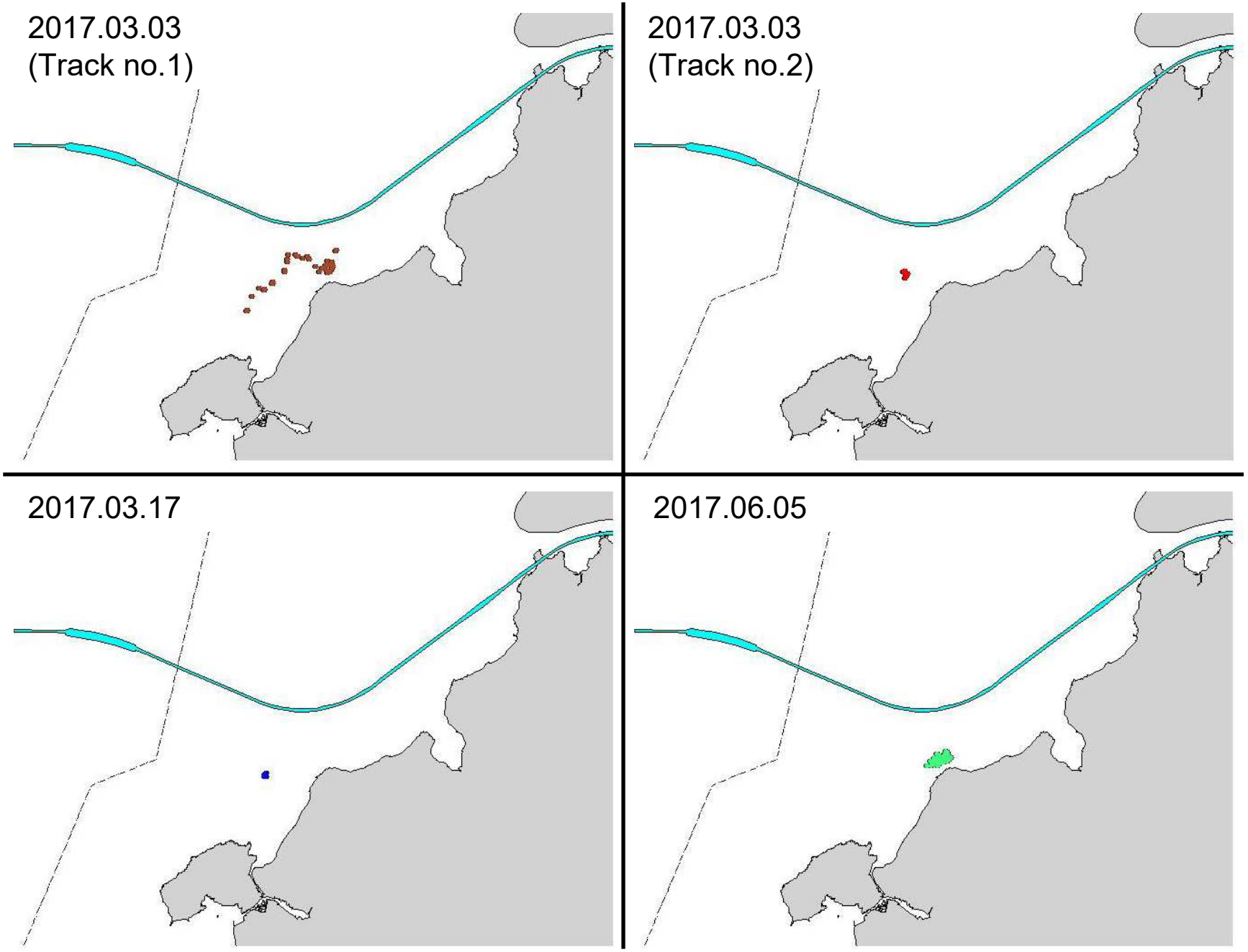
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
27/01/14	HKLR	8:54	14:59	6:05	1-3	2.5	3	517	212	0	4	13	287
06/02/14	HKCRP	9:19	14:18	4:59	2	1.5	0	308	0	0	23	12	271
17/02/14	HKCRP	9:21	13:24	4:03	2	2-3.5	1	276	55	0	2	9	209
14/03/14	HKLR	9:03	15:05	6:02	2-3	2.5	2	717	31	0	46	16	622
19/03/14	HKLR	9:16	14:30	5:14	1	2.5-3	4	543	113	0	49	13	480
16/04/14	HKLR	9:05	14:49	5:44	2-3	2.5-3	2	623	71	0	12	22	517
25/04/14	HKLR	9:08	14:47	5:39	2-4	2	0	405	0	0	10	18	375
19/05/14	HKLR	9:43	15:08	5:25	2-4	1	2	379	95	0	9	3	270
27/05/14	HKLR	9:04	14:32	5:28	1-3	1.5-2.5	1	254	5	0	0	12	234
03/06/14	HKLR	9:27	14:38	5:11	2-3	2	2	418	218	0	3	14	180
06/06/14	HKLR	9:18	15:00	5:42	2-3	1.5	1	359	34	0	0	13	310
11/07/14	HKLR	9:25	14:49	5:24	2	1.5	4	294	32	0	6	14	240
25/07/14	HKLR	9:33	14:54	5:21	2-3	2	2	416	31	4	0	5	374
22/08/14	HKLR	9:24	14:46	5:22	2	1	2	426	97	10	0	30	287
28/08/14	HKLR	9:24	14:56	5:32	2-3	2	1	408	21	15	0	10	362
01/09/14	HKLR	9:15	14:45	5:30	2-3	1-1.5	7	421	117	0	0	11	293
05/09/14	HKLR	9:09	14:33	5:24	2	2.5	1	420	1	5	0	20	392
20/10/14	HKLR	9:16	14:39	5:23	2	2	1	391	1	0	14	14	360
27/10/14	HKLR	9:09	14:38	5:29	1-2	3	3	476	93	0	21	15	345
10/11/14	HKLR	9:05	14:32	5:27	2-3	2-3.5	2	360	18	0	31	15	292
24/11/14	HKLR	9:09	14:38	5:29	2	1	0	482	0	0	31	12	438
05/12/14	HKLR	9:04	14:39	5:35	2	3	0	528	0	0	27	12	488
18/12/14	HKLR	9:00	14:15	5:15	2	2.5	0	407	0	0	7	11	388
02/01/15	HKLR	9:07	14:30	5:23	2	2.5-3	0	440	0	6	0	19	414
21/01/15	HKLR	9:14	13:16	4:02	1-2	3-3.5	0	301	0	10	6	13	270
17/02/15	HKLR	9:03	14:31	5:28	1	3.5-4	0	160	0	0	14	13	132
26/02/15	HKLR	8:59	14:33	5:34	2-3	2	1	298	64	0	15	11	207
09/03/15	HKLR	9:16	14:43	5:27	1	3.5-4	1	407	88	0	6	12	299
13/03/15	HKLR	9:04	14:40	5:36	2	1.5-2	1	446	21	0	16	12	396
14/04/15	HKLR	9:21	14:49	5:28	2	1	1	360	12	0	0	22	324
20/04/15	HKLR	9:14	14:32	5:18	2	3.5	0	268	0	0	20	8	237
11/05/15	HKLR	9:16	14:36	5:20	2	1.5	0	284	0	0	1	15	264
19/05/15	HKLR	9:04	14:05	5:01	2-3	2	0	173	0	0	0	10	161
03/06/15	HKLR	9:12	14:43	5:31	2-4	1	2	335	7	5	0	17	305

Appendix I. (cont'd)

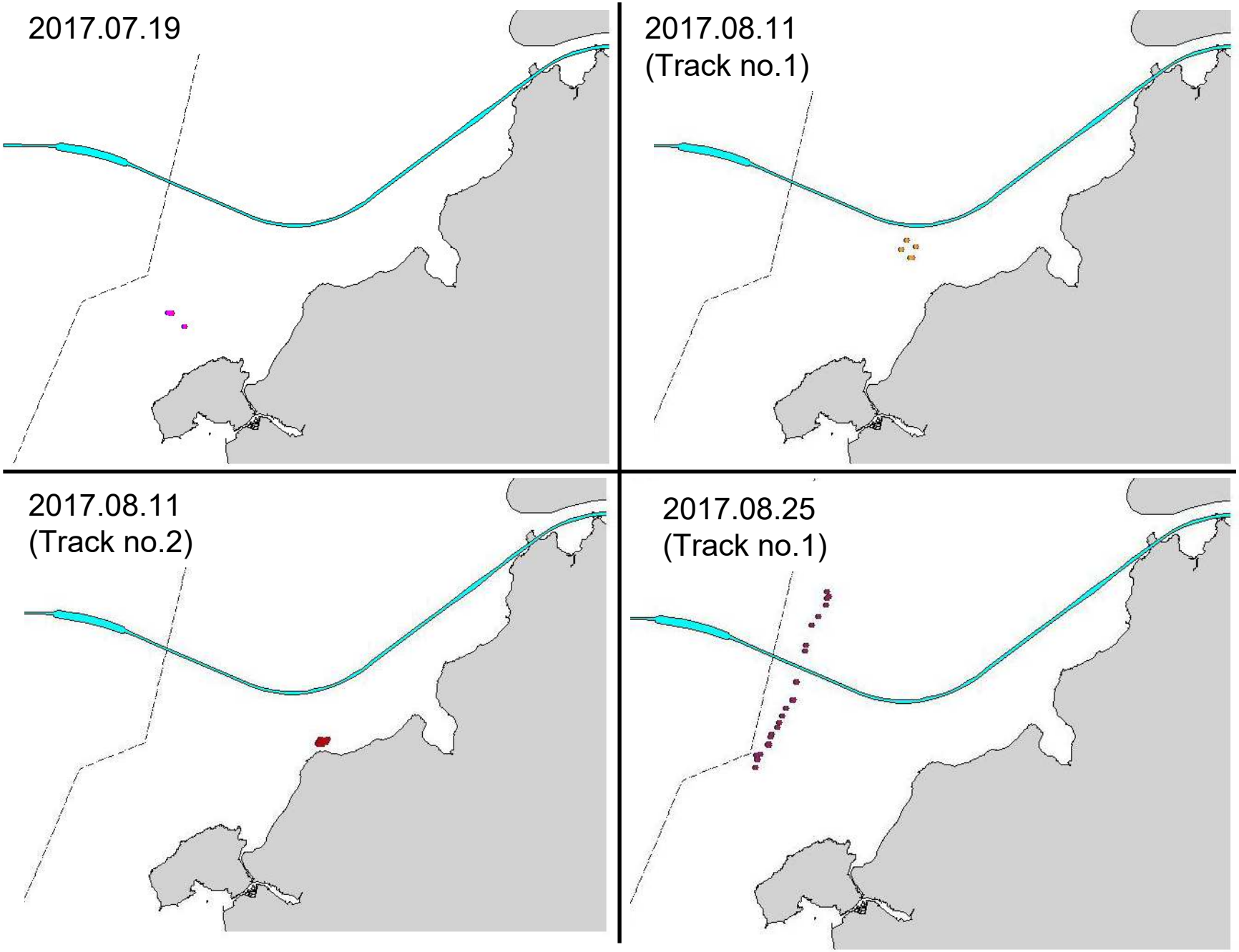
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
11/06/15	HKLR	9:05	14:30	5:25	2	2	0	274	0	0	0	12	259
06/07/15	HKLR	9:22	14:53	5:31	2	2-3	3	300	144	0	0	11	143
16/07/15	HKLR	9:28	14:44	5:16	2	2	2	334	173	0	0	23	136
13/08/15	HKLR	9:05	14:31	5:26	3	2	0	312	0	0	21	20	270
21/08/15	HKLR	9:02	14:16	5:14	2-3	2	1	276	27	30	3	11	203
04/09/15	HKLR	8:59	14:31	5:32	2	1.5	3	384	202	6	6	13	155
23/09/15	HKLR	9:02	14:30	5:28	2	1.5	1	252	10	9	0	8	223
02/10/15	HKLR	8:56	14:17	5:21	2	1.5	2	374	168	6	5	10	182
14/10/15	HKLR	8:58	14:28	5:30	2	3	1	218	83	0	0	9	124
04/11/15	HKLR	9:01	14:28	5:27	2	3	0	170	0	0	0	13	154
20/11/15	HKLR	9:02	14:31	5:29	2	2	1	219	1	6	17	20	173
01/12/15	HKLR	8:58	14:30	5:32	2	3	2	301	143	0	3	16	138
08/12/15	HKLR	8:53	14:24	5:31	2-3	2.5	1	254	68	0	3	7	173
07/01/16	HKLR	9:07	14:34	5:27	2	2	0	267	0	3	3	12	248
12/01/16	HKLR	9:03	14:24	5:21	2	2	2	227	21	0	9	10	186
05/02/16	HKLR	9:09	14:30	5:21	3-4	2.5	0	254	0	6	0	11	235
12/02/16	HKLR	8:56	14:29	5:33	2	3	2	247	89	5	5	17	130
02/03/16	HKLR	9:08	14:30	5:22	1	2.5	3	310	188	0	3	9	175
16/03/16	HKLR	9:25	14:34	5:09	1-2	3-3.5	1	225	1	0	5	11	207
21/04/16	HKLR	9:19	14:30	5:11	1-2	1.5-3.5	0	156	0	0	1	6	148
29/04/16	HKLR	8:57	14:20	5:23	2-3	2	0	251	0	0	0	19	230
09/05/16	HKLR	9:06	14:35	5:29	2	2	2	193	39	0	2	14	137
16/05/16	HKLR	9:11	14:42	5:31	3	1	0	166	0	0	0	11	151
02/06/16	HKLR	9:10	14:32	5:22	3-4	2.5	0	193	0	0	0	15	177
16/06/16	HKLR	9:27	14:31	5:04	2-3	2.5	1	213	3	0	0	12	196
07/07/16	HKLR	9:22	14:30	5:08	2-3	2	1	227	2	0	13	13	197
15/07/16	HKLR	9:24	14:30	5:06	2-4	4.5	1	185	11	5	2	18	147
11/08/16	HKLR	9:57	14:34	4:37	2	2-3	0	70	0	0	4	8	56
25/08/16	HKLR	9:15	14:15	5:00	2	2.5	2	203	41	0	4	13	144
30/09/16	HKLR	9:20	14:30	5:10	3	2.5-3.5	0	106	0	0	5	12	88
03/10/16	HKLR	9:27	14:45	5:18	2	1.5	0	148	0	0	20	23	102
17/10/16	HKLR	9:15	13:59	4:44	2-3	2.5	1	179	7	0	54	10	107
20/10/16	HKLR	9:14	14:31	5:17	2	3-3.5	0	190	0	0	26	17	146

Appendix I. (cont'd)

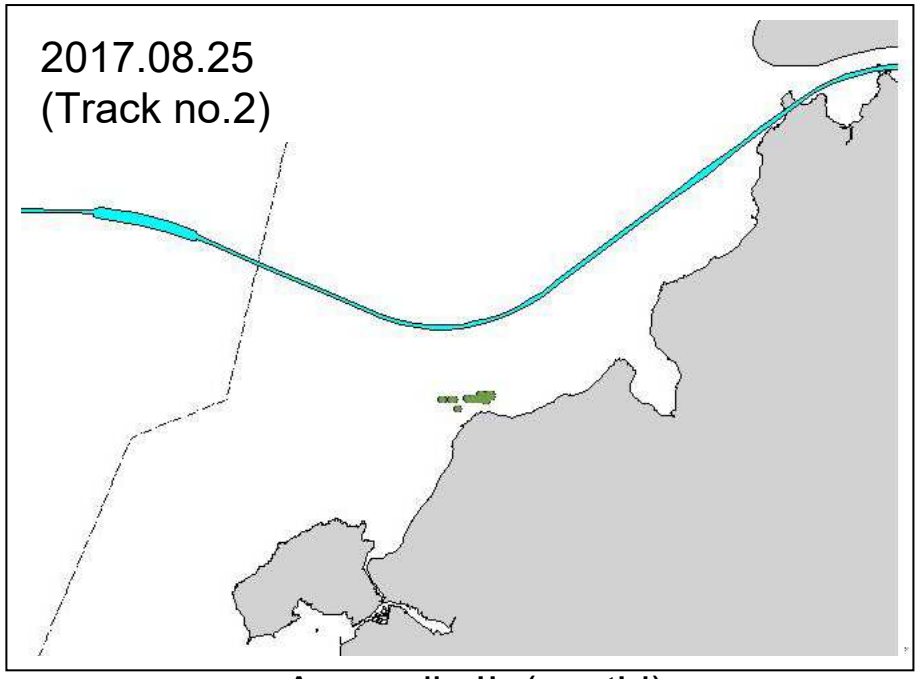
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
08/11/16	HKLR	9:10	14:33	5:23	2	2.5-3.5	0	165	0	0	20	17	126
17/11/16	HKLR	9:01	14:30	5:29	2	2	3	152	94	0	4	11	40
01/12/16	HKLR	9:04	14:30	5:26	3	2.5	2	224	61	0	21	19	122
15/12/16	HKLR	9:17	14:31	5:14	3	2	1	204	50	0	56	12	85
09/01/17	HKLR	9:10	14:11	5:01	2	2.5-3	0	130	0	0	8	12	109
18/01/17	HKLR	9:13	14:15	5:02	2-3	2.5-4	0	79	0	0	7	15	55
02/02/17	HKLR	8:56	14:34	5:38	2	2.5	1	163	14	0	17	21	109
10/02/17	HKLR	9:07	14:32	5:25	2-3	3	2	201	45	0	18	14	123
03/03/17	HKLR	9:02	14:31	5:29	1-3	2	2	243	60	0	30	19	133
17/03/17	HKLR	9:02	14:31	5:29	2-3	2-2.5	1	162	7	17	18	13	106
03/04/17	HKLR	9:15	14:39	5:24	2-3	2	0	135	0	2	8	15	108
13/04/17	HKLR	8:58	14:34	5:36	2	2.5	0	102	0	0	3	14	82
09/05/17	HKLR	9:00	14:34	5:34	1-2	1.5-3	0	81	0	0	15	13	52
29/05/17	HKLR	9:06	14:30	5:24	2-3	1.5	0	86	0	0	2	9	73
05/06/17	HKLR	9:06	14:17	5:11	2-4	1.5	1	178	104	0	10	6	57
22/06/17	HKLR	9:19	14:36	5:17	2	1.5	0	76	0	0	7	6	61
06/07/17	HKLR	9:45	14:55	5:10	2	1.5	0	32	0	0	0	3	29
19/07/17	HKLR	9:15	14:33	5:18	2	2	1	92	8	0	0	6	77
11/08/17	HKLR	9:30	14:33	5:03	2-3	2	2	118	42	0	8	6	61
25/08/17	HKLR	9:25	14:36	5:11	1-2	1.5	2	161	70	14	17	7	52



Appendix II. Nine tracks obtained during theodolite tracking sessions in March – August 2017



Appendix II. (cont'd)



Appendix II. (cont'd)

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Our Ref: MA12014/DCVJV/it190111_3rd

Dragages-China Habour-VSL Joint Venture

Site Office: Tung Chung Waterfront Road,
adjacent to Tung Chung New Development Pier,
New Territories, Hong Kong

By Mail
11 January 2019

Attn.: Mr. W K Poon (Project Director)

Dear Sir,

Contract No. HY/2011/09
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill
- Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (September 2017 – February 2018)

I refer to the revised Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (September 2017 – February 2018) dated April 26, 2018 for the captioned Contract prepared by Samuel Hung of Hong Kong Cetacean Research Project.

I hereby agree and certify that the above report is true and correct to the best of my knowledge.

If you need any further information, please call me at 2151 2089 or 9161 7287.

Yours faithfully,
WELLAB Limited

Dr. Priscilla Choy
Environmental Team Leader

CONTRACT HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill

Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (September 2017 – February 2018)

By Samuel Hung, Ph.D.
Hong Kong Cetacean Research Project (HKCRP)

April 26, 2018

1. INTRODUCTION

The Hong Kong Link Road (HKLR) comprises a 9.4 km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1-km tunnel section to the reclamation formed along the east coast of the Airport Island, and a 1.6-km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). Dragages – China Harbour – VSL JV (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2011/09 – Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill".

According to the HKLR EM&A Manual, a number of environmental monitoring and audit works related to Chinese White Dolphins (a.k.a. Indo-Pacific humpback dolphins, *Sousa chinensis*) are to be conducted during baseline, construction and post-construction phases, including land-based dolphin behaviour and movement monitoring. In September 2016, a continuation of the construction phase monitoring on the north-south movement is commissioned by the Contractor, and this progress report for the land-based monitoring on north-south movement of Chinese White Dolphins across the Hong Kong Link Road presents the methodology and results during the third half-yearly period of monitoring from September 2017 to February 2018, at a location hereafter termed as Sham Wat Station.

2. METHODS

2.1. Monitoring Station

Based on the requirements under the EM&A Manual as described in the EM&A proposal for this work, the Sham Wat Station is located along the northwest coast of Lantau Island (GPS position: 22°16.10' N. and 113°52.32' E, Figure 1). The station was selected based on its height above sea level (minimum requirement of over 20 metres; Würsig et al. 1991), close proximity to shore, and relatively unobstructed views of the HKLR alignment to the west of the airport extending toward the HKSAR Boundary (Figure 2).

The height of the Sham Wat Station established by the HKCRP team is 55.70 metres high at mean low water, 66 metres from shore. The station is only a few hundred metres to the closest point of the HKLR alignment (Figure 2), which is ideal to examine the north-south movements of Chinese White Dolphins in relation to the HKLR alignment.

2.2. Monitoring Period and Definition of Baseline/Construction Phases

Before the present construction phase monitoring study, thirty days of shore-based theodolite tracking works were conducted for each of the baseline and initial construction phases according to the EM&A manual requirements (Table 1). An additional 64 days of shore-based monitoring (twice per month, with 5-6 hours on each survey day) were also conducted throughout the construction period specifically to examine the impact of bridge construction on north-south movement of Chinese White Dolphins across the bridge alignment. Such monitoring commenced after the 30 days of construction phase monitoring in relation to bored piling impact assessment was completed in July 2013, and ended in August 2016. Thereafter, a continuation of the construction phase monitoring was commenced in September 2016 for the present study.

It should be noted that some shore-based theodolite tracking at Sham Wat Station was also conducted as part of the AFCD long-term marine mammal monitoring programme since 2011, and such data was also integrated with the HKLR baseline monitoring data to increase the overall sample size for analysis on the north-south movements of dolphins (Table 1).

Table 1. Different monitoring periods during baseline/construction phases, with the current six-month monitoring period highlighted in **blue**

(* The initial construction phase in March – June 2013 was considered under baseline phase, as only

minor work procedures with lower level of disturbance took place at just two pier sites)

	Survey Type	Time Period	Effort (# of hours)
Baseline Phase	HKCRP	Apr 2011 – Dec 2012	51.1
Baseline Phase (under bored piling monitoring program)	HKLR	Jan 2013	177.8
Initial Construction Phase* (under bored piling monitoring program)	HKLR	Mar-Apr 2013	179.3
	HKCRP	Apr-Jun 2013	30.9
Construction Phase	HKLR/HKCRP	Jul-Dec 2013	107.5
	HKLR/HKCRP	Jan-Dec 2014	134.8
	HKLR	Jan-Dec 2015	128.8
	HKLR	Jan-Aug 2016	84.1
	HKLR	Sep 2016–Feb 2017	63.1
	HKLR	Mar-Aug 2017	64.1
	HKLR	Sep 2017-Feb 2018	65.0

For the examination of north-south movement of Chinese white dolphins across the HKLR alignment, the baseline phase was defined as the time period from April 2011 (i.e. the start of AFCD monitoring at Sham Wat) up to June 2013. Even though bored piling works associated with HKLR construction commenced on March 18th and continued until April 13th of 2013, only minor work procedures with lower level of disturbance (such as installation of permanent casing and excavation for bored pile) took place at two pier sites (P48 and P52). Presumably these works in less than a month at the very initial stage of bored piling works have insignificant impact as obstruction on north-south movements of dolphins. And after this brief period of construction, the bored piling works were suspended for two months in May and June 2013 as part of the environmental permit condition to avoid the peak calving season of Chinese White Dolphins. Therefore, the period of March to June of 2013 was also included as part of the baseline period with very low level of construction activities occurred along the HKLR alignment (Table 1).

On the other hand, the construction phase for this monitoring on north-south movements was defined as the time period starting from July 2013, when marine bored piling activities construction works have intensified significantly until almost all piling works were completed in March 2015, and with subsequent monitoring

works ended in August 2016. The additional 18 months of monitoring starting in September 2016 under the present study is also included as part of the construction phase as well (Table 1).

2.3. Monitoring Methodology

The methodology of the present monitoring programme generally followed the one established under the Piwetz et al. (2012) study that was part of the AFCD long-term marine mammal monitoring programme (Hung 2012). On each survey day from Sham Wat Station, observers searched continuously for Chinese white dolphins using unaided eyes and 7x50 handheld binoculars. A theodolite tracking session was initiated when an individual dolphin or group of dolphins was located, and focal follow methods were used to track the dolphins (Lundquist 2012, Lundquist et al. 2012a and 2012b, Piwetz et al. 2012).

Within a group, a focal individual was selected for the purposes of tracking behaviour and movement of the group, based on its distinctive feature such as colouration or severe injury mark. The focal individual or group were then tracked continuously via the theodolite, with positions recorded whenever a known or unknown dolphin surfaced. If an individual could not be positively distinguished from other members, the group would be tracked by recording positions based on a central point within the group when the dolphins surfaced. Tracking continued until animals were lost from view, moved beyond the range of reliable visibility (generally >3 km but up to >5 km under excellent conditions), or when environmental conditions obstructed visibility (e.g. intense haze).

Positions of dolphins, boats and construction activities were measured using a Sokkisha DT5 digital theodolite with ± 5-sec precision and 30-power magnification connected to a laptop computer running the program *Pythagoras* Version 1.2 (Gailey and Ortega-Ortiz 2002). This program calculates a real-time conversion of horizontal and vertical angles collected by the theodolite into geographic positions of latitude and longitude each time a fix is initiated. *Pythagoras* also displays positions, movements, and distances in real-time. When possible, the position of the focal dolphin was recorded at every surfacing with use of *Pythagoras*.

2.4. Data Analysis

First, the dolphin encounter rates (number of encounters per 100 hours of observation) were calculated before and during HKLR construction. The comparison between different periods of baseline and construction phases would allow

determination of whether the observed level of occurrence was different during construction than it was prior to construction, which could be affected by the bored piling works and presence of bridge piers as obstruction along the HKLR alignment.

To investigate whether the north-south movement of Chinese white dolphins between North and West Lantau waters have been affected by the presence of the Hong Kong Link Road, in particular the spacing between bridge pile cap piers, the number of dolphin groups that moved across the bridge alignment (either from north to south, or from south to north) was examined before and during the construction of the bridge, and compared between the two phases. The proportions of dolphin tracks that crossed the bridge alignment before and during construction were compared, and if a significantly greater percentage of dolphin tracks was recorded crossing the bridge alignment in the baseline phase than in the construction phase, the obstruction of the bridge as a barrier to dolphin movement would become evident.

3. RESULTS AND DISCUSSION

3.1. Summary of Theodolite Tracking Effort

For the present six-month study (i.e. September 2017 to February 2018) under the construction phase monitoring, 65.0 hours of shore-based theodolite tracking effort was conducted on 12 survey days (Appendix I). During these 12 days of land-based monitoring sessions, dolphins were successfully tracked from shore on ten days, with a total of 24 dolphin groups being sighted (Appendix I). All 24 groups were successfully tracked, and 902 fixes of dolphin positions were obtained among these 24 tracks. In addition, 1,193 fixes were obtained from the positions of other vessels in the study area, including 235 fixes on fishing boats, 105 fixes on high-speed ferries, 77 fixes on dolphin-watching boats, and 776 fixes on other vessels including construction vessels (Appendix I).

3.2. Dolphin encounter rates

Encounter rates of dolphins (number of dolphin sightings per 100 hours of tracking effort) were calculated for the baseline phase and different periods of the construction phase (including the six-month period from the present study), and are presented in Table 2.

Table 2. Dolphin encounter rates (number of dolphin sightings per 100 hour of theodolite tracking effort) during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins, with the current six-

month monitoring period highlighted in **blue**

	Time Period	Effort (# of hours)	# of Dolphin Sightings	Encounter Rate
Baseline Phase	Apr 2011-Jan 2013	228.9	99	43.3
	Mar-Jun 2013	210.2	38	18.1
	Overall	***439.1***	***137***	***31.2***
Construction Phase	Jul-Dec 2013	107.5	70	65.1
	Jan-Dec 2014	134.8	42	31.2
	Jan-Dec 2015	128.8	23	17.9
	Jan-Aug 2016	84.1	15	17.8
	Sep 2016-Feb 2017	63.1	10	15.8
	Mar-Aug 2017	64.1	9	14.0
	Sep 2017-Feb 2018	65.0	24	36.9
	Overall	***647.4***	***193***	***29.8***

During the baseline phase, there was a noticeable drop in dolphin encounter rate from 43.3 for the period without any construction activities (i.e. up to January 2013), to only 18.1 at the very initial stage of construction works with just a few sites with some bored piling activities (i.e. March to June 2013) (Table 2). In the following months (July-December 2013) when the construction works resumed after a two-month suspension to satisfy the environmental permit condition, dolphin encounter rate rosed back to a higher level (65.1). Subsequently, the encounter rate quickly reduced to a much lower level in 2015, and remained fairly low in 2016 and the first eight months of 2017 (Table 2).

However, such encounter rate has increased considerably in the present six-month period in September 2017 to February 2018, which was more than double of the previous five periods, and was the highest since the initial construction phase in July-December 2013 (Table 2). Such increase in dolphin occurrence within the study area near Shum Wat and the HKLR09 bridge alignment was in contrary to the regular line-transect dolphin monitoring survey results in West Lantau under the HKLR09 EM&A programme, as the dolphin quarterly encounter rates in the past two quarters of September-November 2017 and December 2017-February 2018 were among the lowest since HKLR09 construction began in 2013.

3.3. North-south movement and distribution of tracks

The 24 dolphin tracks collected during the current six-month period were

analyzed for north-south movements of dolphins across the bridge alignment. These tracks contained 902 individual lat-long locations, which were analyzed to determine whether they were entirely on the north or south side of the alignment, or crossing through the alignment. The different proportions were also compared to the ones from different phases before and during HKLR construction works.

Among the 24 tracks, 79% (19 tracks) were wholly on the south side of the bridge alignment, 17% (four tracks) entirely on the north side, and 4% (one track) passed across the alignment (Table 3; also see tracks in Appendix II).

Table 3. Percentages of dolphin tracks to the south side and north side of HKLR alignment as well as across the alignment during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins, with the current six-month monitoring period highlighted in **blue**

	Time Period	# of Tracks	South Side of HKLR	North Side of HKLR	Across HKLR Alignment
Baseline Phase	Apr 2011-Jan 2013	84	70%	13%	17%
	Mar-Jun 2013	28	68%	4%	28%
	Overall	***112***	***70%***	***11%***	***20%***
Construction Phase	Jul-Dec 2013	45	71%	2%	27%
	Jan-Dec 2014	38	84%	11%	5%
	Jan-Dec 2015	21	71%	0%	29%
	Jan-Aug 2016	9	89%	0%	11%
	Sep 2016-Feb 2017	10	90%	0%	10%
	Mar-Aug 2017	9	89%	0%	11%
	Sep 2017-Feb 2018	24	79%	17%	4%
	Overall	***156***	***79%***	***6%***	***15%***

The percentages of tracks across the alignment were examined across different periods of baseline and construction phases (Table 3). During the baseline period up to June 2013, 20% of tracks passed across the alignment, and in the subsequent months from July to December 2013, such percentage remained similar, with 27% of tracks passed across the alignment. However, such percentage have dropped dramatically to only 5% in 2014, when bored piling works were the most intense, and the spacing between bridge piers became progressively narrower with multiple work fronts.

In 2015, the percentage of tracks across the alignment rebounded to a much higher level (29%), but the total number of tracks and encounter rate of dolphins were both much lower than the ones in 2014. The percentage of tracks across the alignment dropped to a much lower level during the first eight months of 2016 (11%), and it remained low for the two six-month periods afterward (i.e. 10% during September 2016 to February 2017; 11% during March to August 2017) under the present study (Table 3). In the present six-month period (September 2017-February 2018), such percentage fell to the lowest (4%), even though there was one track across the alignment which was the same as the previous three periods.

It appeared that the level of north-south movements have greatly diminished since the completion of bored piling works, and there has been no sign of recovery for dolphin crossings through the alignment. However, there were some positive signs in the present six-month period, as the percentage of tracks to the north of the alignment (17%) was the highest among all periods (including the baseline phase), and those four tracks as well as a number of tracks to the south of the alignment were located fairly close to the bridge alignment (Appendix II), indicating an increase amount of dolphin activities near the alignment. Therefore, the theodolite tracking on investigation of north-south movement should be continued, to continuously assess whether the recovery of such movement would happen in the near future.

4. CONCLUSION

Intensive effort of shore-based theodolite tracking at Sham Wat Station was conducted before and during the construction of HKLR with bored piling works. The results from the tracking sessions revealed that when the bored piling works became most intense and the spacing between bridge piers became narrower, the dolphins have diminished their use in the vicinity of the bridge alignment, and their north-south movements were also affected with seldom crossings underneath the bridge alignment.

The low level of north-south movements of Chinese white dolphins across the HKLR alignment in recent years could possibly be attributed by two factors: 1) the physical presence of bridge piers and narrower spacing between them which could partially obstruct movements of dolphins; and 2) the on-going deterioration of habitat quality in North Lantau waters that makes it less attractive for dolphins to cross the alignment from West Lantau to North Lantau waters. It would be premature at this point to conclude which of the factors, or both factors, have influenced the observed

declining level of north-south movements in recent years. Apparently, continuous monitoring of such movement through shore-based theodolite tracking from Sham Wat Station would be critical in order to determine whether the north-south movement would resume to the level of pre-construction phase, and the dolphins have partially or fully recovered from the impact of the HKLR construction.

5. REFERENCES

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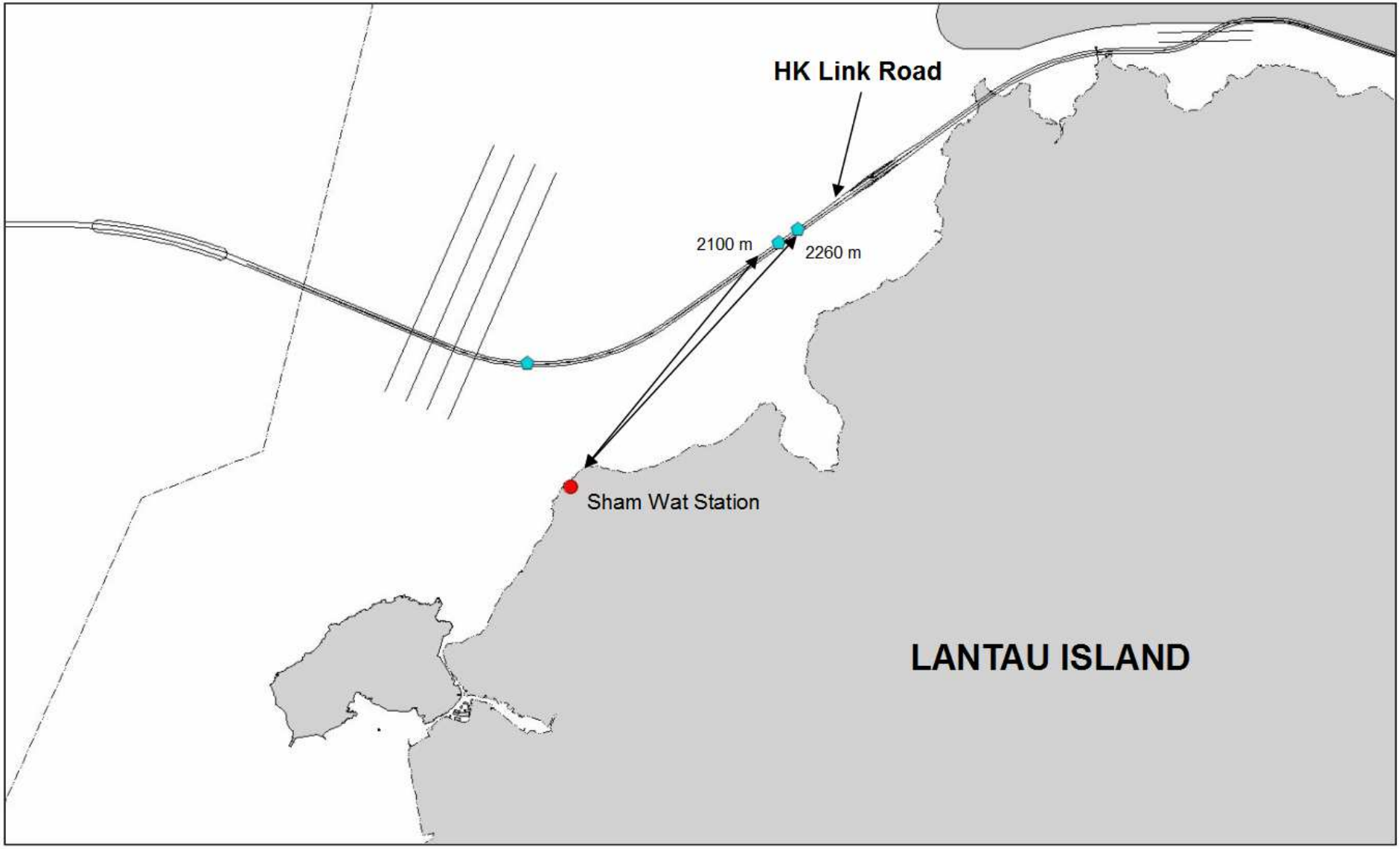


Figure 1. Location of Sham Wat Theodolite Tracking Station in northwestern Lantau with the first few bored piling locations

Figure 2. Panoramic View from the Sham Wat Theodolite Tracking Station (photos taken in 2012 (above) and 2015 (middle & below))

Appendix I. Sham Wat Land-based Theodolite Tracking Database (April 2011 - February 2018)

(note: the current six-month monitoring period is highlighted in **blue**)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
14/04/11	HKCRP	10:00	13:16	3:16	2-4	1-2	2	261	126	0	92	8	34
03/08/11	HKCRP	7:22	13:10	5:48	1-2	4	4	206	78	0	41	9	75
09/09/11	HKCRP	9:42	13:42	4:00	3	3	0	59	0	5	7	6	38
25/12/11	HKCRP	9:04	10:55	1:51	4	1.5	2	64	26	2	14	8	13
15/03/12	HKCRP	9:17	13:30	4:13	2	2	0	88	0	0	30	11	46
26/06/12	HKCRP	9:33	12:59	3:26	2	2	6	108	61	0	33	7	5
02/07/12	HKCRP	8:13	12:17	4:04	2	2	15	190	147	0	18	5	15
13/07/12	HKCRP	6:07	10:30	4:23	2	1	13	145	47	0	58	6	30
31/07/12	HKCRP	6:29	11:00	4:31	1	3	4	152	47	0	45	8	48
20/08/12	HKCRP	9:24	13:15	3:51	1-2	2.5	4	295	233	0	25	13	22
09/10/12	HKCRP	9:31	12:56	3:25	2	2-3.5	1	61	17	0	21	8	13
10/12/12	HKCRP	10:06	14:35	4:29	3	2.5	1	81	25	0	7	4	44
20/12/12	HKCRP	12:56	16:46	3:50	3-4	2-3	1	96	5	3	4	6	76
02/01/13	HKLR	9:20	14:50	5:30	2	2.5	3	156	33	0	22	13	87
03/01/13	HKLR	9:00	14:55	5:55	2-4	2.5	0	175	0	0	34	17	123
04/01/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	157	0	4	0	18	132
05/01/13	HKLR	10:10	15:40	5:30	3	2.5-3	0	215	0	0	30	7	176
06/01/13	HKLR	9:05	14:55	5:50	3-4	2.5-3	0	154	0	0	19	26	108
07/01/13	HKLR	8:57	14:57	6:00	3-4	3-3.5	0	100	0	0	7	14	78
08/01/13	HKLR	9:01	14:51	5:50	2-3	3-3.5	0	110	0	0	9	14	86
09/01/13	HKLR	8:55	13:58	5:03	3-5	2.5-3.5	0	68	0	0	5	7	55
10/01/13	HKLR	9:01	15:31	6:30	2-3	3-3.5	0	95	0	0	6	12	75
11/01/13	HKLR	9:15	15:45	6:30	2-4	2.5-3.5	1	204	19	0	41	23	118
12/01/13	HKLR	9:09	15:09	6:00	2-3	4	1	94	12	0	7	10	64
13/01/13	HKLR	8:54	14:54	6:00	2-4	2.5-4	2	112	16	3	26	20	47
14/01/13	HKLR	8:50	14:50	6:00	2	2.5	0	275	0	0	49	18	206
15/01/13	HKLR	9:27	15:27	6:00	2-4	1.5-3	0	180	0	0	44	16	118
16/01/13	HKLR	9:00	15:00	6:00	2	3-4	0	85	0	0	8	10	64
17/01/13	HKLR	8:55	14:55	6:00	2-3	2-3.5	4	349	184	0	12	13	138
18/01/13	HKLR	8:55	15:00	6:05	2-3	2.5-3.5	0	213	0	0	48	14	146
19/01/13	HKLR	9:10	15:10	6:00	2	2.5	1	247	52	0	55	23	115
20/01/13	HKLR	8:56	14:56	6:00	2-3	2	0	163	0	0	8	27	127
21/01/13	HKLR	8:50	15:10	6:20	1-2	2-3.5	0	248	0	0	18	24	202
22/01/13	HKLR	8:50	15:20	6:30	2-3.5	1	3	253	152	0	6	17	74

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
23/01/13	HKLR	8:28	14:58	6:30	1	3.5-4	0	115	0	0	5	15	92
24/01/13	HKLR	8:23	15:38	7:15	1	3-4	3	412	328	0	5	18	57
25/01/13	HKLR	9:07	15:00	5:53	2-4	2.5-3	0	132	0	0	9	17	105
26/01/13	HKLR	8:55	15:25	6:30	2	2.5-3	9	433	240	0	46	17	128
27/01/13	HKLR	9:11	15:41	6:30	1-3	3.5	4	162	44	0	0	40	78
28/01/13	HKLR	8:55	15:30	6:35	2-3	2-2.5	4	295	96	0	34	12	151
29/01/13	HKLR	8:30	15:00	6:30	1-2	2	7	476	169	0	91	15	200
30/01/13	HKLR	8:18	14:48	6:30	3-4	1.5	4	264	128	0	9	11	112
06/03/13	HKLR	9:07	15:10	6:03	1-2	1.5-2	0	254	0	0	55	11	185
07/03/13	HKLR	8:56	14:57	6:01	1	2.5	1	231	4	0	18	12	196
09/03/13	HKLR	8:55	15:00	6:05	1-3	2	0	258	0	0	47	20	188
10/03/13	HKLR	8:53	14:54	6:01	1-2	1.5-2.5	2	219	42	0	36	36	104
11/03/13	HKLR	9:00	15:01	6:01	2-4	2.5	2	339	31	0	46	15	246
12/03/13	HKLR	8:59	14:59	6:00	2-4	2.5	2	369	37	0	54	17	259
13/03/13	HKLR	9:15	15:15	6:00	1-2	2.5-3	3	386	67	0	57	13	245
14/03/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	363	0	0	39	16	306
15/03/13	HKLR	9:05	15:05	6:00	2	2.5	0	353	0	0	132	15	205
16/03/13	HKLR	8:55	15:00	6:05	2-3	2-2.5	0	326	0	0	94	16	215
17/03/13	HKLR	8:53	14:53	6:00	2-3	2.5	1	382	59	0	49	43	230
18/03/13	HKLR	9:05	15:05	6:00	2	2.5	1	325	1	0	80	16	227
19/03/13	HKLR	9:03	14:27	5:24	2	2	2	389	38	0	72	15	263
20/03/13	HKLR	9:00	15:00	6:00	2	1.5	2	481	70	0	60	11	339
21/03/13	HKLR	9:03	15:03	6:00	2-4	2.5-3	0	261	0	0	18	18	224
22/03/13	HKLR	8:59	14:59	6:00	2	3	1	368	2	0	22	17	325
23/03/13	HKLR	9:00	15:15	6:15	2	2	1	444	6	0	69	16	352
24/03/13	HKLR	9:06	13:43	4:37	1	3	0	254	0	0	49	31	173
25/03/13	HKLR	9:00	15:00	6:00	3-5	2.5-3.5	1	250	7	0	34	13	194
27/03/13	HKLR	9:56	15:35	5:39	2-4	1.5-3	0	273	0	0	48	11	212
28/03/13	HKLR	9:00	11:34	2:34	1-3	2	0	207	0	0	42	7	157
30/03/13	HKLR	9:15	15:07	5:52	3-6	2-2.5	0	276	0	0	66	20	157
01/04/13	HKLR	9:07	15:20	6:13	2	2.5-3	0	432	0	0	90	35	304
02/04/13	HKLR	9:02	13:09	4:07	1-2	3-4	1	250	13	0	65	10	161
04/04/13	HKLR	9:02	15:32	6:30	3-4	2.5-3	2	330	80	0	31	35	182
05/04/13	HKLR	9:53	15:23	5:30	3-4	2.5	0	277	0	0	50	13	212

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
07/04/13	HKLR	9:00	15:00	6:00	2-3	2	0	299	0	0	32	40	226
08/04/13	HKLR	9:05	15:05	6:00	2	2.5	0	233	0	0	17	15	200
09/04/13	HKLR	9:00	15:30	6:30	2-3	2-3	0	193	0	0	16	11	164
10/04/13	HKLR	9:00	15:00	6:00	2	2-2.5	0	315	0	0	27	17	270
11/04/13	HKLR	9:00	14:50	5:50	2	2.5	0	94	0	0	21	0	70
23/04/13	HKCRP	9:36	14:25	4:49	2-3	1.5-3	0	203	0	0	34	11	157
29/04/13	HKCRP	9:03	13:28	4:25	2-3	2.5-3	2	227	60	0	11	12	142
08/05/13	HKCRP	9:03	13:30	4:27	3-4	2.5	0	183	0	0	12	10	160
15/05/13	HKCRP	9:12	13:28	4:16	1-3	1.5	1	193	1	0	21	13	157
30/05/13	HKCRP	10:14	14:16	4:02	1-3	1	4	333	214	0	0	3	115
13/06/13	HKCRP	9:06	13:36	4:30	3	2.5	4	230	107	0	19	8	95
26/06/13	HKCRP	9:04	13:31	4:27	3-5	1	5	271	73	0	9	7	181
04/07/13	HKCRP	9:27	14:03	4:36	2	1.5-2	2	336	28	0	7	8	292
08/07/13	HKLR	9:01	15:01	6:00	1	1	1	371	119	0	36	13	202
09/07/13	HKLR	9:04	15:04	6:00	2-3	1-2	4	389	117	1	40	14	216
10/07/13	HKLR	10:57	17:00	6:03	2	1	5	422	120	2	50	8	241
11/07/13	HKLR	9:08	15:01	5:53	1	1	5	456	211	0	54	5	185
12/07/13	HKLR	9:06	15:06	6:00	2	2.5	15	430	235	11	33	21	129
13/07/13	HKLR	9:06	15:01	5:55	1-3	2.5	7	378	211	0	16	26	122
15/07/13	HKLR	9:06	15:08	6:02	1-3	2-3	2	188	50	0	4	11	103
17/07/13	HKLR	9:02	13:54	4:52	2	2-2.5	1	330	127	6	0	11	185
18/07/13	HKLR	9:14	15:06	5:52	2	1.5-2	0	251	0	0	0	14	236
19/07/13	HKLR	9:10	15:04	5:54	2-3	1-1.5	3	268	39	7	0	12	207
23/07/13	HKLR	9:02	15:02	6:00	2	1.5	7	334	126	0	3	9	195
24/07/13	HKLR	12:30	16:02	3:32	2	1-1.5	1	158	64	0	0	4	88
29/07/13	HKLR	8:56	14:59	6:03	2	1	6	275	117	0	0	6	151
26/08/13	HKCRP	9:06	14:10	5:04	2	1.5-2.5	4	456	167	0	9	16	262
29/08/13	HKCRP	9:11	13:15	4:04	1-2	1	3	215	59	0	10	9	135
28/09/13	HKLR	8:59	15:01	6:02	2-4	3	1	590	10	0	3	14	565
30/09/13	HKLR	10:28	15:33	5:05	2-3	3.5	0	163	0	0	2	1	159
04/12/13	HKCRP	8:58	13:01	4:03	2-3	3-3.5	1	385	1	0	20	7	355
19/12/13	HKCRP	9:03	13:33	4:30	3-4	2-2.5	2	320	20	0	0	5	293
16/01/14	HKCRP	9:03	13:38	4:35	2	3	0	385	0	0	4	11	367
22/01/14	HKLR	9:05	14:33	5:28	2	2.5	1	418	3	0	0	12	402

Appendix I. (cont'd)

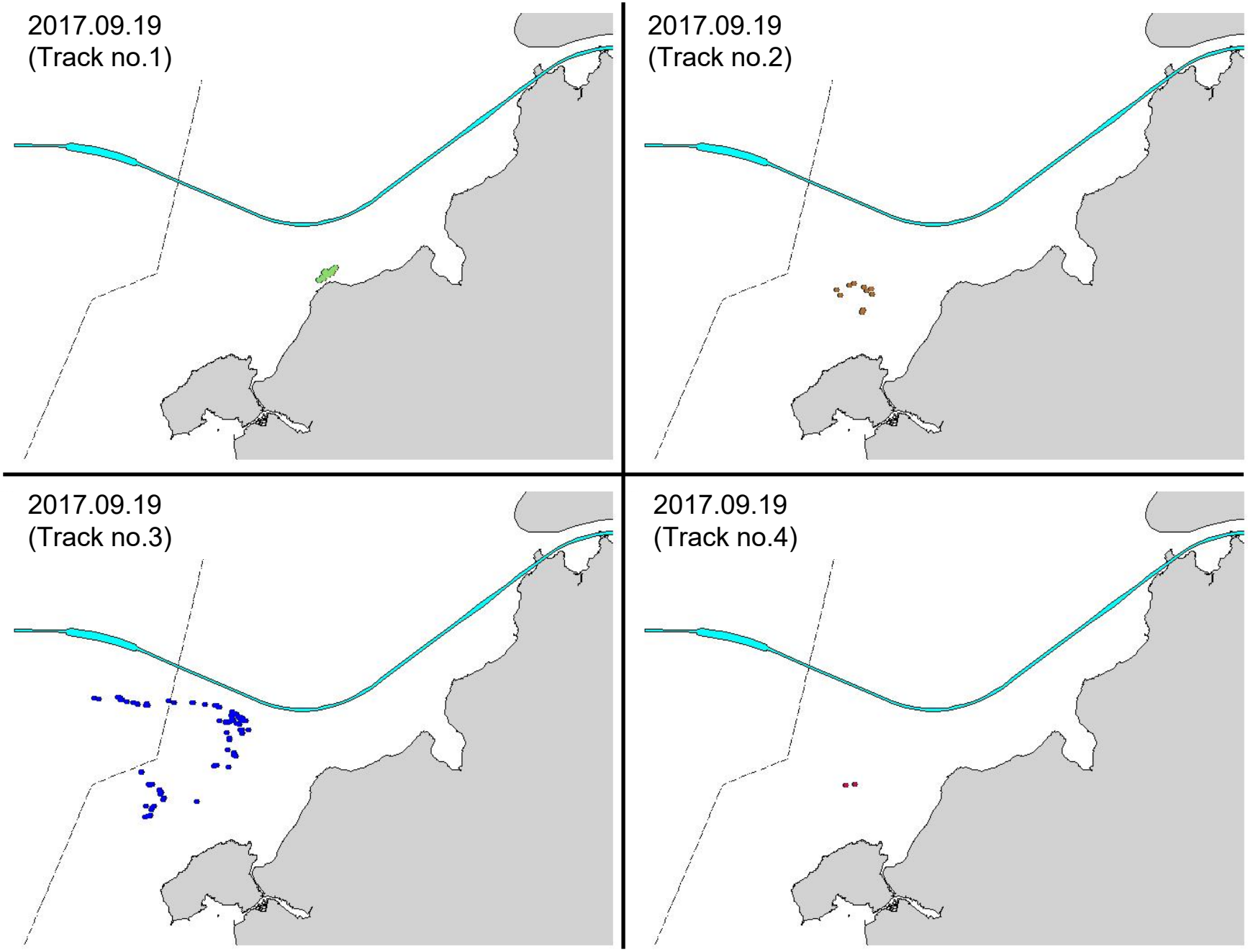
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
27/01/14	HKLR	8:54	14:59	6:05	1-3	2.5	3	517	212	0	4	13	287
06/02/14	HKCRP	9:19	14:18	4:59	2	1.5	0	308	0	0	23	12	271
17/02/14	HKCRP	9:21	13:24	4:03	2	2-3.5	1	276	55	0	2	9	209
14/03/14	HKLR	9:03	15:05	6:02	2-3	2.5	2	717	31	0	46	16	622
19/03/14	HKLR	9:16	14:30	5:14	1	2.5-3	4	543	113	0	49	13	480
16/04/14	HKLR	9:05	14:49	5:44	2-3	2.5-3	2	623	71	0	12	22	517
25/04/14	HKLR	9:08	14:47	5:39	2-4	2	0	405	0	0	10	18	375
19/05/14	HKLR	9:43	15:08	5:25	2-4	1	2	379	95	0	9	3	270
27/05/14	HKLR	9:04	14:32	5:28	1-3	1.5-2.5	1	254	5	0	0	12	234
03/06/14	HKLR	9:27	14:38	5:11	2-3	2	2	418	218	0	3	14	180
06/06/14	HKLR	9:18	15:00	5:42	2-3	1.5	1	359	34	0	0	13	310
11/07/14	HKLR	9:25	14:49	5:24	2	1.5	4	294	32	0	6	14	240
25/07/14	HKLR	9:33	14:54	5:21	2-3	2	2	416	31	4	0	5	374
22/08/14	HKLR	9:24	14:46	5:22	2	1	2	426	97	10	0	30	287
28/08/14	HKLR	9:24	14:56	5:32	2-3	2	1	408	21	15	0	10	362
01/09/14	HKLR	9:15	14:45	5:30	2-3	1-1.5	7	421	117	0	0	11	293
05/09/14	HKLR	9:09	14:33	5:24	2	2.5	1	420	1	5	0	20	392
20/10/14	HKLR	9:16	14:39	5:23	2	2	1	391	1	0	14	14	360
27/10/14	HKLR	9:09	14:38	5:29	1-2	3	3	476	93	0	21	15	345
10/11/14	HKLR	9:05	14:32	5:27	2-3	2-3.5	2	360	18	0	31	15	292
24/11/14	HKLR	9:09	14:38	5:29	2	1	0	482	0	0	31	12	438
05/12/14	HKLR	9:04	14:39	5:35	2	3	0	528	0	0	27	12	488
18/12/14	HKLR	9:00	14:15	5:15	2	2.5	0	407	0	0	7	11	388
02/01/15	HKLR	9:07	14:30	5:23	2	2.5-3	0	440	0	6	0	19	414
21/01/15	HKLR	9:14	13:16	4:02	1-2	3-3.5	0	301	0	10	6	13	270
17/02/15	HKLR	9:03	14:31	5:28	1	3.5-4	0	160	0	0	14	13	132
26/02/15	HKLR	8:59	14:33	5:34	2-3	2	1	298	64	0	15	11	207
09/03/15	HKLR	9:16	14:43	5:27	1	3.5-4	1	407	88	0	6	12	299
13/03/15	HKLR	9:04	14:40	5:36	2	1.5-2	1	446	21	0	16	12	396
14/04/15	HKLR	9:21	14:49	5:28	2	1	1	360	12	0	0	22	324
20/04/15	HKLR	9:14	14:32	5:18	2	3.5	0	268	0	0	20	8	237
11/05/15	HKLR	9:16	14:36	5:20	2	1.5	0	284	0	0	1	15	264
19/05/15	HKLR	9:04	14:05	5:01	2-3	2	0	173	0	0	0	10	161
03/06/15	HKLR	9:12	14:43	5:31	2-4	1	2	335	7	5	0	17	305

Appendix I. (cont'd)

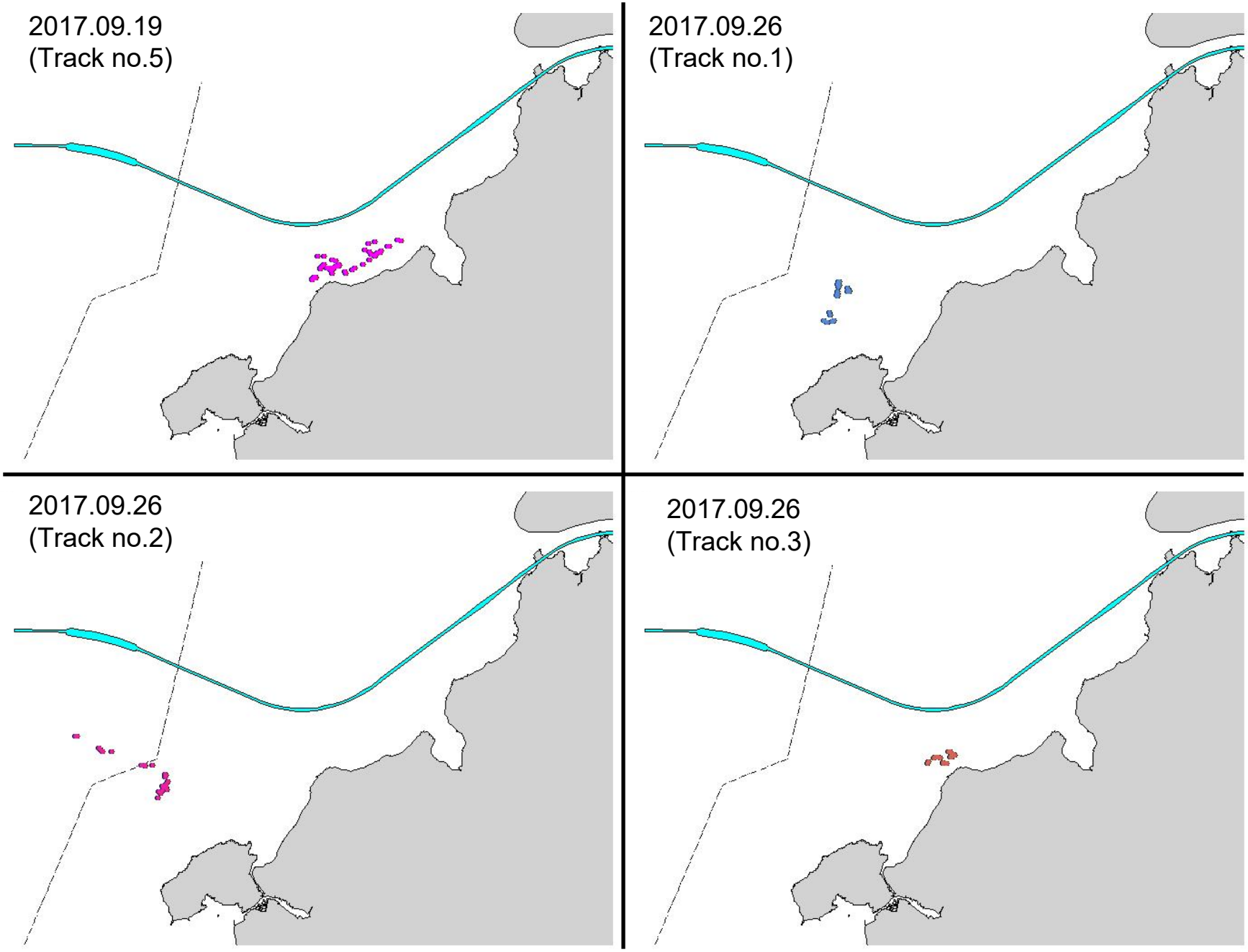
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
11/06/15	HKLR	9:05	14:30	5:25	2	2	0	274	0	0	0	12	259
06/07/15	HKLR	9:22	14:53	5:31	2	2-3	3	300	144	0	0	11	143
16/07/15	HKLR	9:28	14:44	5:16	2	2	2	334	173	0	0	23	136
13/08/15	HKLR	9:05	14:31	5:26	3	2	0	312	0	0	21	20	270
21/08/15	HKLR	9:02	14:16	5:14	2-3	2	1	276	27	30	3	11	203
04/09/15	HKLR	8:59	14:31	5:32	2	1.5	3	384	202	6	6	13	155
23/09/15	HKLR	9:02	14:30	5:28	2	1.5	1	252	10	9	0	8	223
02/10/15	HKLR	8:56	14:17	5:21	2	1.5	2	374	168	6	5	10	182
14/10/15	HKLR	8:58	14:28	5:30	2	3	1	218	83	0	0	9	124
04/11/15	HKLR	9:01	14:28	5:27	2	3	0	170	0	0	0	13	154
20/11/15	HKLR	9:02	14:31	5:29	2	2	1	219	1	6	17	20	173
01/12/15	HKLR	8:58	14:30	5:32	2	3	2	301	143	0	3	16	138
08/12/15	HKLR	8:53	14:24	5:31	2-3	2.5	1	254	68	0	3	7	173
07/01/16	HKLR	9:07	14:34	5:27	2	2	0	267	0	3	3	12	248
12/01/16	HKLR	9:03	14:24	5:21	2	2	2	227	21	0	9	10	186
05/02/16	HKLR	9:09	14:30	5:21	3-4	2.5	0	254	0	6	0	11	235
12/02/16	HKLR	8:56	14:29	5:33	2	3	2	247	89	5	5	17	130
02/03/16	HKLR	9:08	14:30	5:22	1	2.5	3	310	188	0	3	9	175
16/03/16	HKLR	9:25	14:34	5:09	1-2	3-3.5	1	225	1	0	5	11	207
21/04/16	HKLR	9:19	14:30	5:11	1-2	1.5-3.5	0	156	0	0	1	6	148
29/04/16	HKLR	8:57	14:20	5:23	2-3	2	0	251	0	0	0	19	230
09/05/16	HKLR	9:06	14:35	5:29	2	2	2	193	39	0	2	14	137
16/05/16	HKLR	9:11	14:42	5:31	3	1	0	166	0	0	0	11	151
02/06/16	HKLR	9:10	14:32	5:22	3-4	2.5	0	193	0	0	0	15	177
16/06/16	HKLR	9:27	14:31	5:04	2-3	2.5	1	213	3	0	0	12	196
07/07/16	HKLR	9:22	14:30	5:08	2-3	2	1	227	2	0	13	13	197
15/07/16	HKLR	9:24	14:30	5:06	2-4	4.5	1	185	11	5	2	18	147
11/08/16	HKLR	9:57	14:34	4:37	2	2-3	0	70	0	0	4	8	56
25/08/16	HKLR	9:15	14:15	5:00	2	2.5	2	203	41	0	4	13	144
30/09/16	HKLR	9:20	14:30	5:10	3	2.5-3.5	0	106	0	0	5	12	88
03/10/16	HKLR	9:27	14:45	5:18	2	1.5	0	148	0	0	20	23	102
17/10/16	HKLR	9:15	13:59	4:44	2-3	2.5	1	179	7	0	54	10	107
20/10/16	HKLR	9:14	14:31	5:17	2	3-3.5	0	190	0	0	26	17	146

Appendix I. (cont'd)

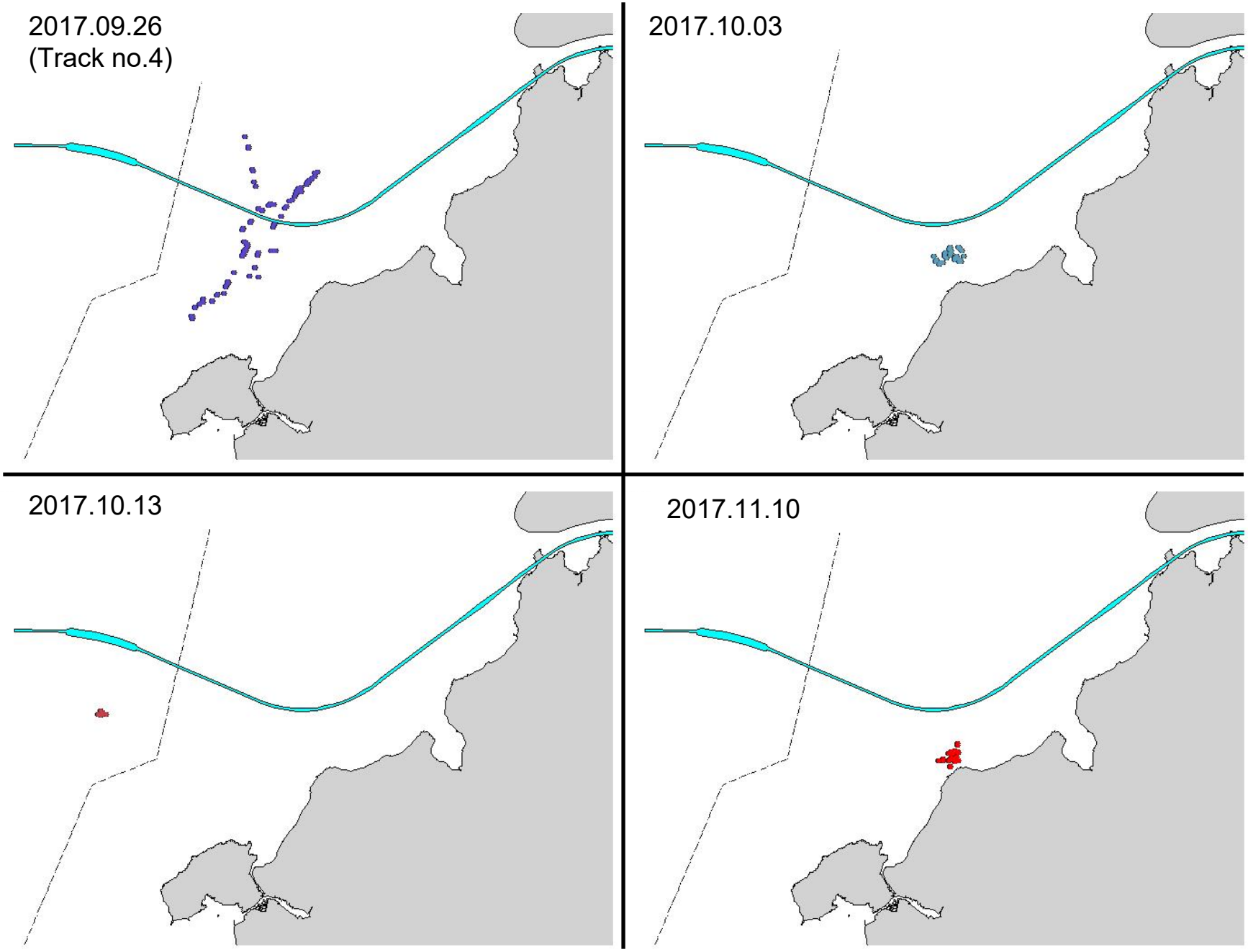
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
08/11/16	HKLR	9:10	14:33	5:23	2	2.5-3.5	0	165	0	0	20	17	126
17/11/16	HKLR	9:01	14:30	5:29	2	2	3	152	94	0	4	11	40
01/12/16	HKLR	9:04	14:30	5:26	3	2.5	2	224	61	0	21	19	122
15/12/16	HKLR	9:17	14:31	5:14	3	2	1	204	50	0	56	12	85
09/01/17	HKLR	9:10	14:11	5:01	2	2.5-3	0	130	0	0	8	12	109
18/01/17	HKLR	9:13	14:15	5:02	2-3	2.5-4	0	79	0	0	7	15	55
02/02/17	HKLR	8:56	14:34	5:38	2	2.5	1	163	14	0	17	21	109
10/02/17	HKLR	9:07	14:32	5:25	2-3	3	2	201	45	0	18	14	123
03/03/17	HKLR	9:02	14:31	5:29	1-3	2	2	243	60	0	30	19	133
17/03/17	HKLR	9:02	14:31	5:29	2-3	2-2.5	1	162	7	17	18	13	106
03/04/17	HKLR	9:15	14:39	5:24	2-3	2	0	135	0	2	8	15	108
13/04/17	HKLR	8:58	14:34	5:36	2	2.5	0	102	0	0	3	14	82
09/05/17	HKLR	9:00	14:34	5:34	1-2	1.5-3	0	81	0	0	15	13	52
29/05/17	HKLR	9:06	14:30	5:24	2-3	1.5	0	86	0	0	2	9	73
05/06/17	HKLR	9:06	14:17	5:11	2-4	1.5	1	178	104	0	10	6	57
22/06/17	HKLR	9:19	14:36	5:17	2	1.5	0	76	0	0	7	6	61
06/07/17	HKLR	9:45	14:55	5:10	2	1.5	0	32	0	0	0	3	29
19/07/17	HKLR	9:15	14:33	5:18	2	2	1	92	8	0	0	6	77
11/08/17	HKLR	9:30	14:33	5:03	2-3	2	2	118	42	0	8	6	61
25/08/17	HKLR	9:25	14:36	5:11	1-2	1.5	2	161	70	14	17	7	52
19/09/17	HKLR	9:20	14:34	5:14	1-2	2	5	292	208	0	10	10	62
26/09/17	HKLR	9:13	14:31	5:18	1-2	1.5	4	244	119	0	69	12	42
03/10/17	HKLR	9:17	14:31	5:14	2	1.5	1	133	38	0	32	6	56
13/10/17	HKLR	9:06	14:30	5:24	3-4	1.5-2	1	134	7	13	43	6	64
10/11/17	HKLR	9:09	14:31	5:22	2	1.5-2	1	245	107	35	15	4	84
15/11/17	HKLR	9:07	14:51	5:44	2	1-1.5	2	129	14	11	0	16	86
13/12/17	HKLR	9:00	14:26	5:26	2-4	1.5	0	97	0	4	3	6	83
27/12/17	HKLR	9:03	14:29	5:26	2	2.5	3	195	121	6	14	12	41
12/01/18	HKLR	9:06	14:30	5:24	2-3	1-1.5	1	118	37	8	6	9	56
18/01/18	HKLR	9:08	14:31	5:23	1	3	3	219	123	0	17	11	67
05/02/18	HKLR	9:02	14:31	5:29	2-3	2	0	78	0	0	3	8	66
15/02/18	HKLR	8:52	14:30	5:38	1	2.5	3	226	128	0	23	5	69



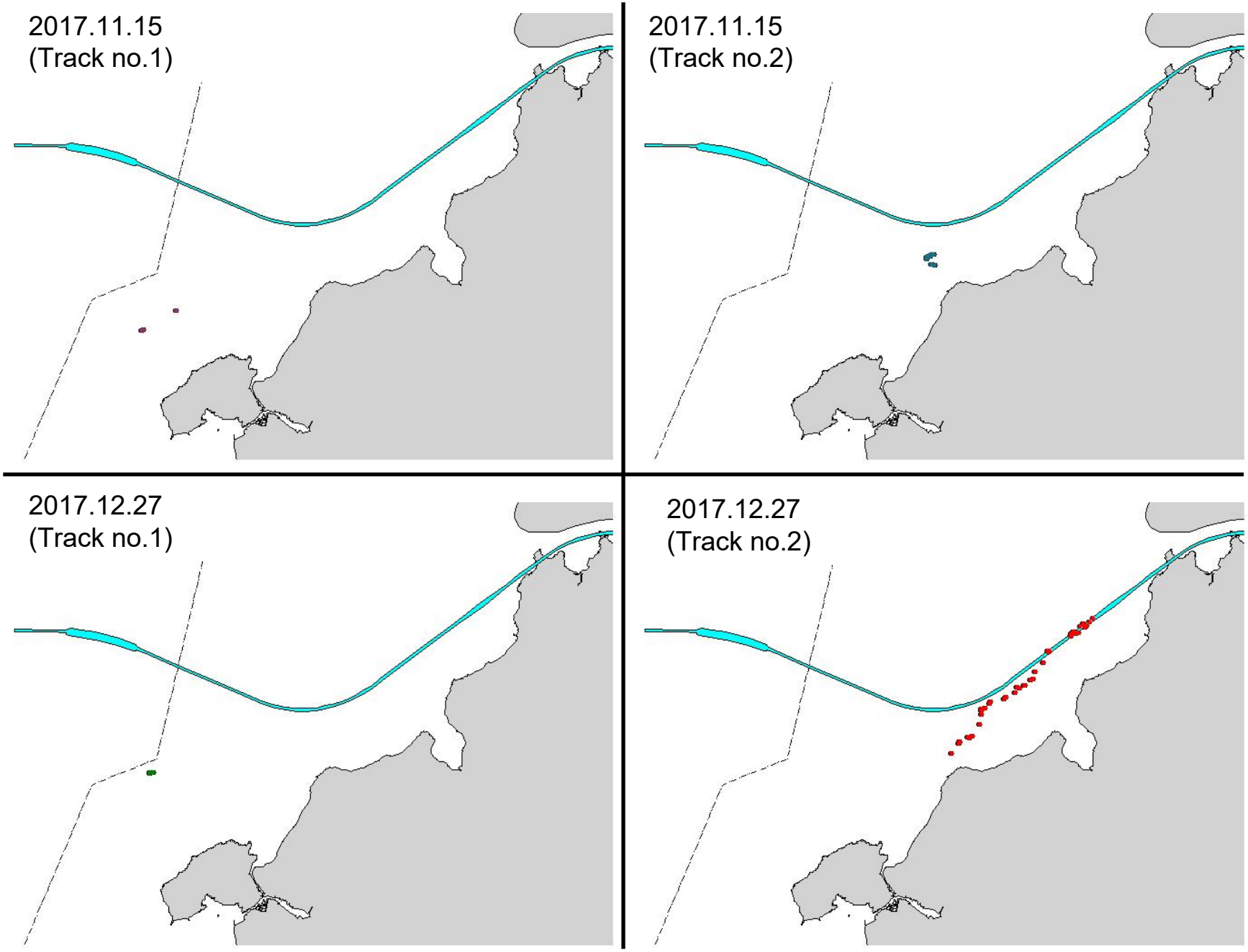
Appendix II. Twenty-four tracks obtained during theodolite tracking sessions in September 2017 – February 2018



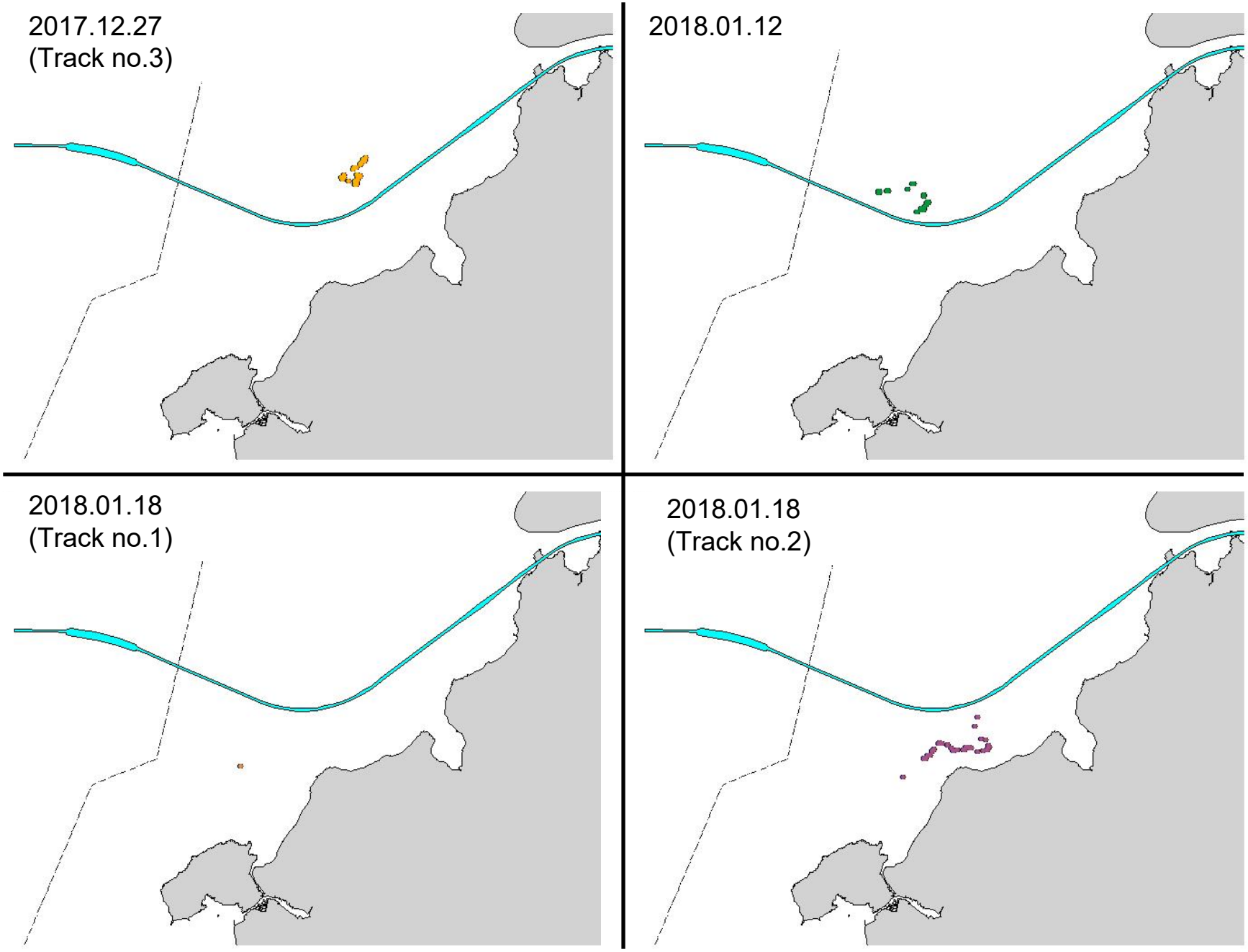
Appendix II. (cont'd)



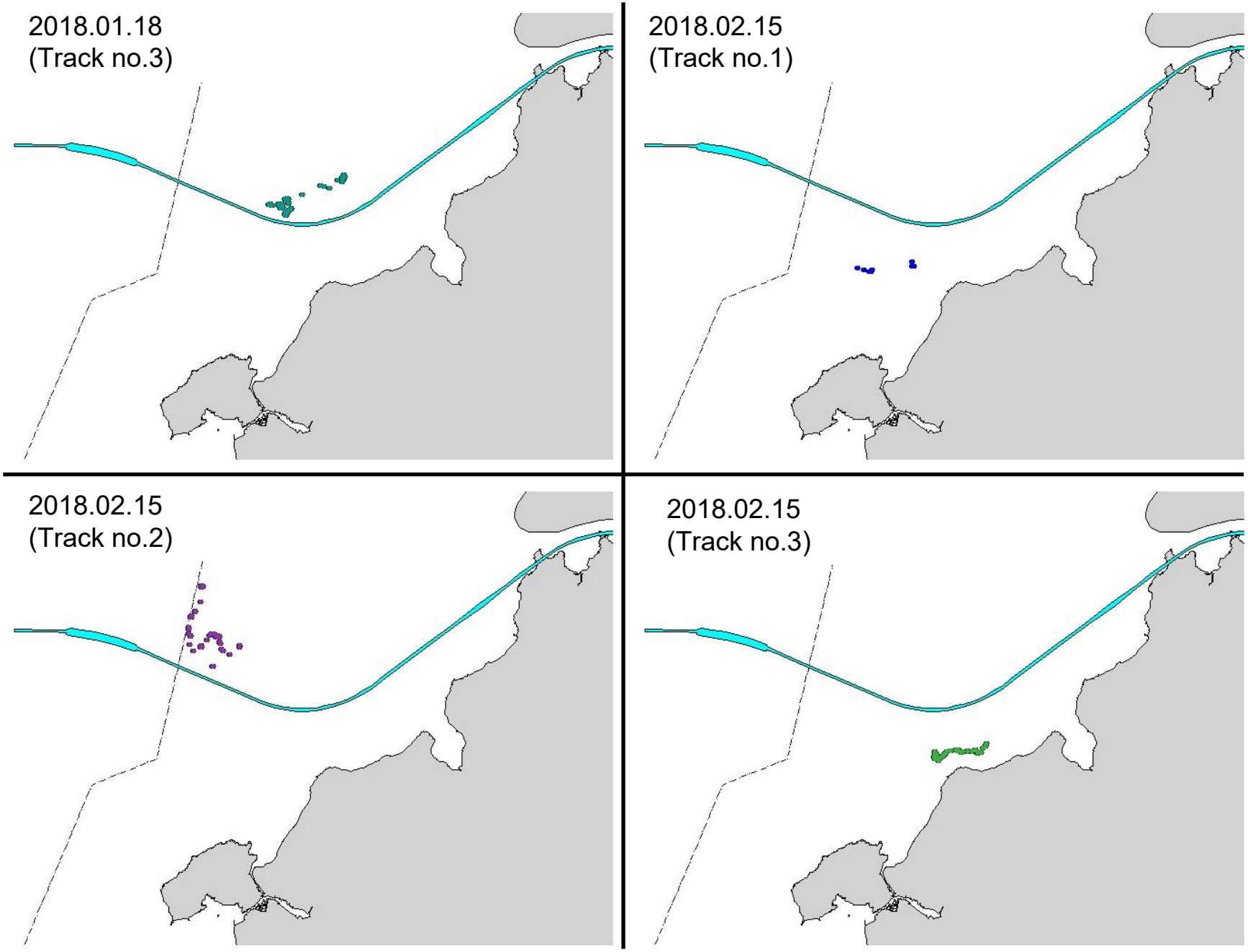
Appendix II. (cont'd)



Appendix II. (cont'd)



Appendix II. (cont'd)



Appendix II. (cont'd)

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Dragages-China Habour-VSL Joint Venture

Site Office: Tung Chung Waterfront Road,
adjacent to Tung Chung New Development Pier,
New Territories, Hong Kong

By Mail
11 January 2019

Attn.: Mr. W K Poon (Project Director)

Dear Sir,

Contract No. HY/2011/09
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill
- Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (March – August 2018)

I refer to the revised Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (March – August 2018) dated 10 September 2018 for the captioned Contract prepared by Samuel Hung of Hong Kong Cetacean Research Project.

I hereby agree and certify that the above report is true and correct to the best of my knowledge.

If you need any further information, please call me at 2151 2089 or 9161 7287.

Yours faithfully,
WELLAB Limited

Dr. Priscilla Choy
Environmental Team Leader

CONTRACT HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill

Progress Report for Land-based Monitoring on North-South Movement of Chinese White Dolphins from Shum Wat Station (March – August 2018)

By Samuel Hung, Ph.D.
Hong Kong Cetacean Research Project (HKCRP)

10 September 2018

1. INTRODUCTION

The Hong Kong Link Road (HKLR) comprises a 9.4 km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1-km tunnel section to the reclamation formed along the east coast of the Airport Island, and a 1.6-km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). Dragages – China Harbour – VSL JV (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2011/09 – Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill".

According to the HKLR EM&A Manual, a number of environmental monitoring and audit works related to Chinese White Dolphins (a.k.a. Indo-Pacific humpback dolphins, *Sousa chinensis*) are to be conducted during baseline, construction and post-construction phases, including land-based dolphin behaviour and movement monitoring. In September 2016, a continuation of the construction phase monitoring on the north-south movement is commissioned by the Contractor. This progress report for the land-based monitoring on north-south movement of Chinese White Dolphins across the Hong Kong Link Road presents the methodology and results during the fourth half-yearly period of monitoring from March to August 2018, at a location hereafter termed as Sham Wat Station.

2. METHODS

2.1. Monitoring Station

Based on the requirements under the EM&A Manual as described in the EM&A proposal for this work, the Sham Wat Station is located along the northwest coast of Lantau Island (GPS position: 22°16.10' N. and 113°52.32' E, Figure 1). The station was selected based on its height above sea level (minimum requirement of over 20 metres; Würsig et al. 1991), close proximity to shore, and relatively unobstructed views of the HKLR alignment to the west of the airport extending toward the HKSAR Boundary (Figure 2).

The height of the Sham Wat Station established by the HKCRP team is 55.70 metres high at mean low water, 66 metres from shore. The station is only a few hundred metres to the closest point of the HKLR alignment (Figure 2), which is ideal to examine the north-south movements of Chinese White Dolphins in relation to the HKLR alignment.

2.2. Monitoring Period and Definition of Baseline/Construction Phases

Before the present construction phase monitoring study, thirty days of shore-based theodolite tracking works were conducted for each of the baseline and initial construction phases according to the EM&A manual requirements (Table 1). An additional 64 days of shore-based monitoring (twice per month, with 5-6 hours on each survey day) were also conducted throughout the construction period specifically to examine the impact of bridge construction on north-south movement of Chinese White Dolphins across the bridge alignment. Such monitoring commenced after the 30 days of construction phase monitoring in relation to bored piling impact assessment was completed in July 2013, and ended in August 2016. Thereafter, a continuation of the construction phase monitoring was commenced in September 2016 for the present study.

It should be noted that some shore-based theodolite tracking at Sham Wat Station was also conducted as part of the AFCD long-term marine mammal monitoring programme since 2011, and such data was also integrated with the HKLR baseline monitoring data to increase the overall sample size for analysis on the north-south movements of dolphins (Table 1).

Table 1. Different monitoring periods during baseline/construction phases, with the current six-month monitoring period highlighted in **blue**

(* The initial construction phase in March – June 2013 was considered under baseline phase, as only minor work procedures with lower level of disturbance took place at just two pier sites)

	Survey Type	Time Period	Effort (# of hours)
Baseline Phase	HKCRP	Apr 2011 – Dec 2012	51.1
Baseline Phase (under bored piling monitoring program)	HKLR	Jan 2013	177.8
Initial Construction Phase* (under bored piling monitoring program)	HKLR	Mar-Apr 2013	179.3
	HKCRP	Apr-Jun 2013	30.9
Construction Phase	HKLR/HKCRP	Jul-Dec 2013	107.5
	HKLR/HKCRP	Jan-Dec 2014	134.8
	HKLR	Jan-Dec 2015	128.8
	HKLR	Jan-Aug 2016	84.1
	HKLR	Sep 2016–Feb 2017	63.1
	HKLR	Mar-Aug 2017	64.1
	HKLR	Sep 2017-Feb 2018	65.0
	HKLR	Mar-Aug 2018	64.3

For the examination of north-south movement of Chinese white dolphins across the HKLR alignment, the baseline phase was defined as the time period from April 2011 (i.e. the start of AFCD monitoring at Sham Wat) up to June 2013. Even though bored piling works associated with HKLR construction commenced on March 18th and continued until April 13th of 2013, only minor work procedures with lower level of disturbance (such as installation of permanent casing and excavation for bored pile) took place at two pier sites (P48 and P52). Presumably these works in less than a month at the very initial stage of bored piling works have insignificant impact as obstruction on north-south movements of dolphins. And after this brief period of construction, the bored piling works were suspended for two months in May and June 2013 as part of the environmental permit condition to avoid the peak calving season of Chinese White Dolphins. Therefore, the period of March to June of 2013 was also included as part of the baseline period with very low level of construction activities occurred along the HKLR alignment (Table 1).

On the other hand, the construction phase for this monitoring on north-south movements was defined as the time period starting from July 2013, when marine bored piling activities construction works have intensified significantly until almost all piling works were completed in March 2015, and with subsequent monitoring works ended in August 2016. The additional 24 months of monitoring starting in September 2016 under the present study is also included as part of the construction phase as well (Table 1).

2.3. Monitoring Methodology

The methodology of the present monitoring programme generally followed the one established under the Piwetz et al. (2012) study that was part of the AFCD long-term marine mammal monitoring programme (Hung 2012). On each survey day from Sham Wat Station, observers searched continuously for Chinese white dolphins using unaided eyes and 7x50 handheld binoculars. A theodolite tracking session was initiated when an individual dolphin or group of dolphins was located, and focal follow methods were used to track the dolphins (Lundquist 2012, Lundquist et al. 2012a and 2012b, Piwetz et al. 2012).

Within a group, a focal individual was selected for the purposes of tracking behaviour and movement of the group, based on its distinctive feature such as colouration or severe injury mark. The focal individual or group were then tracked continuously via the theodolite, with positions recorded whenever a known or unknown dolphin surfaced. If an individual could not be positively distinguished from other members, the group would be tracked by recording positions based on a central point within the group when the dolphins surfaced. Tracking continued until animals were lost from view, moved beyond the range of reliable visibility (generally >3 km but up to >5 km under excellent conditions), or when environmental conditions obstructed visibility (e.g. intense haze).

Positions of dolphins, boats and construction activities were measured using a Sokkisha DT5 digital theodolite with ± 5-sec precision and 30-power magnification connected to a laptop computer running the program *Pythagoras* Version 1.2 (Gailey and Ortega-Ortiz 2002). This program calculates a real-time conversion of horizontal and vertical angles collected by the theodolite into geographic positions of latitude and longitude each time a fix is initiated. *Pythagoras* also displays positions, movements, and distances in real-time. When possible, the position of the focal dolphin was recorded at every surfacing with use of *Pythagoras*.

2.4. Data Analysis

First, the dolphin encounter rates (number of encounters per 100 hours of observation) were calculated before and during HKLR construction. The comparison between different periods of baseline and construction phases would allow determination of whether the observed level of occurrence was different during construction than it was prior to construction, which could be affected by the bored piling works and presence of bridge piers as obstruction along the HKLR alignment.

To investigate whether the north-south movement of Chinese white dolphins between North and West Lantau waters have been affected by the presence of the Hong Kong Link Road, in particular the spacing between bridge pile cap piers, the number of dolphin groups that moved across the bridge alignment (either from north to south, or from south to north) was examined before and during the construction of the bridge, and compared between the two phases. The proportions of dolphin tracks that crossed the bridge alignment before and during construction were compared, and if a significantly greater percentage of dolphin tracks was recorded crossing the bridge alignment in the baseline phase than in the construction phase, the obstruction of the bridge as a barrier to dolphin movement would become evident.

3. RESULTS AND DISCUSSION

3.1. Summary of Theodolite Tracking Effort

For the present six-month study (i.e. March to August 2018) under the construction phase monitoring, 64.3 hours of shore-based theodolite tracking effort was conducted on 12 survey days (Appendix I). During these 12 days of land-based monitoring sessions, dolphins were successfully tracked from shore on seven days, with a total of 25 dolphin groups being sighted (Appendix I). All 25 groups were successfully tracked, and 867 fixes of dolphin positions were obtained among these 25 tracks. In addition, 1,289 fixes were obtained from the positions of other vessels in the study area, including 171 fixes on fishing boats, 115 fixes on high-speed ferries, 54 fixes on dolphin-watching boats, and 949 fixes on other vessels including construction vessels (Appendix I).

3.2. Dolphin encounter rates

Encounter rates of dolphins (number of dolphin sightings per 100 hours of tracking effort) were calculated for the baseline phase and different periods of the construction phase (including the six-month period from the present study), and are presented in Table 2.

Table 2. Dolphin encounter rates (number of dolphin sightings per 100 hour of theodolite tracking effort) during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins, with the current six-month monitoring period highlighted in **blue**

	Time Period	Effort (# of hours)	# of Dolphin Sightings	Encounter Rate
Baseline Phase	Apr 2011-Jan 2013	228.9	99	43.3
	Mar-Jun 2013	210.2	38	18.1
	Overall	***439.1***	***137***	***31.2***
Construction Phase	Jul-Dec 2013	107.5	70	65.1
	Jan-Dec 2014	134.8	42	31.2
	Jan-Dec 2015	128.8	23	17.9
	Jan-Aug 2016	84.1	15	17.8
	Sep 2016-Feb 2017	63.1	10	15.8
	Mar-Aug 2017	64.1	9	14.0
	Sep 2017-Feb 2018	65.0	24	36.9
	Mar-Aug 2018	64.3	25	38.9
	Overall	***711.7***	***218***	***30.6***

During the baseline phase, there was a noticeable drop in dolphin encounter rate from 43.3 for the period without any construction activities (i.e. up to January 2013), to only 18.1 at the very initial stage of construction works with just a few sites with some bored piling activities (i.e. March to June 2013) (Table 2). In the following months (July-December 2013) when the construction works resumed after a two-month suspension to satisfy the environmental permit condition, dolphin encounter rate rosed back to a higher level (65.1). Subsequently, the encounter rate quickly reduced to a much lower level in 2015, and remained fairly low in 2016 and the first eight months of 2017 (Table 2).

However, such encounter rates have increased considerably in the previous (September 2017 to February 2018) and present (March to August 2018) six-month periods, both of which were more than double of the previous five periods, and were the highest since the initial construction phase in July-December 2013 (Table 2). Notably, the increase in dolphin occurrence within the study area near Shum Wat and the HKLR09 bridge alignment in the past six months (March to August 2018) coincided well with the regular line-transect dolphin monitoring survey results in West Lantau under the HKLR09 EM&A programme, as the dolphin quarterly

encounter rates in the past two quarters increased noticeably from the ones in previous quarters, and the one in the past quarter (June to August 2018) was the fourth highest since HKLR09 construction began in 2013, or the highest in the past four years.

3.3. North-south movement and distribution of tracks

The 25 dolphin tracks collected during the current six-month period were analyzed for north-south movements of dolphins across the bridge alignment. These tracks contained 867 individual lat-long locations, which were analyzed to determine whether they were entirely on the north or south side of the alignment, or crossing through the alignment. The different proportions were also compared to the ones from different phases before and during HKLR construction works.

Among the 25 tracks, 80% (20 tracks) were wholly on the south side of the bridge alignment, 0% (zero tracks) entirely on the north side, and 20% (five tracks) passed across the alignment (Table 3; also see tracks in Appendix II).

Table 3. Percentages of dolphin tracks to the south side and north side of HKLR alignment as well as across the alignment during different periods of baseline and construction phases of HK Link Road to examine north-south movement of dolphins, with the current six-month monitoring period highlighted in **blue**

	Time Period	# of Tracks	South Side of HKLR	North Side of HKLR	Across HKLR Alignment
Baseline Phase	Apr 2011-Jan 2013	84	70%	13%	17%
	Mar-Jun 2013	28	68%	4%	28%
	Overall	***112***	***70%***	***11%***	***20%***
Construction Phase	Jul-Dec 2013	45	71%	2%	27%
	Jan-Dec 2014	38	84%	11%	5%
	Jan-Dec 2015	21	71%	0%	29%
	Jan-Aug 2016	9	89%	0%	11%
	Sep 2016-Feb 2017	10	90%	0%	10%
	Mar-Aug 2017	9	89%	0%	11%
	Sep 2017-Feb 2018	24	79%	17%	4%
	Mar-Aug 2018	25	80%	0%	20%
	Overall	***181***	***79%***	***5%***	***16%***

The percentages of tracks across the alignment were examined across different periods of baseline and construction phases (Table 3). During the baseline period up

to June 2013, 20% of tracks passed across the alignment, and in the subsequent months from July to December 2013, such percentage was slightly higher, with 27% of tracks passed across the alignment. However, such percentage have dropped dramatically to only 5% in 2014, when bored piling works were the most intense, and the spacing between bridge piers became progressively narrower with multiple work fronts. In 2015, the percentage of tracks across the alignment rebounded to a much higher level (29%), but the total number of tracks and encounter rate of dolphins were also much lower than the ones in 2014. During the first eight months of 2016, the percentage of tracks across the alignment dropped to a much lower level (11%), and remained low for the two consecutive six-month periods afterward (i.e. 10% during September 2016 to February 2017; 11% during March to August 2017) (Table 3). Subsequently, the percentage fell to the lowest (4%) in the next six-month period (September 2017 to February 2018), although the sample size was very small with only one track across the alignment (which was the same as in the previous three periods).

In the present six-month period (March to August 2018), the percentage of tracks across the alignment has increased dramatically to 20%, or the highest since 2016. This percentage was also comparable to the previous highs during the baseline period and initial construction periods in 2013 and 2015 (see Table 3). It appeared that the level of north-south movements have improved noticeably since the completion of construction works of Hong Kong Link Road, with sign of recovery for dolphins crossing through the alignment. However, it remains to be seen whether such higher level of north-south movement across the bridge alignment was only temporary for this half-yearly period, or will be persistent in future months. It is critical to continue this theodolite tracking works to investigate the north-south movement well into the post-construction period, in order to continuously assess whether the recovery of such movement is consistent in the near future.

4. CONCLUSION

Intensive effort of shore-based theodolite tracking at Sham Wat Station was conducted before and during the construction of HKLR with bored piling works. The results from the tracking sessions revealed that when the bored piling works became most intense and the spacing between bridge piers became narrower, the dolphins have diminished their use in the vicinity of the bridge alignment, and their north-south movements were also affected with seldom crossings underneath the bridge alignment

until recent months.

The low level of north-south movements of Chinese white dolphins across the HKLR alignment in recent years could possibly be attributed by two factors: 1) the physical presence of bridge piers and narrower spacing between them which could partially obstruct movements of dolphins; and 2) the on-going deterioration of habitat quality in North Lantau waters that makes it less attractive for dolphins to cross the alignment from West Lantau to North Lantau waters. It would be premature at this point to conclude which of the factors, or both factors, have influenced the observed declining level of north-south movements in recent years, and whether the observed recovery of such movements in the past six months will be persistent in the near future. Apparently, continuous monitoring of such movement through shore-based theodolite tracking from Sham Wat Station would be critical in order to determine whether the north-south movement would consistently resume to the level of pre-construction phase, and the dolphins have partially or fully recovered from the impact of the HKLR construction.

5. REFERENCES

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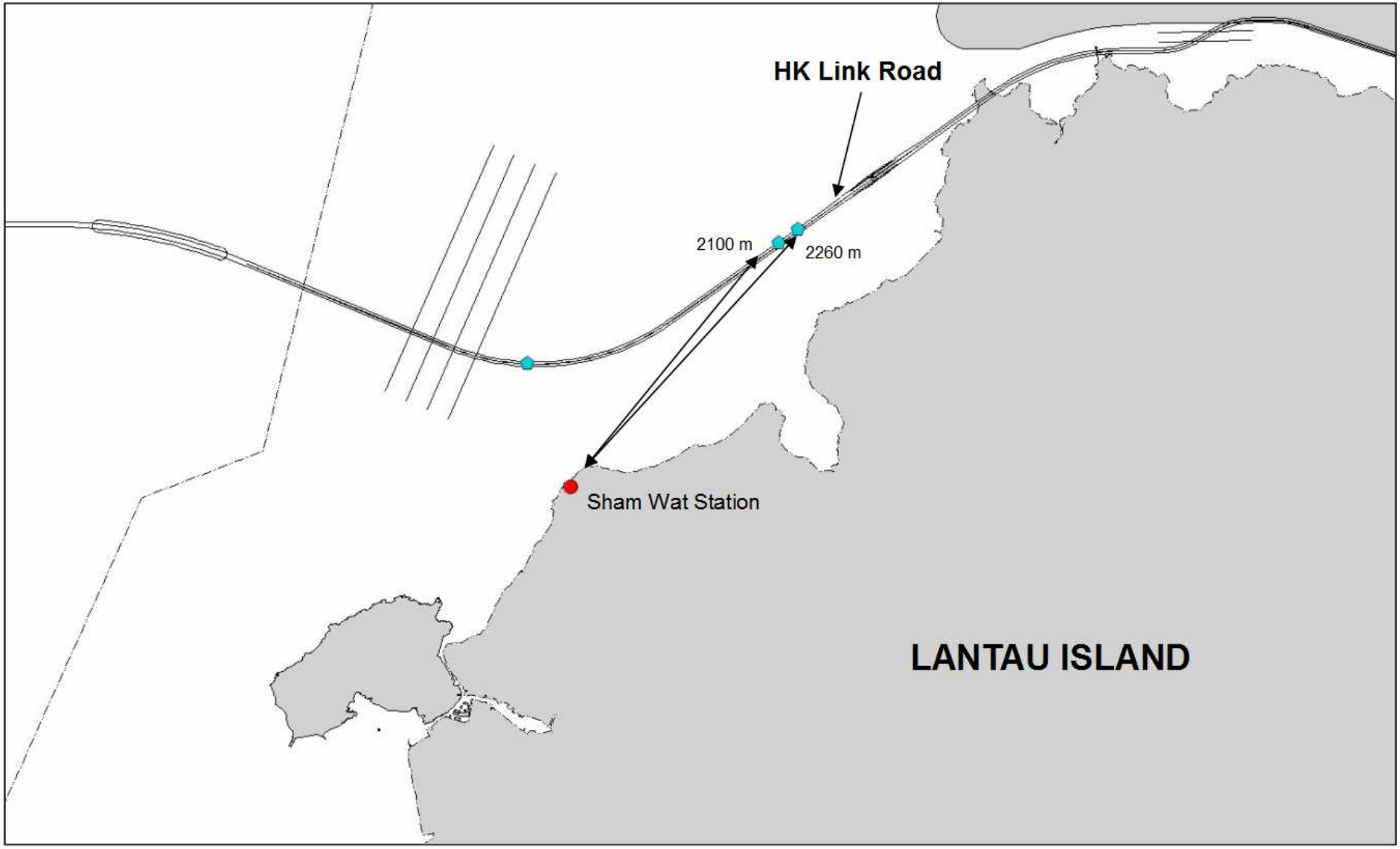


Figure 1. Location of Sham Wat Theodolite Tracking Station in northwestern Lantau with the first few bored piling locations

Figure 2. Panoramic View from the Sham Wat Theodolite Tracking Station (photos taken in 2012 (above) and 2015 (middle & below))

Appendix I. Sham Wat Land-based Theodolite Tracking Database (April 2011 - August 2018)

(note: the current six-month monitoring period is highlighted in **blue**)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
14/04/11	HKCRP	10:00	13:16	3:16	2-4	1-2	2	261	126	0	92	8	34
03/08/11	HKCRP	7:22	13:10	5:48	1-2	4	4	206	78	0	41	9	75
09/09/11	HKCRP	9:42	13:42	4:00	3	3	0	59	0	5	7	6	38
25/12/11	HKCRP	9:04	10:55	1:51	4	1.5	2	64	26	2	14	8	13
15/03/12	HKCRP	9:17	13:30	4:13	2	2	0	88	0	0	30	11	46
26/06/12	HKCRP	9:33	12:59	3:26	2	2	6	108	61	0	33	7	5
02/07/12	HKCRP	8:13	12:17	4:04	2	2	15	190	147	0	18	5	15
13/07/12	HKCRP	6:07	10:30	4:23	2	1	13	145	47	0	58	6	30
31/07/12	HKCRP	6:29	11:00	4:31	1	3	4	152	47	0	45	8	48
20/08/12	HKCRP	9:24	13:15	3:51	1-2	2.5	4	295	233	0	25	13	22
09/10/12	HKCRP	9:31	12:56	3:25	2	2-3.5	1	61	17	0	21	8	13
10/12/12	HKCRP	10:06	14:35	4:29	3	2.5	1	81	25	0	7	4	44
20/12/12	HKCRP	12:56	16:46	3:50	3-4	2-3	1	96	5	3	4	6	76
02/01/13	HKLR	9:20	14:50	5:30	2	2.5	3	156	33	0	22	13	87
03/01/13	HKLR	9:00	14:55	5:55	2-4	2.5	0	175	0	0	34	17	123
04/01/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	157	0	4	0	18	132
05/01/13	HKLR	10:10	15:40	5:30	3	2.5-3	0	215	0	0	30	7	176
06/01/13	HKLR	9:05	14:55	5:50	3-4	2.5-3	0	154	0	0	19	26	108
07/01/13	HKLR	8:57	14:57	6:00	3-4	3-3.5	0	100	0	0	7	14	78
08/01/13	HKLR	9:01	14:51	5:50	2-3	3-3.5	0	110	0	0	9	14	86
09/01/13	HKLR	8:55	13:58	5:03	3-5	2.5-3.5	0	68	0	0	5	7	55
10/01/13	HKLR	9:01	15:31	6:30	2-3	3-3.5	0	95	0	0	6	12	75
11/01/13	HKLR	9:15	15:45	6:30	2-4	2.5-3.5	1	204	19	0	41	23	118
12/01/13	HKLR	9:09	15:09	6:00	2-3	4	1	94	12	0	7	10	64
13/01/13	HKLR	8:54	14:54	6:00	2-4	2.5-4	2	112	16	3	26	20	47
14/01/13	HKLR	8:50	14:50	6:00	2	2.5	0	275	0	0	49	18	206
15/01/13	HKLR	9:27	15:27	6:00	2-4	1.5-3	0	180	0	0	44	16	118
16/01/13	HKLR	9:00	15:00	6:00	2	3-4	0	85	0	0	8	10	64
17/01/13	HKLR	8:55	14:55	6:00	2-3	2-3.5	4	349	184	0	12	13	138
18/01/13	HKLR	8:55	15:00	6:05	2-3	2.5-3.5	0	213	0	0	48	14	146
19/01/13	HKLR	9:10	15:10	6:00	2	2.5	1	247	52	0	55	23	115
20/01/13	HKLR	8:56	14:56	6:00	2-3	2	0	163	0	0	8	27	127
21/01/13	HKLR	8:50	15:10	6:20	1-2	2-3.5	0	248	0	0	18	24	202
22/01/13	HKLR	8:50	15:20	6:30	2-3.5	1	3	253	152	0	6	17	74

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
23/01/13	HKLR	8:28	14:58	6:30	1	3.5-4	0	115	0	0	5	15	92
24/01/13	HKLR	8:23	15:38	7:15	1	3-4	3	412	328	0	5	18	57
25/01/13	HKLR	9:07	15:00	5:53	2-4	2.5-3	0	132	0	0	9	17	105
26/01/13	HKLR	8:55	15:25	6:30	2	2.5-3	9	433	240	0	46	17	128
27/01/13	HKLR	9:11	15:41	6:30	1-3	3.5	4	162	44	0	0	40	78
28/01/13	HKLR	8:55	15:30	6:35	2-3	2-2.5	4	295	96	0	34	12	151
29/01/13	HKLR	8:30	15:00	6:30	1-2	2	7	476	169	0	91	15	200
30/01/13	HKLR	8:18	14:48	6:30	3-4	1.5	4	264	128	0	9	11	112
06/03/13	HKLR	9:07	15:10	6:03	1-2	1.5-2	0	254	0	0	55	11	185
07/03/13	HKLR	8:56	14:57	6:01	1	2.5	1	231	4	0	18	12	196
09/03/13	HKLR	8:55	15:00	6:05	1-3	2	0	258	0	0	47	20	188
10/03/13	HKLR	8:53	14:54	6:01	1-2	1.5-2.5	2	219	42	0	36	36	104
11/03/13	HKLR	9:00	15:01	6:01	2-4	2.5	2	339	31	0	46	15	246
12/03/13	HKLR	8:59	14:59	6:00	2-4	2.5	2	369	37	0	54	17	259
13/03/13	HKLR	9:15	15:15	6:00	1-2	2.5-3	3	386	67	0	57	13	245
14/03/13	HKLR	9:00	15:00	6:00	2-3	2.5-3	0	363	0	0	39	16	306
15/03/13	HKLR	9:05	15:05	6:00	2	2.5	0	353	0	0	132	15	205
16/03/13	HKLR	8:55	15:00	6:05	2-3	2-2.5	0	326	0	0	94	16	215
17/03/13	HKLR	8:53	14:53	6:00	2-3	2.5	1	382	59	0	49	43	230
18/03/13	HKLR	9:05	15:05	6:00	2	2.5	1	325	1	0	80	16	227
19/03/13	HKLR	9:03	14:27	5:24	2	2	2	389	38	0	72	15	263
20/03/13	HKLR	9:00	15:00	6:00	2	1.5	2	481	70	0	60	11	339
21/03/13	HKLR	9:03	15:03	6:00	2-4	2.5-3	0	261	0	0	18	18	224
22/03/13	HKLR	8:59	14:59	6:00	2	3	1	368	2	0	22	17	325
23/03/13	HKLR	9:00	15:15	6:15	2	2	1	444	6	0	69	16	352
24/03/13	HKLR	9:06	13:43	4:37	1	3	0	254	0	0	49	31	173
25/03/13	HKLR	9:00	15:00	6:00	3-5	2.5-3.5	1	250	7	0	34	13	194
27/03/13	HKLR	9:56	15:35	5:39	2-4	1.5-3	0	273	0	0	48	11	212
28/03/13	HKLR	9:00	11:34	2:34	1-3	2	0	207	0	0	42	7	157
30/03/13	HKLR	9:15	15:07	5:52	3-6	2-2.5	0	276	0	0	66	20	157
01/04/13	HKLR	9:07	15:20	6:13	2	2.5-3	0	432	0	0	90	35	304
02/04/13	HKLR	9:02	13:09	4:07	1-2	3-4	1	250	13	0	65	10	161
04/04/13	HKLR	9:02	15:32	6:30	3-4	2.5-3	2	330	80	0	31	35	182
05/04/13	HKLR	9:53	15:23	5:30	3-4	2.5	0	277	0	0	50	13	212

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
07/04/13	HKLR	9:00	15:00	6:00	2-3	2	0	299	0	0	32	40	226
08/04/13	HKLR	9:05	15:05	6:00	2	2.5	0	233	0	0	17	15	200
09/04/13	HKLR	9:00	15:30	6:30	2-3	2-3	0	193	0	0	16	11	164
10/04/13	HKLR	9:00	15:00	6:00	2	2-2.5	0	315	0	0	27	17	270
11/04/13	HKLR	9:00	14:50	5:50	2	2.5	0	94	0	0	21	0	70
23/04/13	HKCRP	9:36	14:25	4:49	2-3	1.5-3	0	203	0	0	34	11	157
29/04/13	HKCRP	9:03	13:28	4:25	2-3	2.5-3	2	227	60	0	11	12	142
08/05/13	HKCRP	9:03	13:30	4:27	3-4	2.5	0	183	0	0	12	10	160
15/05/13	HKCRP	9:12	13:28	4:16	1-3	1.5	1	193	1	0	21	13	157
30/05/13	HKCRP	10:14	14:16	4:02	1-3	1	4	333	214	0	0	3	115
13/06/13	HKCRP	9:06	13:36	4:30	3	2.5	4	230	107	0	19	8	95
26/06/13	HKCRP	9:04	13:31	4:27	3-5	1	5	271	73	0	9	7	181
04/07/13	HKCRP	9:27	14:03	4:36	2	1.5-2	2	336	28	0	7	8	292
08/07/13	HKLR	9:01	15:01	6:00	1	1	1	371	119	0	36	13	202
09/07/13	HKLR	9:04	15:04	6:00	2-3	1-2	4	389	117	1	40	14	216
10/07/13	HKLR	10:57	17:00	6:03	2	1	5	422	120	2	50	8	241
11/07/13	HKLR	9:08	15:01	5:53	1	1	5	456	211	0	54	5	185
12/07/13	HKLR	9:06	15:06	6:00	2	2.5	15	430	235	11	33	21	129
13/07/13	HKLR	9:06	15:01	5:55	1-3	2.5	7	378	211	0	16	26	122
15/07/13	HKLR	9:06	15:08	6:02	1-3	2-3	2	188	50	0	4	11	103
17/07/13	HKLR	9:02	13:54	4:52	2	2-2.5	1	330	127	6	0	11	185
18/07/13	HKLR	9:14	15:06	5:52	2	1.5-2	0	251	0	0	0	14	236
19/07/13	HKLR	9:10	15:04	5:54	2-3	1-1.5	3	268	39	7	0	12	207
23/07/13	HKLR	9:02	15:02	6:00	2	1.5	7	334	126	0	3	9	195
24/07/13	HKLR	12:30	16:02	3:32	2	1-1.5	1	158	64	0	0	4	88
29/07/13	HKLR	8:56	14:59	6:03	2	1	6	275	117	0	0	6	151
26/08/13	HKCRP	9:06	14:10	5:04	2	1.5-2.5	4	456	167	0	9	16	262
29/08/13	HKCRP	9:11	13:15	4:04	1-2	1	3	215	59	0	10	9	135
28/09/13	HKLR	8:59	15:01	6:02	2-4	3	1	590	10	0	3	14	565
30/09/13	HKLR	10:28	15:33	5:05	2-3	3.5	0	163	0	0	2	1	159
04/12/13	HKCRP	8:58	13:01	4:03	2-3	3-3.5	1	385	1	0	20	7	355
19/12/13	HKCRP	9:03	13:33	4:30	3-4	2-2.5	2	320	20	0	0	5	293
16/01/14	HKCRP	9:03	13:38	4:35	2	3	0	385	0	0	4	11	367
22/01/14	HKLR	9:05	14:33	5:28	2	2.5	1	418	3	0	0	12	402

Appendix I. (cont'd)

Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
27/01/14	HKLR	8:54	14:59	6:05	1-3	2.5	3	517	212	0	4	13	287
06/02/14	HKCRP	9:19	14:18	4:59	2	1.5	0	308	0	0	23	12	271
17/02/14	HKCRP	9:21	13:24	4:03	2	2-3.5	1	276	55	0	2	9	209
14/03/14	HKLR	9:03	15:05	6:02	2-3	2.5	2	717	31	0	46	16	622
19/03/14	HKLR	9:16	14:30	5:14	1	2.5-3	4	543	113	0	49	13	480
16/04/14	HKLR	9:05	14:49	5:44	2-3	2.5-3	2	623	71	0	12	22	517
25/04/14	HKLR	9:08	14:47	5:39	2-4	2	0	405	0	0	10	18	375
19/05/14	HKLR	9:43	15:08	5:25	2-4	1	2	379	95	0	9	3	270
27/05/14	HKLR	9:04	14:32	5:28	1-3	1.5-2.5	1	254	5	0	0	12	234
03/06/14	HKLR	9:27	14:38	5:11	2-3	2	2	418	218	0	3	14	180
06/06/14	HKLR	9:18	15:00	5:42	2-3	1.5	1	359	34	0	0	13	310
11/07/14	HKLR	9:25	14:49	5:24	2	1.5	4	294	32	0	6	14	240
25/07/14	HKLR	9:33	14:54	5:21	2-3	2	2	416	31	4	0	5	374
22/08/14	HKLR	9:24	14:46	5:22	2	1	2	426	97	10	0	30	287
28/08/14	HKLR	9:24	14:56	5:32	2-3	2	1	408	21	15	0	10	362
01/09/14	HKLR	9:15	14:45	5:30	2-3	1-1.5	7	421	117	0	0	11	293
05/09/14	HKLR	9:09	14:33	5:24	2	2.5	1	420	1	5	0	20	392
20/10/14	HKLR	9:16	14:39	5:23	2	2	1	391	1	0	14	14	360
27/10/14	HKLR	9:09	14:38	5:29	1-2	3	3	476	93	0	21	15	345
10/11/14	HKLR	9:05	14:32	5:27	2-3	2-3.5	2	360	18	0	31	15	292
24/11/14	HKLR	9:09	14:38	5:29	2	1	0	482	0	0	31	12	438
05/12/14	HKLR	9:04	14:39	5:35	2	3	0	528	0	0	27	12	488
18/12/14	HKLR	9:00	14:15	5:15	2	2.5	0	407	0	0	7	11	388
02/01/15	HKLR	9:07	14:30	5:23	2	2.5-3	0	440	0	6	0	19	414
21/01/15	HKLR	9:14	13:16	4:02	1-2	3-3.5	0	301	0	10	6	13	270
17/02/15	HKLR	9:03	14:31	5:28	1	3.5-4	0	160	0	0	14	13	132
26/02/15	HKLR	8:59	14:33	5:34	2-3	2	1	298	64	0	15	11	207
09/03/15	HKLR	9:16	14:43	5:27	1	3.5-4	1	407	88	0	6	12	299
13/03/15	HKLR	9:04	14:40	5:36	2	1.5-2	1	446	21	0	16	12	396
14/04/15	HKLR	9:21	14:49	5:28	2	1	1	360	12	0	0	22	324
20/04/15	HKLR	9:14	14:32	5:18	2	3.5	0	268	0	0	20	8	237
11/05/15	HKLR	9:16	14:36	5:20	2	1.5	0	284	0	0	1	15	264
19/05/15	HKLR	9:04	14:05	5:01	2-3	2	0	173	0	0	0	10	161
03/06/15	HKLR	9:12	14:43	5:31	2-4	1	2	335	7	5	0	17	305

Appendix I. (cont'd)

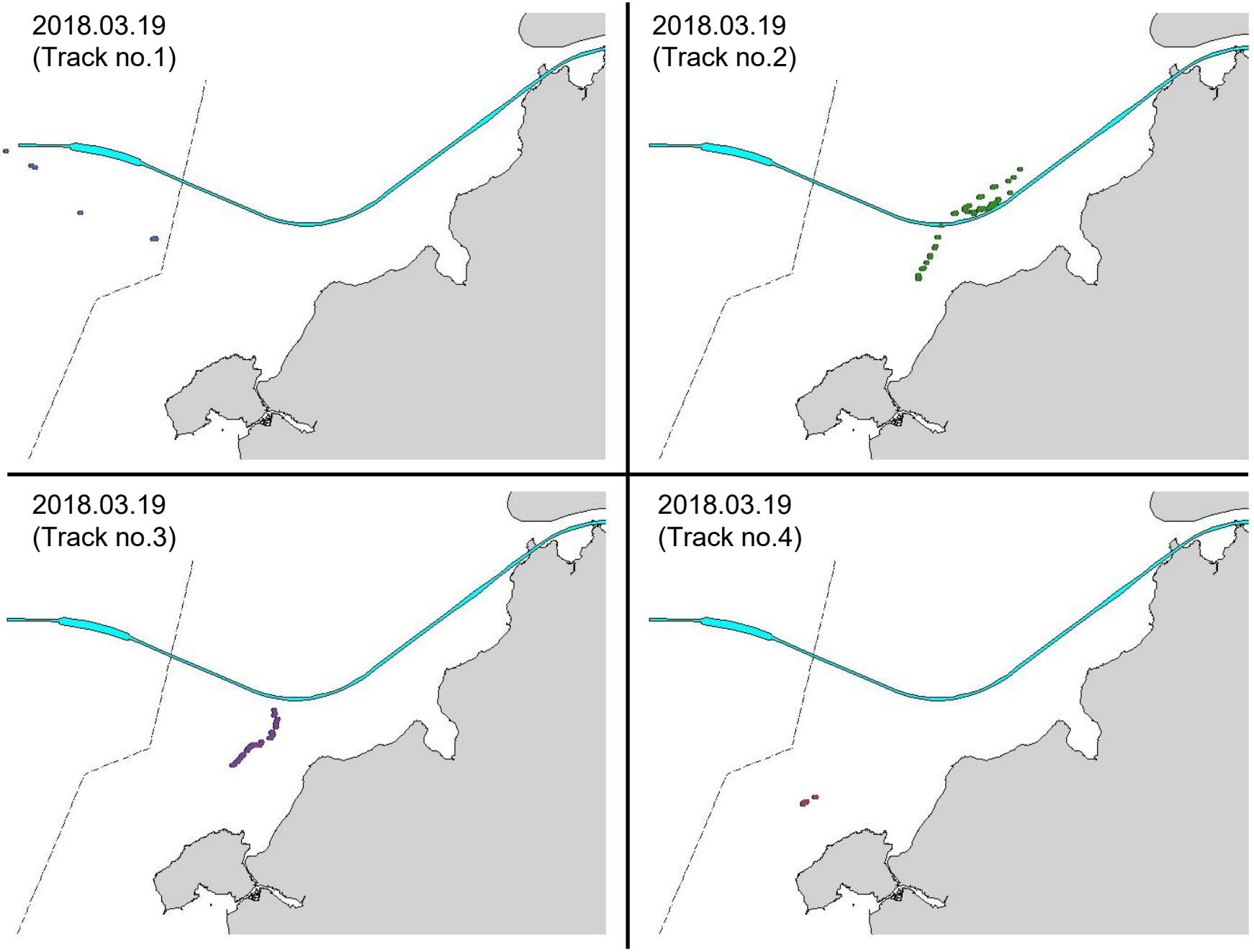
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
11/06/15	HKLR	9:05	14:30	5:25	2	2	0	274	0	0	0	12	259
06/07/15	HKLR	9:22	14:53	5:31	2	2-3	3	300	144	0	0	11	143
16/07/15	HKLR	9:28	14:44	5:16	2	2	2	334	173	0	0	23	136
13/08/15	HKLR	9:05	14:31	5:26	3	2	0	312	0	0	21	20	270
21/08/15	HKLR	9:02	14:16	5:14	2-3	2	1	276	27	30	3	11	203
04/09/15	HKLR	8:59	14:31	5:32	2	1.5	3	384	202	6	6	13	155
23/09/15	HKLR	9:02	14:30	5:28	2	1.5	1	252	10	9	0	8	223
02/10/15	HKLR	8:56	14:17	5:21	2	1.5	2	374	168	6	5	10	182
14/10/15	HKLR	8:58	14:28	5:30	2	3	1	218	83	0	0	9	124
04/11/15	HKLR	9:01	14:28	5:27	2	3	0	170	0	0	0	13	154
20/11/15	HKLR	9:02	14:31	5:29	2	2	1	219	1	6	17	20	173
01/12/15	HKLR	8:58	14:30	5:32	2	3	2	301	143	0	3	16	138
08/12/15	HKLR	8:53	14:24	5:31	2-3	2.5	1	254	68	0	3	7	173
07/01/16	HKLR	9:07	14:34	5:27	2	2	0	267	0	3	3	12	248
12/01/16	HKLR	9:03	14:24	5:21	2	2	2	227	21	0	9	10	186
05/02/16	HKLR	9:09	14:30	5:21	3-4	2.5	0	254	0	6	0	11	235
12/02/16	HKLR	8:56	14:29	5:33	2	3	2	247	89	5	5	17	130
02/03/16	HKLR	9:08	14:30	5:22	1	2.5	3	310	188	0	3	9	175
16/03/16	HKLR	9:25	14:34	5:09	1-2	3-3.5	1	225	1	0	5	11	207
21/04/16	HKLR	9:19	14:30	5:11	1-2	1.5-3.5	0	156	0	0	1	6	148
29/04/16	HKLR	8:57	14:20	5:23	2-3	2	0	251	0	0	0	19	230
09/05/16	HKLR	9:06	14:35	5:29	2	2	2	193	39	0	2	14	137
16/05/16	HKLR	9:11	14:42	5:31	3	1	0	166	0	0	0	11	151
02/06/16	HKLR	9:10	14:32	5:22	3-4	2.5	0	193	0	0	0	15	177
16/06/16	HKLR	9:27	14:31	5:04	2-3	2.5	1	213	3	0	0	12	196
07/07/16	HKLR	9:22	14:30	5:08	2-3	2	1	227	2	0	13	13	197
15/07/16	HKLR	9:24	14:30	5:06	2-4	4.5	1	185	11	5	2	18	147
11/08/16	HKLR	9:57	14:34	4:37	2	2-3	0	70	0	0	4	8	56
25/08/16	HKLR	9:15	14:15	5:00	2	2.5	2	203	41	0	4	13	144
30/09/16	HKLR	9:20	14:30	5:10	3	2.5-3.5	0	106	0	0	5	12	88
03/10/16	HKLR	9:27	14:45	5:18	2	1.5	0	148	0	0	20	23	102
17/10/16	HKLR	9:15	13:59	4:44	2-3	2.5	1	179	7	0	54	10	107
20/10/16	HKLR	9:14	14:31	5:17	2	3-3.5	0	190	0	0	26	17	146

Appendix I. (cont'd)

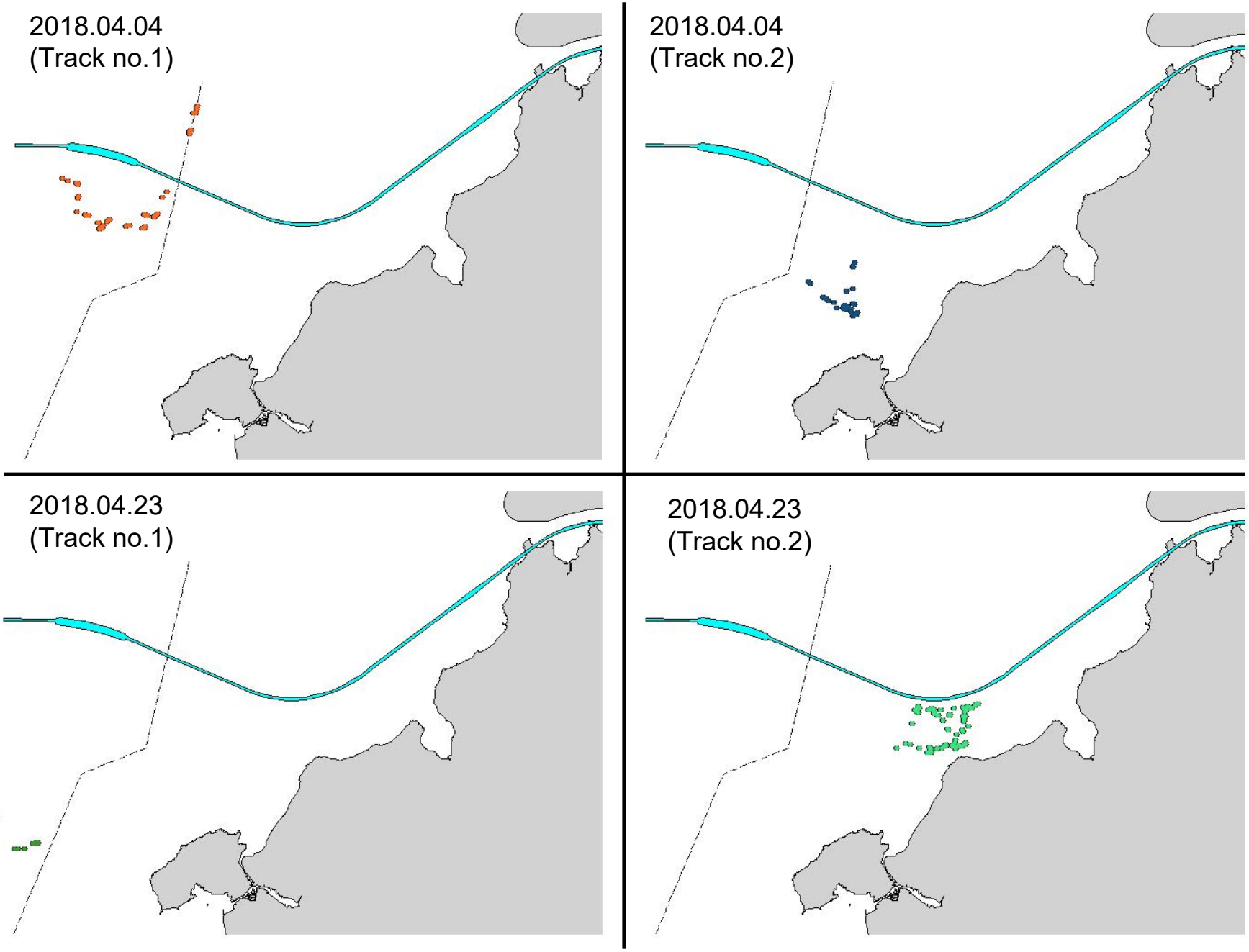
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
08/11/16	HKLR	9:10	14:33	5:23	2	2.5-3.5	0	165	0	0	20	17	126
17/11/16	HKLR	9:01	14:30	5:29	2	2	3	152	94	0	4	11	40
01/12/16	HKLR	9:04	14:30	5:26	3	2.5	2	224	61	0	21	19	122
15/12/16	HKLR	9:17	14:31	5:14	3	2	1	204	50	0	56	12	85
09/01/17	HKLR	9:10	14:11	5:01	2	2.5-3	0	130	0	0	8	12	109
18/01/17	HKLR	9:13	14:15	5:02	2-3	2.5-4	0	79	0	0	7	15	55
02/02/17	HKLR	8:56	14:34	5:38	2	2.5	1	163	14	0	17	21	109
10/02/17	HKLR	9:07	14:32	5:25	2-3	3	2	201	45	0	18	14	123
03/03/17	HKLR	9:02	14:31	5:29	1-3	2	2	243	60	0	30	19	133
17/03/17	HKLR	9:02	14:31	5:29	2-3	2-2.5	1	162	7	17	18	13	106
03/04/17	HKLR	9:15	14:39	5:24	2-3	2	0	135	0	2	8	15	108
13/04/17	HKLR	8:58	14:34	5:36	2	2.5	0	102	0	0	3	14	82
09/05/17	HKLR	9:00	14:34	5:34	1-2	1.5-3	0	81	0	0	15	13	52
29/05/17	HKLR	9:06	14:30	5:24	2-3	1.5	0	86	0	0	2	9	73
05/06/17	HKLR	9:06	14:17	5:11	2-4	1.5	1	178	104	0	10	6	57
22/06/17	HKLR	9:19	14:36	5:17	2	1.5	0	76	0	0	7	6	61
06/07/17	HKLR	9:45	14:55	5:10	2	1.5	0	32	0	0	0	3	29
19/07/17	HKLR	9:15	14:33	5:18	2	2	1	92	8	0	0	6	77
11/08/17	HKLR	9:30	14:33	5:03	2-3	2	2	118	42	0	8	6	61
25/08/17	HKLR	9:25	14:36	5:11	1-2	1.5	2	161	70	14	17	7	52
19/09/17	HKLR	9:20	14:34	5:14	1-2	2	5	292	208	0	10	10	62
26/09/17	HKLR	9:13	14:31	5:18	1-2	1.5	4	244	119	0	69	12	42
03/10/17	HKLR	9:17	14:31	5:14	2	1.5	1	133	38	0	32	6	56
13/10/17	HKLR	9:06	14:30	5:24	3-4	1.5-2	1	134	7	13	43	6	64
10/11/17	HKLR	9:09	14:31	5:22	2	1.5-2	1	245	107	35	15	4	84
15/11/17	HKLR	9:07	14:51	5:44	2	1-1.5	2	129	14	11	0	16	86
13/12/17	HKLR	9:00	14:26	5:26	2-4	1.5	0	97	0	4	3	6	83
27/12/17	HKLR	9:03	14:29	5:26	2	2.5	3	195	121	6	14	12	41
12/01/18	HKLR	9:06	14:30	5:24	2-3	1-1.5	1	118	37	8	6	9	56
18/01/18	HKLR	9:08	14:31	5:23	1	3	3	219	123	0	17	11	67
05/02/18	HKLR	9:02	14:31	5:29	2-3	2	0	78	0	0	3	8	66
15/02/18	HKLR	8:52	14:30	5:38	1	2.5	3	226	128	0	23	5	69

Appendix I. (cont'd)

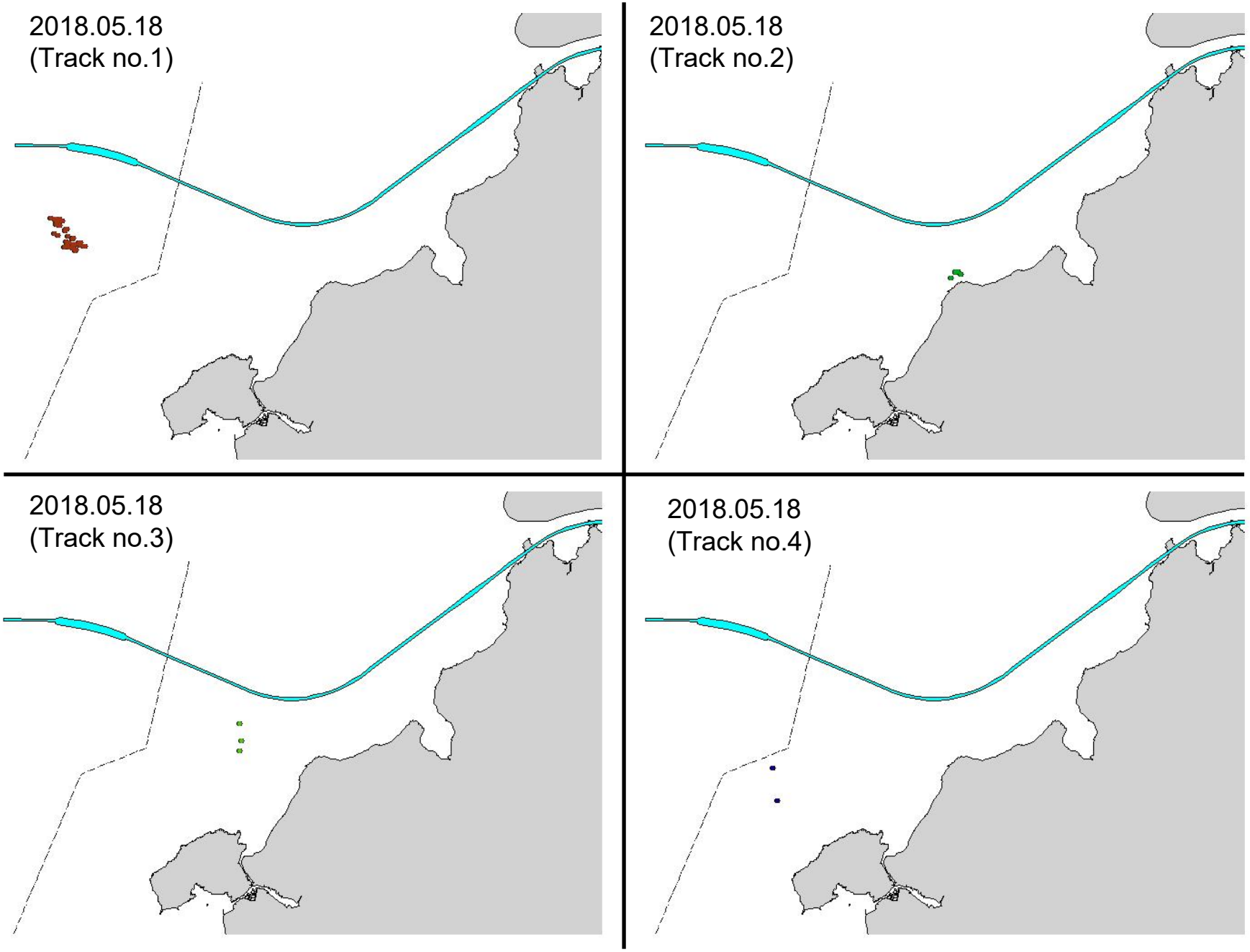
Date	Survey Type	Start Time	End Time	Duration	Beaufort	Visibility	No. of CWD Groups	Total No. of Fixes	No. of fix (dolphin)	No. of fix (DW boat)	No. of fix (fishing boat)	No. of fix (hi-speed ferry)	No. of fix (other vessels)
19/03/18	HKLR	9:00	14:33	5:33	2	2.5	4	225	137	0	20	16	39
22/03/18	HKLR	9:06	14:30	5:24	1-2	3	0	136	0	0	28	15	92
04/04/18	HKLR	9:14	14:31	5:17	2-3	2	2	262	143	31	18	6	60
23/04/18	HKLR	9:08	14:31	5:23	2	1.5	2	190	80	0	9	12	88
18/05/18	HKLR	9:05	14:28	5:23	2-3	1.5	5	427	335	4	3	0	83
25/05/18	HKLR	9:04	14:31	5:27	2-3	1	0	139	0	0	0	14	124
04/06/18	HKLR	9:00	14:27	5:27	2-3	2	0	74	0	0	0	10	63
14/06/18	HKLR	9:06	14:32	5:26	2-3	3	0	111	0	0	3	13	94
04/07/18	HKLR	9:07	14:28	5:21	3	2	0	128	0	5	0	5	116
26/07/18	HKLR	9:13	14:30	5:17	2	1.5	4	138	64	0	31	11	57
02/08/18	HKLR	9:37	14:29	4:52	2-3	1	6	91	41	0	6	4	38
09/08/18	HKLR	9:01	14:30	5:29	3	2	2	239	67	14	53	9	95



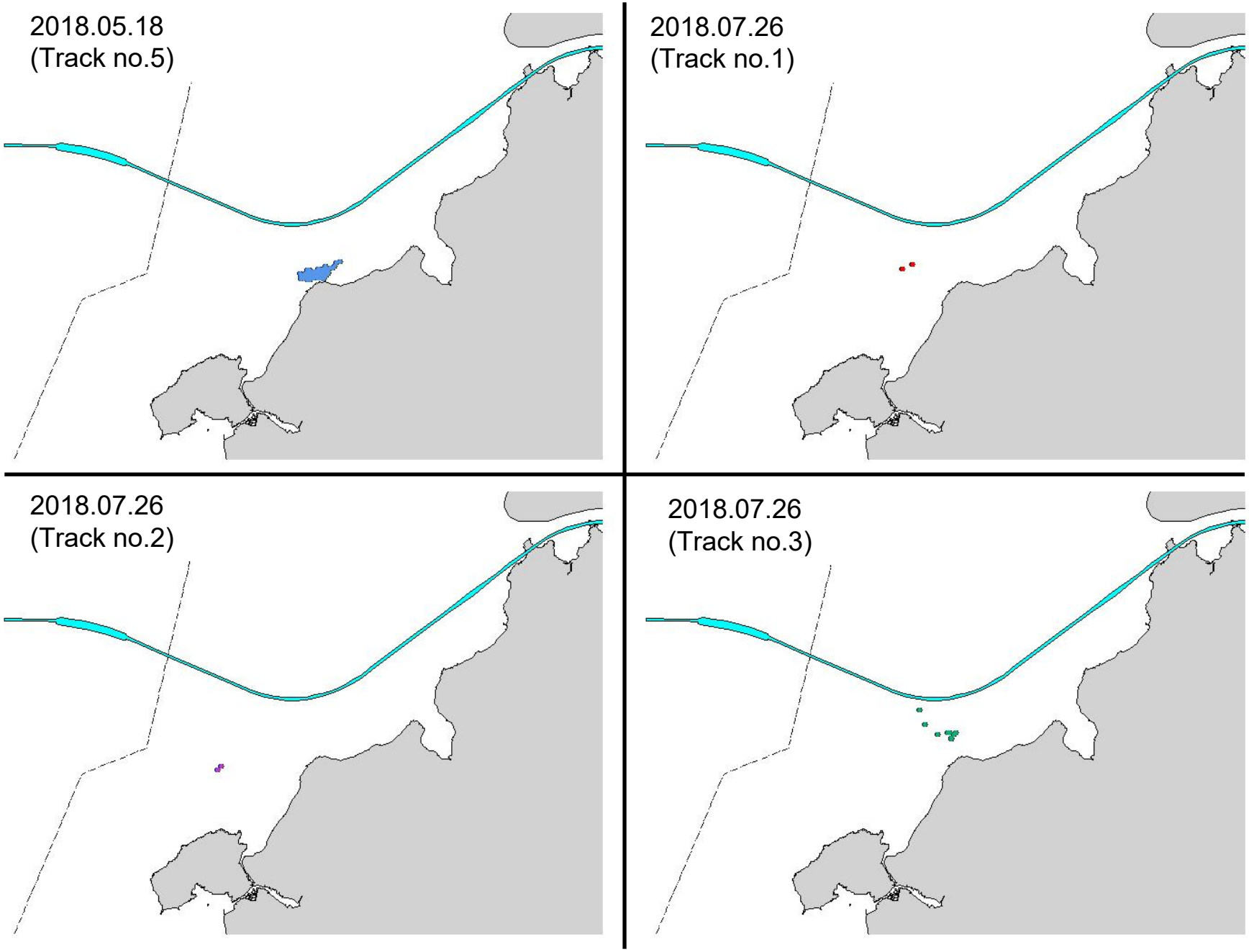
Appendix II. Twenty-five tracks obtained during theodolite tracking sessions in March – August 2018



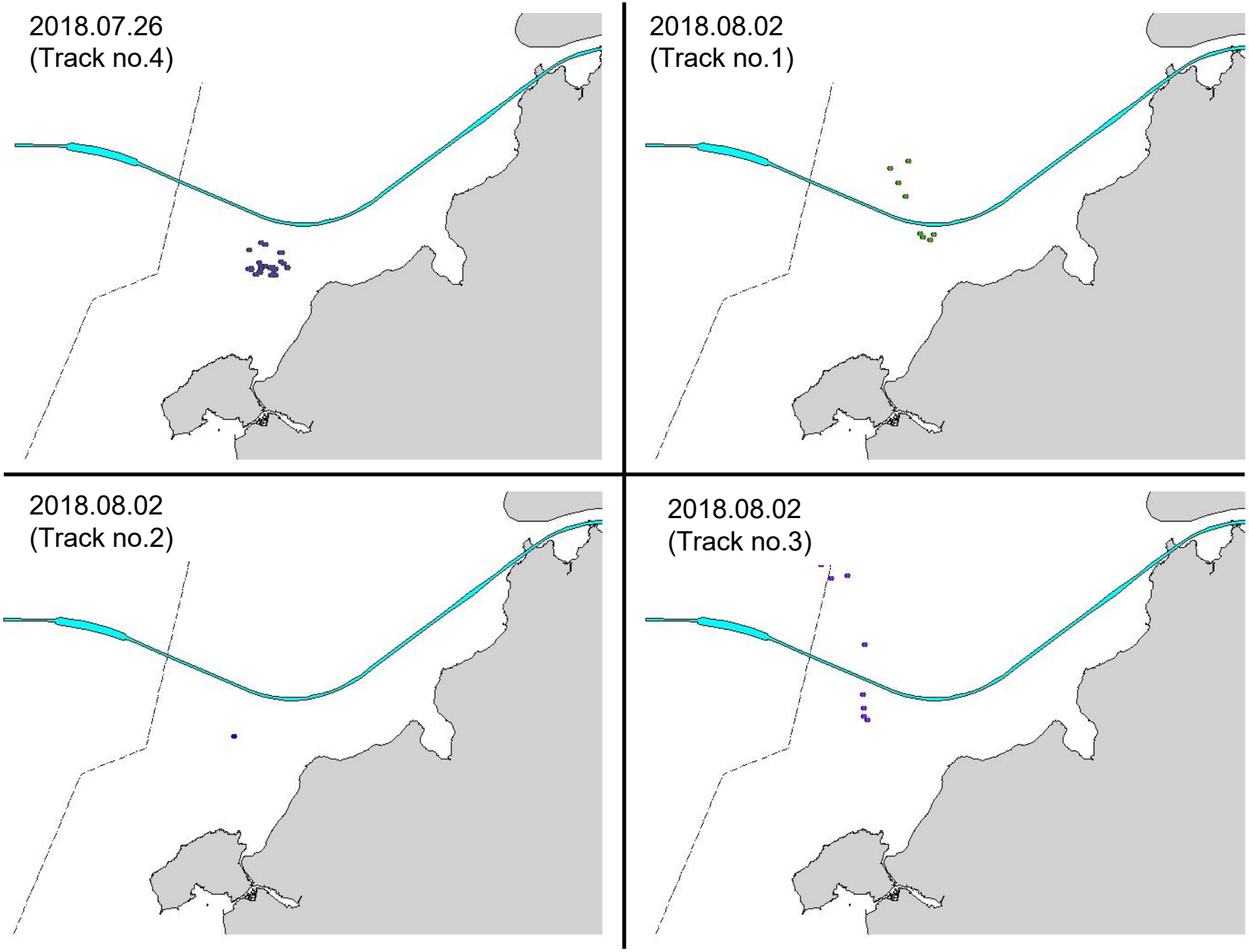
Appendix II. (cont'd)



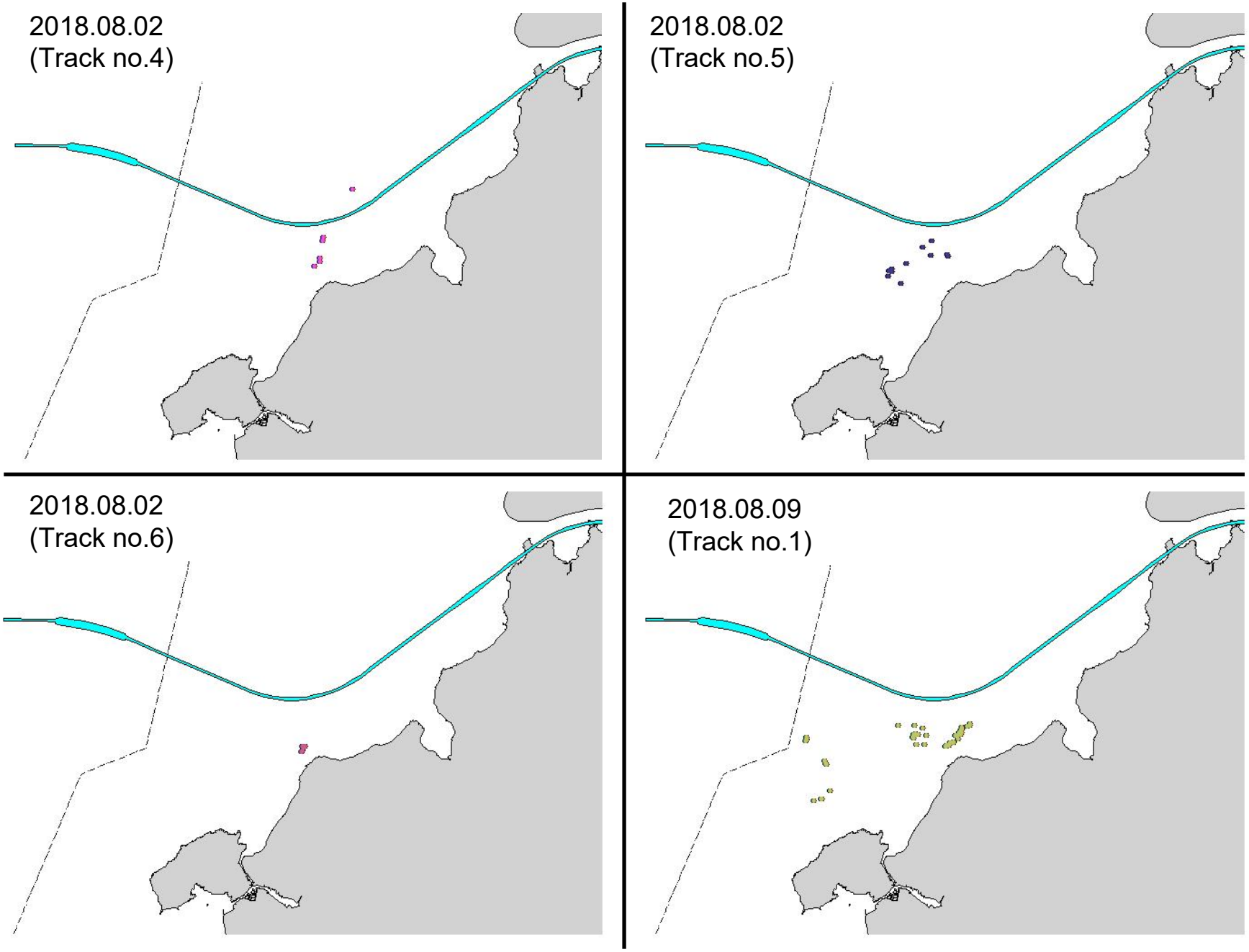
Appendix II. (cont'd)



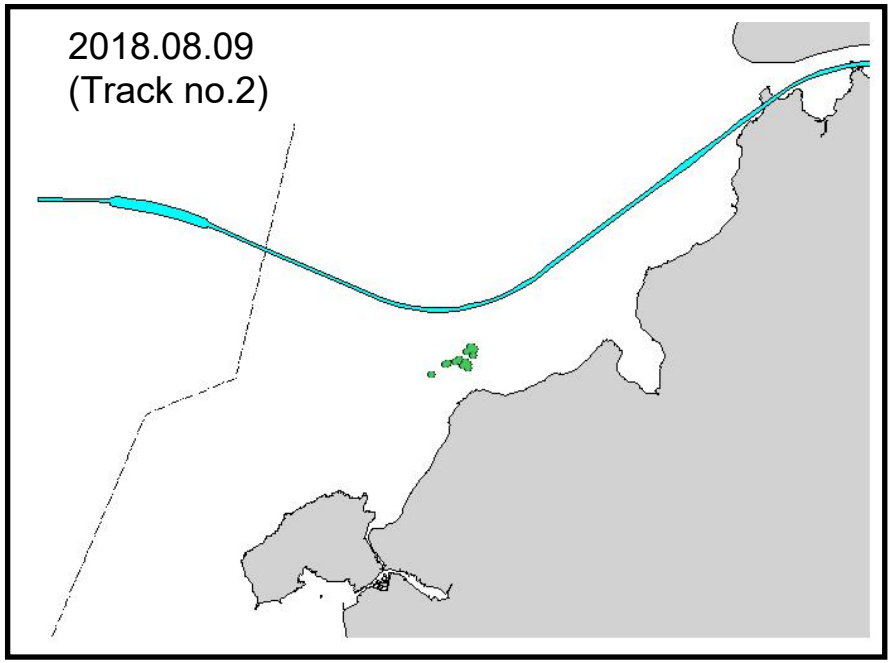
Appendix II. (cont'd)



Appendix II. (cont'd)



Appendix II. (cont'd)



Appendix II. (cont'd)