Satellite tracking of Spotted Seals of Yellow Sea and Bohai Sea

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目 录

1 Background

The spotted seal (*Phoca largha*) inhabits the ice and waters of North Pacific Ocean and adjacent seas（Shaughnessy et al. 1977）, and Liaodong Bay in China is the southern-most of the eight putative breeding ground（Wang 1985） (Fig 1-1). Due to lack of extensively quantified abundance data, spotted seal is list as data deficient in redlist by IUCN. However, it is clear that the spotted seal in Bohai Sea and Yellow Sea declined dramatically in recent years（Dong, et al. 1991）. For protecting spotted seal, the governments of China and Korea have established MPAs in Yellow Sea and Bohai Sea. Meanwhile, spotted seal has high mobility with seasonal migratory in the distribution region. Tracking the migration routes and distribution patterns can strengthen the protection effectiveness and promote the connectivity among these MPAs. In previous research, satellite tracking technique has been proved an efficient tool for seasonal movements of seals.

Population genetic information is essential for the informed conservation of spotted seal, especially the phylogenetic relationship between Bohai &Yellow sea population and the other populations for conversation of spotted seal in Yellow sea region. Some former researches have reveal that Bohai &Yellow sea population have less genetic flow with other populations, and might have evolve into a distinct population segment. Therefore it is needed to enhance the research to obtain the comprehensive and precise genetic information. This study has primarily depended on tissue sampling and tagging, which are expensive and potentially harmful. However, environment DNA (eDNA) can be used to obtain population genetic information at the population level without harm to species.

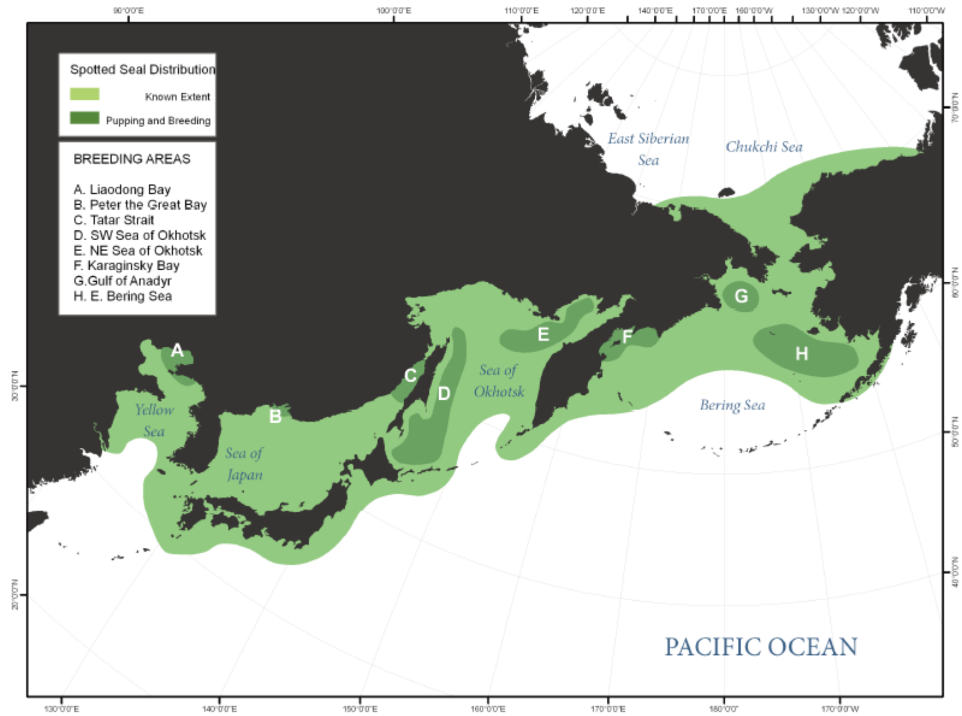


Fig 1-1 The breeding ground and distribution region of spotted seals （Boveng et al. 2009）

2 Materials and methods

2.1 Research methods

Every January and February, Liaodong Bay population breeds in this sea area, and inhabits in Bohai and Yellow Sea from March to May. After May, except for a few individuals, most of them choose to leave for Yellow Sea and East Sea. It has been known that there are 8 haul-out sites in Bohai and Yellow sea, 6 are in China and 2 are in Korea. China and Korea both use satellite to track animal’s migration. From 2008, more than 20 tagged individuals had been released in Chinese sea area, which provided more information about migration routes and distribution patterns. Most existing research of releasing focused on after May, and the object of study were based on individuals whom had been rescued or artificial bred. Therefore, it is necessary to cover wild individuals and advance the releasing time to correspond with main distribution period, in order to make the result more accurately reflect the population’s migration and distribution.

We glued the satellite tags with integrated temperature and depth sensors to the fur of head or dorsal surface, and use ARGOS system to receive location information. ARGOS is a satellite system widely used in wildlife tracking, it is developed by French Centre National d’Etudes Spatiales and NOAA（National Oceanic and Atmospheric Administration） and operated by CLS CO..

2.2 Experiment object

In this study, 9 spotted seals were released in 2019. 2 spotted seals without shedding their fine hairs were recused in the wild of Panjin, Liaoning in spring, 2019. After temporary cultivation, they were tagged and released where they were recused in April. Among 7 other spotted seals, 5 were recused in the past and trained in Dalian before release; 2 were born in Yantai aquarium in 2019 and trained before release. Dalian coastal area and Yantai Miao Island area were all possible channels for spotted seals entering Bohai Sea, so these two spots were chosen for spotted seal release in order to study their migratory pattern. See the Table 2-1 below for details.

Table 2-1 Data on individual animals tagged

ARGOS ID	Weight（kg）	Length（cm）	Sex	PTT	Age	Release Site	Release Date
128486	25.6		Female	SPOT5	1	Panjin	2019.4.24
128489	30.2		Male	SPOT5	1	Panjin	2019.4.24
182153				SPOT6	1	Yantai	2019.11.20
182156				SPOT6	1	Yantai	2019.11.20
182165	86	1.38	Male	F6G 276D DIVE	Adult	Dalian	2019.12.12
182166	51	1.16	Female	F6G 276D DIVE	3	Dalian	2019.12.12
182167	57	1.07	Female	F6G 276D DIVE	>4	Dalian	2019.12.12
182168	38	0.95	Female	F6G 276D DIVE	>4	Dalian	2019.12.12
182169	82	1.32	Female	F6G 276D DIVE	Adult	Dalian	2019.12.12

2.3 Installation and analysis

（1） Tagging and installing

The research target is spotted seal with planned period of more than half year. Sensor is superior with small size and can transmit signal in water. In this study, two types of tags were used: Wildlife Computers tags (2 SPOT5 and 2 SPOT6) and SIRTRACK Co. tags (5 F6G 276D DIVE) （Table 2-1）.

Gluing should ensure seals' healthy and normal activity. Before that, seals were driven into a customized cage to make surface dry, people should immobilize seals to prevent struggling. A satellite-linked platform transmitter terminal was glued to the fur below the neck surface using a fast-setting epoxy, and needed to press stably for 10 minutes. The glued point should avoid liquid; sensor should avoid redundant glue to make signal reception normal and successful. Usually, tagging is early than releasing at least one day, it is necessary to check stability of transmitter and observe physical condition of seals.

Fig 2-1 Transmitter glued onto the head of a seal

Fig 2-2 Animals were released

（2） Releasing

Chose Dalian, Panjin and Shandong long island as the releasing places.

Fig 2-3 Release Sites of seals

（3）Data analysis

Argos assigns a quality ranking of 3,2,1,0,A or B to each location. The accuracy of quality 3 is less than 150m, quality 2 ranges from 150 to 350m, quality 1 ranges from 350 to 1000m, quality 0 exceeds 1000m, and no predicted accurate results of quality A and B which could be estimated application effect. Usually, for most diving marine mammals, locations are based on few uplinks; more results are assigned quality 0, A or B. Using Distance filter（Keating et al. 1994） and RMS velocity filters（McConnell et al. 1992） orderly to remove incredible locations.

3 Results

3.1 Evaluation of transmitter performance

The location signals from most seals could be received at the day of releasing or 1 or 2 days later. Median lifetime was 52 days (range 7-121). Individual performances are shown in Table 3-1. The study was lasted from April to December. No exact reason could explain signal disappeared; the common causes include transmitter damage, premature tags drop, no battery, accidental death, etc. This research tends to consider transmitter drop.

Table 3-1 Transmissions delivered from the 10 transmitters deployed

ID	First transmission	Last transmission	Transmission days
128486	4/25/2019	5/29/2019	34
128489	4/25/2019	6/13/2019	49
182153	11/20/2019	3/12/2020	113
182156	11/21/2019	11/27/2019	7
182165	12/12/2019	12/24/2019	11
182166	12/14/2019	4/13/2020	121
182167	12/12/2019	1/27/2020	45
182168	12/13/2019	2/24/2020	72
182169	12/12/2019	12/26/2020	13

Transmitters on diving animal only send one signal location at one time. When they surfaced, there were rare quality 0-3 locating signals instead of most quality A or B.

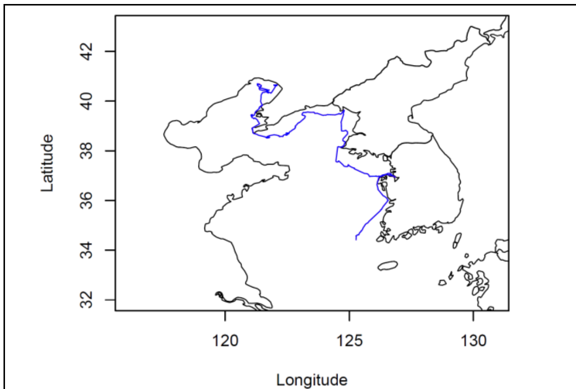
These locations would be accurate which need more evaluation. The results from White and Sjöberg（2002）showed that average accuracy of quality 0 and A from *Halichoerus gryphus* within 5km, and quality B closed to 50km. Therefore, quality 0, A or B should not be removed easily. McConnell（1992）used RMS velocity filters to calculate *Mirounga leonine*'s maximum permission speed was 12.6km/h. Analytical data in this research is not include ashore locations and bases on RMS velocity filters（McConnell ,1992）with reducing to 88.3% of original data (range 79.8%-97.8%).

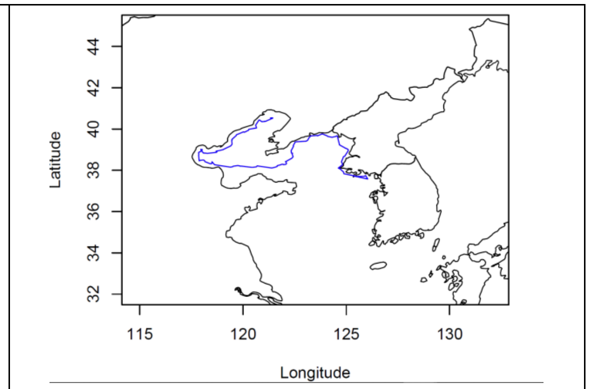
Totally, we received 3595 location records from 9 transmitters, including 3171 valid. An average of 352 effective signals was received from each transmitter. 30.3% of signals were quality1-3(within 1km). In view of actual effective days, each transmitter gave an average of 6.9 effective signals per day (range 2.0-17.1).

Table 3-2 Summary information on positions received from the 9 transmitters

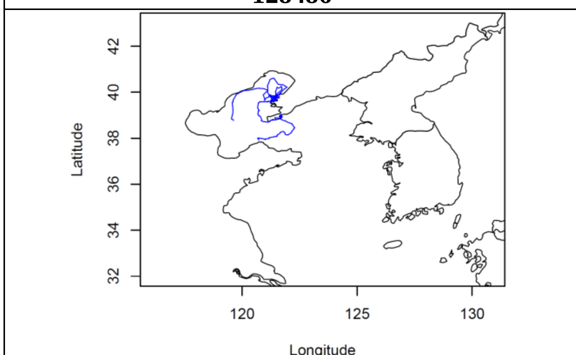
ARGOS ID	Signal numbers of different class level						No. of Signals	Pos/day	Class 1-3
	B	A	0	1	2	3			
128486	190	193	10	38	65	86	582	17.1	189
128489	90	76	3	10	15	22	216	4.4	47
182153	387	350	66	165	137	94	1199	10.6	396
182156	11	8	1	2	4	5	31	4.4	11
182165	40	14	3	8	3	3	71	6.5	14
182166	293	142	33	88	49	30	635	5.2	167
182167	99	38	13	21	13	12	196	4.4	46
182168	49	35	2	7	26	28	147	2.0	61
182169	33	22	9	16	10	4	94	7.2	30
Mean							352.33	6.9	106.8
SD							384.68	4.5	126.0
Total							3171	61.9	961

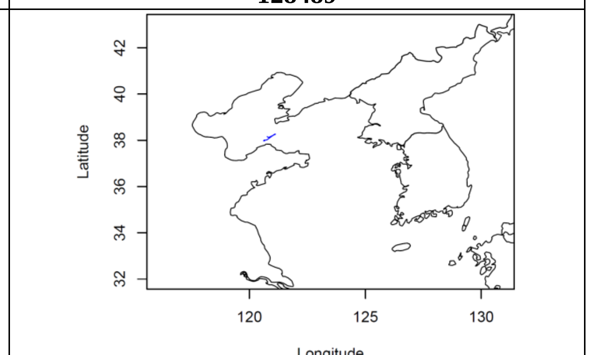
3.2 Location tracking



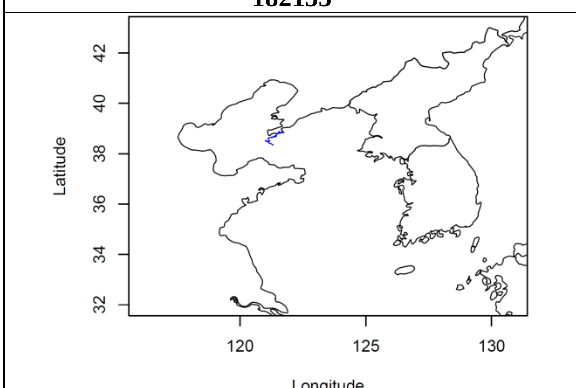


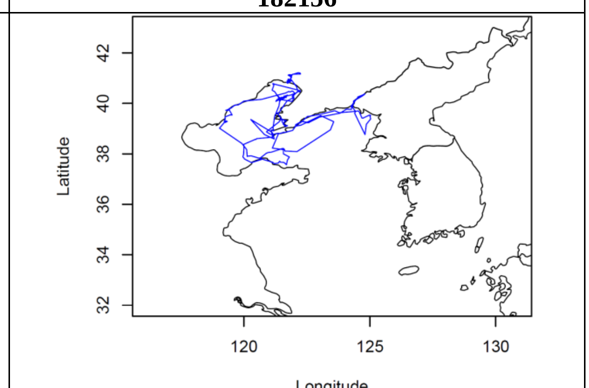
128486 128489



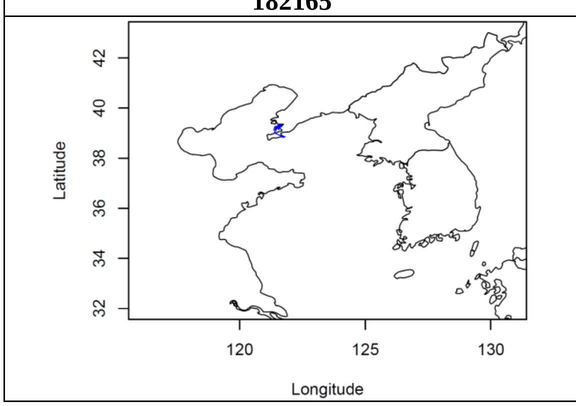


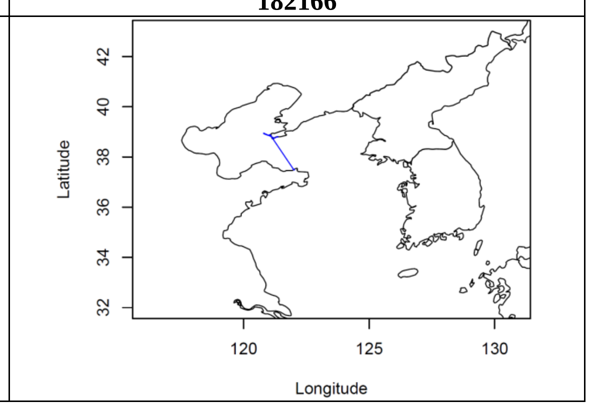
182153 182156

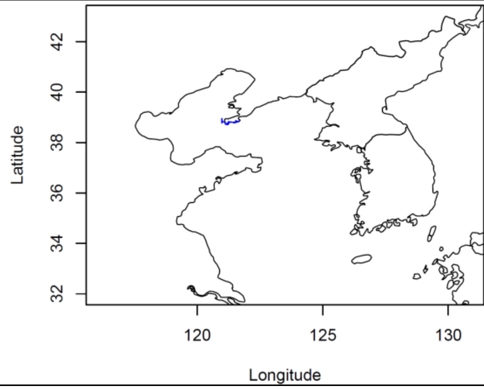




182165 182166





182167	**182168**
	
182169	

Based on these effective locations, we drew the distribution maps. It showed that all seals spread in Bohai and Yellow Sea before signal disappeared.

Seals No.128486 and 128489 were released in spring. We found they moved gradually to the South Korean water and arrived western of Korean peninsula in mid-May. Before the signal disappeared, No.128486 kept moving southward and arrived in south of Korean peninsula at the end of May, No.128489 kept staying for long time after it arrived in Baengnyeong Island until signal lost at the beginning of June.

Other 7 spotted seals were released in winter and stayed in north Bohai and Yellow Sea. Seal 182156, 182165 and 182169 were tracked only 10 days; the activities were focused near the releasing place. After a period of activities in north Yellow sea, No.182153 entered into Bohai Sea. 2 months later, it began to move southward in this early March. No.182166 mainly stayed in Bohai Sea and north Yellow Sea; finally, records lost in Liao River estuary in Panjin. No.182167 and No.182168 only stayed in a small area until signals disappeared.

4 Discussion

The tags could work effectively for 7 to 121 days, only 3 tags worked in a shorter time. No exact reason could explain signal disappeared; the common causes include transmitter damage, premature tags drop, no battery, accidental death, etc. This research tends to consider transmitter drop.

Existing research showed that there were two migration routes, part of seals moved southward from Liaoning coast to North Korea west coast, others traveled from Miaodao Archipelago to deep waters of northern Yellow Sea and finally arrived at North Korea west coast. The movement paths of 2 spotted seals which were released in Panjin in spring conformed to known migration routes. No 128489 kept staying in Baengnyeong Island until signal lost, but No.128486 kept moving southward. It showed that Baengnyeong Island was not the only summer habitat.

There was no significant move trend in 7 spotted seals which were released in winter. No.182166 kept wandering in Bohai Sea, it moved as far as the mouth of Yalu River and back to Bohai Sea. In 2020 spring, it arrived at the haul-out site in Liao River. This research demonstrated it could blend into the natural species.

Compared with the individual activity characteristics in two releasing seasons, except the obvious differences in migration direction, the movement range of No.182167 and No. 182168 which released in winter was smaller in a long time.

In this research, no matter pups or adults, we could track the signals for more than 2 months. It illustrated that released seals could adapt in the wild, and artificial breeding seals after training could survive adaptively.

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