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Waterfowl Community and Protective Value at Gangjin Bay in Gyeongsangnam-do, Korea

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Abstract: This study conducted the total six times of survey at Gangjin Bay in Gyeongsangnamdo from June in 2012 to March in 2013. The number of waterfowl observed during the survey period was the total of 48 species and 17,799 individuals for the maximum number of individuals. The most dominant species was *Aythya marila* (37.0%), followed by *Aythya ferina* (28.8%). The monthly appearance species (appearance rate of 100%) was recorded as 7 species including *Anas poecilorhyncha*, *Ardea cinerea*, *Egretta alba modesta*, *Egretta garzetta*, *Falco tinnunculus*, *Larus crassirostris*, and *Larus ridibundus*. The legally protected species was found to be total 8 species including Endangered Species I (2 species), II (5 species), and natural monument (6 species). The mudflat grade for birds showed high protective value with II grade, which was the same grade as at Gangjin Bay and Muan Bay in Jeollanamdo. Therefore, it is suggested to prepare for the plan to protect and manage waterfowls and ducks at Gangjin Bay areas during the wintering season.

Keywords: Waterfowl Community, Gangjin Bay

Introduction

The waterfowl is the highest taxa in the coastal ecosystem. Particularly, it is sensitive to the coastal environment as a predictive factor in the environmental changes. It, thus, plays a role as index to evaluate the healthiness of mudflats. The ecosystem of coastal wetlands has been changed over time due to the damages caused by human activities and development. As the significance of coastal wetlands has currently been widely recognized around the world, we, thus, need to pay sustained attention to the preservation of mudflats. Also, the consistent monitoring of mudflat is considered absolutely indispensable for securing the fundamental data to establish the preservation policy in the future (Ministry of Oceans and Fisheries, 2013).

Since the coastal wetland in Korea is located in the middle of migrating path of East Asian-Australasian, it is a geographically critical place as a stopover and wintering site for a variety of seasonally migrating waterbirds. As most waterbirds migrating to Korea feed and rest on stopover sites and seaside mudflat as wintering site, the coastal wetlands are very crucial habitats for waterbirds (Burger *et*

al., 1977; Schneider, 1978; Evans *et al.*, 1979; Lee *et al.*, 2008).

The previous studies on the bird distribution in the coastal wetlands with tide and mudflat investigated the bay areas such as Muan Bay (Kang *et al.*, 2008), Suncheon Bay, Boseong-Deungnyang Bay (Choi, 2006). For the research site in this study, Gangjin Bay in Gyeongsangnamdo, winter migratory bird census has been conducted in Changsundo nearby the research site by the Ministry of Environment since 2010. In 2010, Namhae region was surveyed as part of National Natural Environment Survey. Also, the areas were studied as part of the close investigation of coastal wetlands by Ministry of Maritime Affairs and Fisheries. The study on the evaluation of mud flat grade has been studied only about the criteria for grading of the mudflat (Lee *et al.*, 2004) and the mudflat grade evaluation in Muan Bay (Kang *et al.*, 2008) and Doam Bay (Shin *et al.*, 2011). However, little research has been carried out for the distribution of waterfowl inhabiting mudflat and wetlands and the mudflat grade.

Therefore, this study aimed to obtain the primary data in the research site through understanding the distribution of waterfowl wintering and inhabiting Gangjin Bay. Moreover, this study graded mudflat in Gangjin Bay by using birds to conduct comparative analysis with other mudflat areas. Finally, the plan to protect and manage Gangjin Bay areas

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was suggested.

Material and Methods

1. Study Area

Geographically, Gangjin Bay in Gyeongsangnamdo is located in the southern sea (34°48'~34°58' N, 127°53'~ 128°03' E). The southern sea consists of major wintering places of migratory birds, such as Suncheon Bay and Galsa Bay, as well as Gangjin Bay. The wintering sites of migratory birds in nearby Gangjin Bay have wide mudflat and farmlands. The administrative district of coastal wetlands in Gangjin Bay belongs to Namhae-gun (southwest), Sacheon-si (northeast), and Hadong-gun in Gyeongsangnamdo. The water level of Gangjin Bay in the southern sea is deeper than that in the western sea. The area is characterized to have small mudflat due to the small tidal range (Fig. 1).

2. Method

The waterfowls wintering at bay areas and nearby wetlands were surveyed and censused for six times from June in 2012 to March in 2013. In order to identify the distribution and the usage of habitat, more than two teams with two people of each surveyed at two hours before and after the full tide.

The survey was conducted by walking or moving along the bank by car at 2 km per hour. The survey types included the line census and the point census. The former was carried out by recording the number of observed species and individuals by using binoculars. The latter was conducted to record the observed birds all over the waters by using telescope (Field scope, Swarovski, ×20~60) after choosing convenient places for observation.

The results of this study were analyzed by calculating dominance and species diversity (Shannon & Weaver, 1949). The evaluation of mudflat grade was based on criteria offered by Lee *et al.* (2004) and Ministry of Maritime Affairs and Fisheries (2005). The evaluation criteria included the number of individuals, the number of protected species, the number of individuals of protected species, the number of internationally surviving species, and the number of domestically surviving species. Each was scored ranging from 3 to 0 point based on the criteria. Then, the sum of all scores was graded from I grade for the highest to V grade for the lowest.

Table 1. Scoring by the 5 criterion on mudflat

Score	0	1	2	3
supporting birds on mudflat	less than 5,000	5,000-10,000	10,000-20,000	more than 20,000
protected bird species	0	1-4	5-9	>10
population size of the protected birds	less than 10	10-100	100-1,000	more than 1,000
waterbird species over 1% level of the survival population	0	1-4	5-9	more than 10
waterbird species over 1% level in Korea population	0	1-4	5-9	more than 10

1) Individuals of birds

Based on the international criteria of wetland suggested by the Ramsar Convention on Wetlands, the mudflat which was inhabited by more than 20,000 individuals of birds was scored with the maximum of 3 points, followed by the minimum of 0 point for the mudflat of less than 5,000 individuals.

2) Protected bird species

The mudflat which was inhabited by more than 10 protected species was scored with the maximum of 3 points, followed by the minimum of 0 point for the mudflat with no species.

3) Individuals of the protected birds

Regardless of the number of protected species, the mudflat which was inhabited by more than 1,000 individuals was scored with the maximum of 3 points, followed by the minimum of 0 point for the mudflat of less than 10 individuals.

4) Waterbird species over 1% level of the survival population

The mudflat, which was inhabited by more than 10 species and each species with over 1% of the surviving population, was scored with the maximum of 3 points, followed by the minimum of 0 point for the mudflat with no species to meet the 1% criteria.

5) Waterbird species over 1% level in Korea population

The mudflat, which was inhabited by more than 10 species and each species with over 1% of the domestically migrating population, was scored with the maximum of 3 points, followed by the minimum of 0 point for the mudflat with no species to meet the 1% criteria.

Table 2. Grading level of 1-5 by total score of 4 or 5 criteria by birds on mudflat

Total score by 5 criteria	Total score by 4 criteria	Grade
more than 13	more than 11	I
10-12	8-10	II
7-9	5-7	III
4-6	3-4	IV
0-3	0-2	V

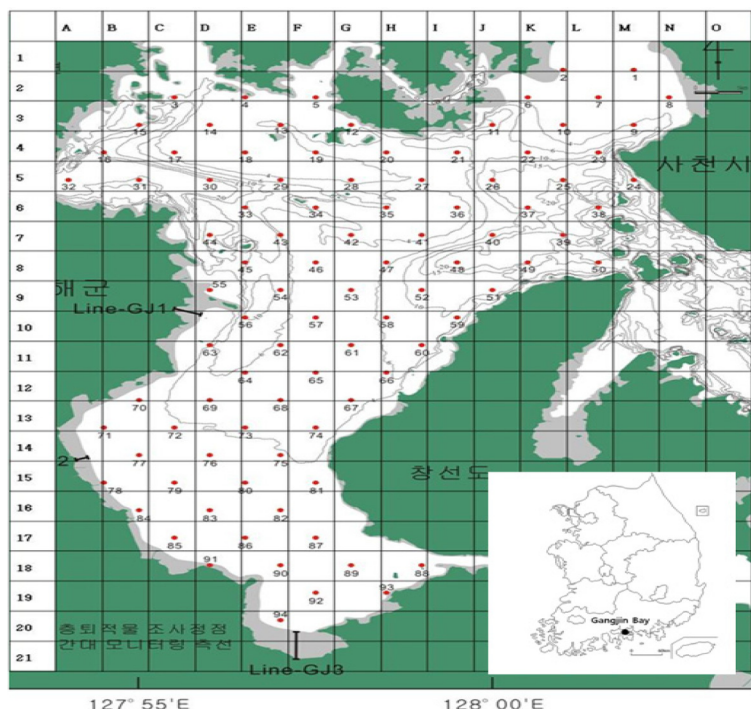


Fig. 1. Map of Gangjin Bay in Gyeongsangnamdo showing the survey sites.

Results and Discussion

1. Overall result

The waterfowls observed at Gangjin Bay in Gyeongsangnamdo during the wintering season and migrating period from June to March were recorded as total 89 species and 18,873 individuals for the sum of maximum counts. The maximum counts of wintering individuals were recorded as 17,482 individuals. The most dominant species was *Aythya marila* (34.9%), followed by *Aythya ferina* (27.1%).

Of those, waterfowls including raptorial birds were recorded as 48 species and 17,799 individuals. The number of species accounted for approximately 53.9% of the total

species including arbor birds whereas the number of individuals accounted for approximately 94.3%. This result indicated that most of migrating birds to Gangjin Bay were waterfowls. In particular, the mainly dominant species was the diving duck. This is because Gangjin Bay has small tidal range and its sea level is deep so that the area is appropriate habitat for the diving ducks. The number of individuals was increased because most of the birds wintered with large groups.

The seasonal change of the number of species revealed that the smallest number of waterbird species was recorded as 16 species in summer which is the breeding season of the waterbird. However, the number of species gradually

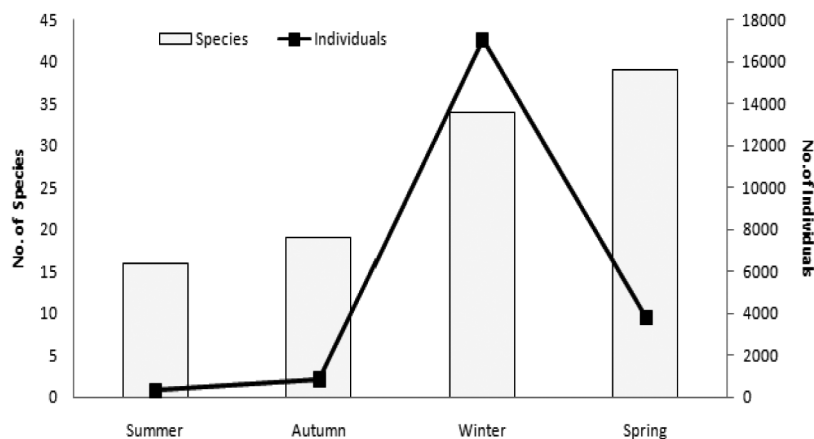


Fig. 2. Monthly change of the species number and individuals of the waterbirds at Gangjin Bay.

increased and the largest number of species were recorded as 39 species in spring (Fig. 2). This result might be caused by the inflow of both the ducks leaving for the breeding sites and the trespassing shorebirds.

The seasonal change of the number of individuals showed that the number of individuals gradually increased from summer and it was recorded as the maximum of 17,041 individuals in wintering season. After then, it decreased (Fig. 2).

2. Appearance species of waterfowls and their change of the individual number

The appearance species (appearance rate of 100%) during the whole period of survey was recorded as 3 species including *Ardea cinerea*, *Egretta garzetta*, and *Anas poecilorhyncha*. 3 species including *Egretta alba modesta*, *Larus ridibundus*, and *Larus crassirostris* showed 83% of appearance rate

(Table 3). According to the previous result from 2010 to 2012 (Ministry of Environment, Winter Migratory Bird Census, 2010, 2011, 2012), the total of 36 waterbird species including raptorial birds were recorded in the southern sea areas in 2010; 23 species in 2011; 24 species in 2012. In this study, the total of 34 species including raptorial birds was recorded in winter, which revealed that there was no difference in the number of species compared to the previous data.

Ardea cinerea, *Egretta alba modesta*, and *Egretta garzetta* showed the largest number of individuals during the migrating period in September (*Ardea cinerea*: 161, *Egretta alba modesta*: 108, *Egretta garzetta*: 31), followed by the number during the breeding period in summer (June and July). Wintering birds such as *Anas poecilorhyncha* and *Larus ridibundus* showed the smallest number of individuals in June and July. However, they gradually increased. In the

Table 3. The results of appearance ratio (75%≤) in Gangjin Bay with a few waterbird species

No.	Scientific name	2012			2013			Frequency (%)
		Jun.	Jul.	Sep.	Jan.	Feb.	Mar.	
1	<i>Ardea cinerea</i>	65	51	161	46	14	54	100%
2	<i>Ardea alba modesta</i>	93	44	108	32		37	83%
3	<i>Egretta garzetta</i>	20	15	31	2	2	7	100%
4	<i>Anas poecilorhyncha</i>	39	23	63	458	430	201	100%
5	<i>Larus ridibundus</i>		27	39	550	290	358	83%
6	<i>Larus crassirostris</i>	20	72	312	3		307	83%
7	<i>Falco tinnunculus</i>		2	10	1		2	67%
No. of species		5	7	7	7	4	7	

*1: Frequency of appearance (%)

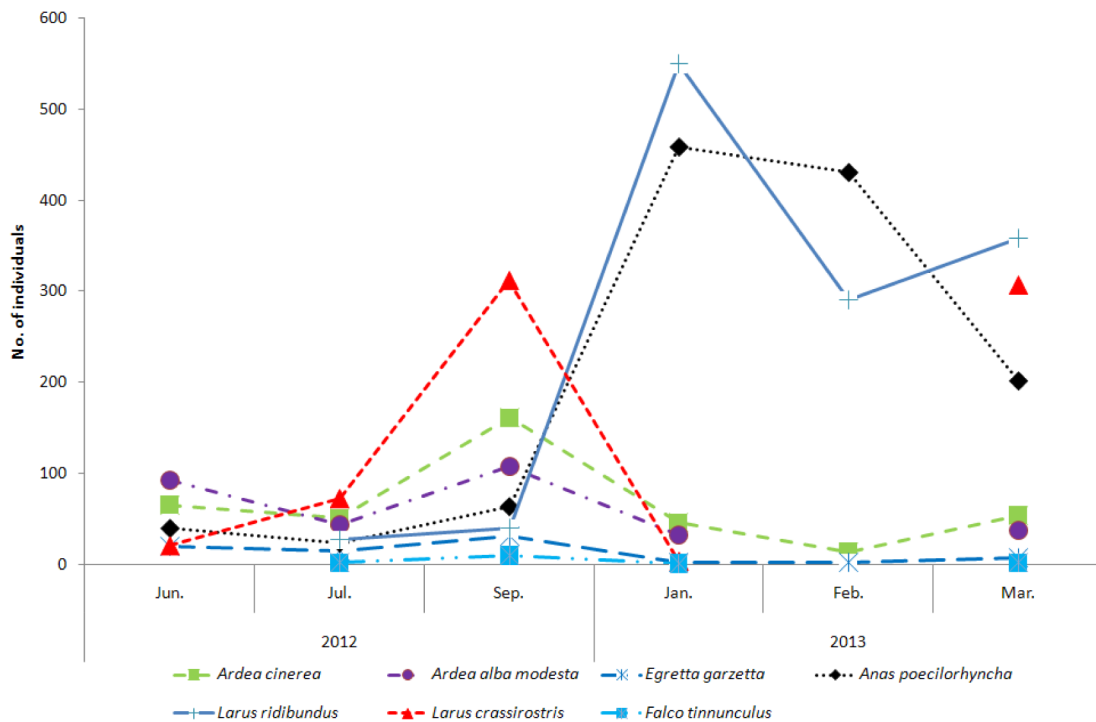


Fig. 3. The individual number of appearance species in Gangjin Bay.

Table 4. The list of species of natural monuments and endangered waterbirds

No.	Scientific name	2012		2013		Total	Peak Count	Remark*
		Summer	Autumn	Winter	Spring			
1	<i>Cygnus cygnus</i>			15	15	30	15	○, ◎
2	<i>Platalea leucorodia</i>				1	1	1	○, ◎
3	<i>Egretta europhotes</i>				2	2	2	●, ◎
4	<i>Falco tinnunculus</i>	2	10	1	2	15	10	◎
5	<i>Falco peregrinus</i>				1	1	1	●, ◎
6	<i>Pandion haliaetus</i>		1	1		2	1	○
7	<i>Haematopus ostralegus</i>	8		36	36	80	36	●, ◎
8	<i>Larus saundersi</i>		15	37	8	60	37	◎
	No. of species	2	3	5	7	8	7	
	No. of individual	10	26	90	65	191	110	

* ●: Endangered Species I, ○: Endangered Species II, ◎: Natural monument

wintering season in January, the sum of maximum counts was 458 for *Anas poecilorhyncha* and 550 for *Larus ridibundus*. As for *Larus crassirostris*, the largest number of individuals was recorded as 312 in September when they gathered after breeding in uninhabited islands (Fig. 3).

3. Summary of legally protected species

The legally protected species identified during the research period between June 2012 and March 2013 was recorded as total 8 species: Endangered Species I, designated by Ministry of Environment, was recorded as 2 species including *Egretta europhotes* and *Falco peregrinus*; Endangered Species II was recorded as 5 species including *Cygnus cygnus*, *Platalea leucorodia*, *Pandion haliaetus*, *Haematopus ostralegus*, and *Larus saundersi*. Natural monument species, designated by Culture Heritage Administration, was recorded as 6 species including *Cygnus cygnus*, *Platalea leucorodia*, *Egretta europhotes*, *Falco tinnunculus*, *Falco peregrinus*, and *Haematopus ostralegus* (Table 4). *Falco peregrinus* and *Egretta europhotes* belonging to both Natural monument and Endangered Species I were observed at nearby Namhae-eup area in Gangjin Bay. However, this area needs immediate management plans because the area has heavy traffic and has been frequently visited by people for the mudflat close to the downtown.

By seasons, the largest number of legally protected species was recorded as 7 in spring. On the other hand, the smallest number was recorded as 2 species in summer. Most of legally protected species were wintering migratory birds and resident birds.

4. Value of Gangjin Bay as wintering site for waterfowls

Gangjin Bay is the area in which *Aythya marila* widely inhabits in winter. This study observed 6,580 individuals of which number is over 1% level of internationally surviving individuals. Thus, the significance of the findings lies in the fact that waterfowls tend to increase, compared to the previous study in Changsundo (Ministry of Environment.

2010~2012).

The mudflat in Gangjin Bay was evaluated based on the mudflat grading criteria (Lee *et al.*, 2004, Ministry of Maritime Affairs and Fisheries, 2005). The evaluation indicated the total 10 points with II grade, scored by total number of individuals (2 points), number of protected species (2 points), number of individuals of protected species (2 points), 1% level of World population (1 point), and 1% level of Korean population (3 points). The grade was shown to be the same as other mudflat areas such as Doam Bay (Shin *et al.*, 2011) and Muan Bay (Kang *et al.*, 2008) but it was higher than that of Huido tidal flat and Daecheon Bay of which grade was IV. The number of waterbird species observed at coastal wetlands in Gangjin Bay was less than that in the mudflats in Suncheon Bay, Boseong-Deungnyang Bay, and Doam Bay. This might result from the fact that the mudflat of Gangjin Bay interrupts waterfowls inhabiting this area because the area of mudflat is small. In addition, the mudflat in Gangjin Bay is close to the tourist attractions so it is frequently visited by many tourists. Moreover, it might be because the observed number of shorebirds and dabbling ducks which tend to group together was small. In particular, even though the nearby mudflats in Namhae-eup of Gangjin Bay and in Idong-myeon do not have large mudflat areas compared to other coastal wetlands, the areas have appropriate condition of habitat for waterbirds because the areas are formed with back marsh. Nevertheless, the areas have coastal roads and are easily exposed to potential risks such as by vehicle traffic and fishing. Therefore, it is suggested to prepare for the plans such as developing screen shields and controlling vehicle for the stable wintering and inhabitation of waterbirds.

This study indicated that the mudflat of Gangjin Bay was evaluated as mudflat grade II. As the grade was shown to be the same grade as Muan Bay and Gangjin Bay in Jeollanamdo, the mudflat of Gangjin Bay is considered significantly valuable not only as habitats for birds but also

Table 5. Grade by the scoring of bird census data on 7 mudflat area, Korea

Mudflat area	Peak count	Protected species	Protected birds population	1% level of World population	1% level of Korean population	Grade	Source
Gangjin Bay	17,7991(22)	8(2)	103(2)	1(1)	6(3)	II	This study
Doam Bay	9,730(1)	13(3)	1,190(3)	1(1)	9(2)	II	Shin <i>et al.</i> , 2011
Daecheon Bay	6,302(1)	5(2)	37(1)	1(1)	3(1)	IV	Ministry of Land, Transport and Maritime Affaire, 2011
Muan Bay	15,755(2)	5(2)	13(1)	2(1)	12(3)	II	Kang <i>et al.</i> , 2008
Bosung Bulgyo Tidal Flat	4,876(0)	5(2)	175(2)	1(1)	5(2)	III	Ministry of Land, Transport and Maritime Affaire, 2010
Suncheon Bay	12,736(2)	13(3)	948(2)	4(1)	9(2)	II	Ministry of Land, Transport and Maritime Affaire, 2010
Hauido Tidal Flat	1,669(0)	8(2)	14(1)	0(0)	2(1)	IV	Ministry of Land, Transport and Maritime Affaire, 2009

*1: No. of individuals, 2: Score

as wintering sites for the diving ducks in wintering season. Therefore, it is required to prepare for the plans to conserve the waterfowl and also to protect and manage the coastal wetlands in Gangjin Bay through the designation of the coastal wetlands area.

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Appendix 1. Water birds observed at Gangjin bay

No.	Scientific name	2012		2013		Total	Peak Count	Dominance value
		Summer	Autumn	Winter	Spring			
1	<i>Cygnus cygnus</i>			15	15	30	15	0.1
2	<i>Tadorna tadorna</i>			187	174	361	187	1.1
3	<i>Anas strepera</i>			20	2	22	20	0.1
4	<i>Anas falcata</i>			41	41	82	41	0.2
5	<i>Anas penelope</i>			324	133	457	324	1.8
6	<i>Anas platyrhynchos</i>			536	440	976	536	3.0
7	<i>Anas poecilorhyncha</i>	39	63	458	201	761	458	2.6
8	<i>Anas acuta</i>			151	135	286	151	0.8
9	<i>Anas crecca</i>	1		470	380	851	470	2.6
10	<i>Aythya ferina</i>			5,120	232	5,352	5,120	28.8
11	<i>Aythya fuligula</i>			500	20	520	500	2.8
12	<i>Aythya marila</i>	2		6,580	50	6,632	6,580	37.0
13	<i>Bucephala clangula</i>			340	1	341	340	1.9
14	<i>Mergus merganser</i>			587	82	669	587	3.3
15	<i>Mergus serrator</i>			65	28	93	65	0.4
16	<i>Tachybaptus ruficollis</i>		2	1	1	4	2	<0.1
17	<i>Podiceps cristatus</i>			14	3	17	14	0.1
18	<i>Podiceps nigricollis</i>			2	2	4	2	<0.1
19	<i>Platalea leucorodia</i>				1	1	1	<0.1
20	<i>Butorides striata</i>	1				1	1	<0.1
21	<i>Bubulcus ibis</i>	3				3	3	<0.1
22	<i>Ardea cinerea</i>	65	161	46	54	326	161	0.9
23	<i>Ardea alba modesta</i>	94	108	32	37	271	108	0.6
24	<i>Egretta intermedia</i>	1	3			4	3	<0.1
25	<i>Egretta garzetta</i>	20	31	2	7	60	31	0.2
26	<i>Egretta europhotes</i>				2	2	2	<0.1
27	<i>Phalacrocorax capillatus</i>		4	7	1	12	7	<0.1
28	<i>Falco tinnunculus</i>	2	10	1	2	15	10	0.1
29	<i>Falco peregrinus</i>				1	1	1	<0.1
30	<i>Pandion haliaetus</i>		1	1		2	1	<0.1
31	<i>Buteo buteo</i>			2	1	3	2	<0.1
32	<i>Gallinula chloropus</i>	2				2	2	<0.1
33	<i>Haematopus ostralegus</i>	8		36	36	80	36	0.2
34	<i>Charadrius dubius</i>	2				2	2	<0.1
35	<i>Charadrius alexandrinus</i>		1		1	2	1	<0.1
36	<i>Numenius phaeopus</i>		27		6	33	27	0.2
37	<i>Tringa nebularia</i>		8	6	4	18	8	<0.1
38	<i>Tringa ochropus</i>			1		1	1	<0.1
39	<i>Xenus cinereus</i>				1	1	1	<0.1
40	<i>Actitis hypoleucos</i>	1	9			10	9	0.1
41	<i>Heteroscelus brevipes</i>		12		2	14	12	0.1
42	<i>Calidris alba</i>		6			6	6	<0.1
43	<i>Calidris alpina</i>		60	630	674	1,364	674	3.8
44	<i>Larus crassirostris</i>	72	312	3	307	694	312	1.8
45	<i>Larus camus</i>			8	70	78	70	0.4
46	<i>Larus vegae</i>			268	308	576	308	1.7
47	<i>Larus ridibundus</i>	27	39	550	358	974	550	3.1
48	<i>Larus saundersi</i>		15	37	8	60	37	0.2
	No. of species	16	19	34	39	48	48	
	No. of individuals	340	872	17,041	3,821	22,074	17,799	
	Species diversity	1.94	2.06	1.92	2.69	2.36	2.07	