

**CORMORANT AND BROWN PELICAN USE OF EXCLUDER-FITTED PILE DIKES  
IN THE COLUMBIA RIVER ESTUARY, 2001**

**2001 Final Report**

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The purpose of this study was to monitor the use of pile dikes in the Columbia River estuary by piscivorous (fish-eating) birds. Most of the pile dikes had been fitted with bird excluders (wire spike strips) to discourage cormorants from perching, roosting, and staging foraging activities on out-migrating juvenile salmonids from these structures. A primary objective of the study was to evaluate the efficacy of these excluders for reducing the numbers of cormorants perching on and foraging near pile dikes (see Figures 1 and 2 for maps of the study area). The study species were double-crested cormorants (*Phalacrocorax auritus*), pelagic cormorants (*P. pelagicus*), and Brandt's cormorants (*P. penicillatus*), all of which nest in the estuary. California brown pelicans (*Pelecanus occidentalis californicus*), a species listed as endangered under the U.S. Endangered Species Act, are also known to use pile dikes as perching sites, so the effects of excluders on use of pile dikes by pelicans was also of interest. A total of 19 pile dikes in the estuary were

monitored, 17 of which were at least partly fitted with bird excluders (Table 1). Pile dikes included in this study were located from river mile 3.00 (West Sand Island) to river mile 51.42 (Eureka Bar; Figure 1). The study was conducted from 7 May to 30 September 2001. This time period generally coincided with the breeding season for cormorants in the Columbia River estuary and the post-breeding season for California brown pelicans (brown pelicans do not breed in the study area). In this report, individual pile dikes are referenced by their location on the lower Columbia River in river miles (e.g., pile dikes 3.00 and 51.42 are the lower- and upper-most dikes in the study area, respectively; see Figure 1)

## **Distribution and Behavior of Cormorants and Pelicans at Pile Dikes**

### Methods

Bird excluders were installed or repaired at all but two of the 19 pile dikes during late May and early June 2001 (Table 1). Pile dikes 3.00 and 4.47 were not fitted with any bird excluders, while pile dikes 4.01, 5.15, 6.37, 37.90, and 38.25 were only partially covered with bird excluders (Table 1). Nine of the 17 pile dikes with bird excluders were equipped with excluders during spring 2000, and these excluders were repaired as needed in early June. Repair consisted of replacing spike strips that had been washed away, broken, or bent since the 2000 breeding season. Two of these nine excluder-equipped pile dikes from 2000 (pile dikes 37.90 and 38.25) were not completely covered with excluders in either year (Table 1).

We counted the number of cormorants and pelicans on or adjacent to the 19 pile dikes located from river mile 3.00 to river mile 51.42 (Figure 1) each week throughout the study period. All cormorants and pelicans counted were assigned to one of three activity categories: perching, foraging, or nesting. Birds were classified as foraging if they were observed on the water within

50 m of the pile dike (either upstream or downstream). Although brown pelicans occasionally were observed resting on the water during slack tide, most pelicans on the water surface near pile dikes were foraging. The distribution of birds along each dike (northern, central, and southern third of the dike) was also noted.

Counts of cormorants at 14 pile dikes located in the upper Columbia River estuary from river mile 22.75 to river mile 51.42 (Figure 1) were conducted once a week from a boat (one count per pile dike per week). Counts were not conducted at these dikes if it was determined that human activity on or near the dike (e.g., fishers tied up to dike, dike maintenance activity) was affecting bird use of the pile dike.

Counts of cormorants and pelicans at five pile dikes located in the lower Columbia River estuary near East Sand Island (river mile 3.00 to river mile 6.37; Figure 2) were conducted from shore immediately adjacent to the dike or from channel markers located at the offshore end of the dike. Each of these five pile dikes was observed for 8 hrs per week, with bird counts conducted every 15 min throughout each 8-hr period. In most cases, both upstream and downstream foraging areas were visible from the vantages used by observers. Occasionally the normal vantage point for a pile dike could not be accessed by the observers without disturbing brown pelicans in the vicinity; in these cases counts of foraging birds on one side of the dike were doubled to estimate the total number of foraging birds near the dike. Seasonal and weekly summaries presented here were based on mean number of cormorants and pelicans counted per 15-minute observation period in the case of the five pile dikes located from river mile 3.00 to river mile 6.37, or on the once weekly counts in the case of the 14 pile dikes located from river mile 22.75 to river mile 51.42. Missing bars in the attached histograms indicate insufficient sample size or no data. To

better evaluate the efficacy of bird excluders, we compared the data collected on cormorant and pelican use of the five pile dikes in the lower Columbia River estuary (river miles 3.00 – 6.37) in 2001, with counts conducted during the same time period (August – September) in 2000, prior to the installation of bird excluders. We also compared cormorant use of pile dikes in the upper estuary during 2001 with counts of cormorants on or near these pile dikes in 1998, 1999, and 2000 (D.E. Lyons, unpubl. data; C.D. Anderson, unpubl. data). We do not compare bird use of pile dikes before and after installation/repair of bird excluders in 2001 because there were few recorded observations prior to excluder installation/repair. Also, the timing of excluder installation/repair in 2001 coincided with seasonal declines in cormorant use of pile dikes in the upper estuary during previous years (C.D. Anderson, unpubl. data; D.E. Lyons, unpubl. data). These seasonal trends confounded the effects of newly installed/repared excluders on pile dike use by cormorants.

### Results and Discussion

*Cormorants:* Use of pile dikes by cormorants after installation of excluders was greatest on average at the five pile dikes in the lower estuary (pile dikes 3.00, 4.01, 4.47, 5.15, 6.37; Figures 3-5). Of these five pile dikes, cormorant use was greatest at pile dike 4.47, one of the two dikes not fitted with excluders (Table 1) and the pile dike nearest the large double-crested cormorant breeding colony on East Sand Island (Figure 3). The five pile dikes located near Miller Sands Island (pile dikes 22.75 – 24.63; Figure 4) had the next highest cormorant use, on average. All five of these pile dikes had been fitted with bird excluders in 2000, and some repairs were made in 2001. In 2001, scant use of pile dikes by cormorants was observed above Miller Sands Island (pile dikes 26.86 – 51.42), the portion of the study area furthest removed from the East Sand Island breeding colony (Figure 5; see Figure 1). All of these nine pile dikes had bird excluders

installed in either 2000 or 2001, with the exception of pile dikes 37.90 and 38.25 which had only partial excluder coverage in both years (Table 1). The average number of cormorants observed on or near pile dikes ranged from 19.8 to 101.1 at pile dikes 3.00 – 6.37 (Figure 3), from 1.8 to 17.3 at pile dikes 22.75 – 24.63 (Figure 4), and from 0.1 to 2.1 at pile dikes 26.86 – 51.42 (Figure 5). In general, more cormorants were observed perching on pile dikes than foraging near them, but pile dikes 5.15, 23.71, 24.63, and 28.95 were exceptions (Figures 3 –5).

Nearly all cormorants observed on or near pile dikes were double-crested cormorants, presumably associated with the large double-crested cormorant breeding colony on East Sand Island. One notable exception was a small nesting colony of Brandt's cormorants on pile dike 4.47 (30 –50 pairs; roughly the same size as in 2000). This species normally nests on coastal cliffs, so this Brandt's cormorant colony on a pile dike is apparently unique in the Pacific Northwest. Double-crested cormorants also nested at the northern end of pile dike 6.37 (3 pairs), where no bird excluders had been erected. None of the pile dikes in the upper estuary were used by nesting cormorants, although about 75 pairs of cormorants nested on channel markers near the Miller Sands pile dikes and about 150 pairs nested on the west end of Rice Island, about 3 kilometers from the Miller Sands pile dikes. Seasonal trends in cormorant use of pile dikes are presented in Table 2 and Figure 6, and the distribution of cormorants among the three segments of each pile dike are presented in Figures 7 – 9.

Comparing cormorant use of the five pile dikes 3.00 – 6.37 during August – September 2000 (no bird excluders in place) with use during August – September 2001 (bird excluders installed on part of three pile dikes) suggests that bird excluders were partially effective in reducing the numbers of perching cormorants on particular pile dikes. At pile dikes fitted with excluders in

2001 (pile dikes 4.01, 5.15, and 6.37), the mean total number of perching cormorants counted on these three dikes was 118 in 2001, compared to 338 during this same time period in 2000, a 65% decrease (Figure 10). At pile dikes not fitted with excluders (pile dikes 3.00 and 4.47), the mean total number of perching cormorants counted on these two dikes was 107 in 2001, compared to 58 during this same time period in 2000, a 84% increase (Figure 10). The mean total number of foraging cormorants near pile dikes partially fitted with bird excluders in 2001 was, however, similar in 2000 and 2001 (65 and 70 foraging cormorants, respectively). At the two pile dikes not fitted with excluders in 2001, the mean total number of foraging cormorants near the pile dikes was 46 in 2001, compared to 22 during this same time period in 2000, a 109% increase (Figure 10). Compared to the previous year, the average total number of cormorants perching on all five pile dikes in the lower estuary decreased 43% in 2001, while the average total number of cormorants foraging near all the dikes increased by 33% in 2001. These observations suggest that the total number of foraging cormorants near pile dikes in the lower estuary was not reduced by the partial installation of bird excluders. At best, the bird excluders may have redistributed foraging cormorants among the available pile dikes in the lower estuary, none of which was completely covered with bird excluders.

Observations of cormorant use of pile dikes 22.75 – 51.42 indicate that bird excluders are effective in discouraging cormorants from perching on pile dikes, and may be effective in reducing cormorant foraging near pile dikes. Among-year comparisons of cormorant use of pile dikes show reductions in numbers of cormorants using pile dikes in the upper estuary following the installation of excluders (Table 4). Cormorant numbers presented in Table 4 are restricted to June and July, however, because this was the period when data were available in all four years. In 1998 (prior to the installation of bird excluders), mean number of cormorants counted in the

vicinity of the four Miller Sands pile dikes (pile dikes 22.75 – 23.71) combined was over 150 birds, with the large majority counted on or immediately adjacent to the pile dikes (Table 4; D.E. Lyons, OSU, unpublished data). In 1999, this mean count declined by nearly 50% (Table 4), perhaps due to the abandonment of the large cormorant colony on nearby Rice Island (ca. 950 breeding pairs) in that year. In 2000, after the installation of bird excluders on the Miller Sands pile dikes, the mean number of cormorants counted on or near these pile dikes was only 10 birds (Table 4). At nearby pilings not equipped with excluders, however, the average number of perching and foraging cormorants during the same period was 49 (C.D. Anderson, unpubl. data).

Cormorant use of the two pile dikes on Pillar Rock Sands (pile dikes 26.86 and 27.08) increased by nearly an order of magnitude in 2000, after bird excluders were installed on the nearby Miller Sands pile dikes, compared to the previous year (Table 4). Following installation of excluders on the Pillar Rock pile dikes in 2001 cormorant use of these two dikes was reduced to very low levels, compared to the previous three years (Table 4). Thus cormorants in the upper estuary appeared to shift their perching and foraging activity from piles dikes fitted with bird excluders to those pile dikes and pilings without bird excluders, as was observed in the lower estuary.

Despite the reduction in cormorant use of Miller Sands pile dikes fitted with bird excluders in 2000, cormorant perching did commonly occur on some of these pile dikes in 2001 where bird excluders installed in 2000 had been damaged (e.g., wire spikes lying flat on the pilings), but not replaced. Also, some pilings on or near these pile dikes were below the high tide line and not fitted with excluders, allowing cormorants to use them as perches at low tide. The comparatively large numbers of cormorants perching on pile dikes 23.07 and 23.39 in the Miller Sands area in 2001 was attributable to these factors (Figure 4 and Table 2).

*Brown pelicans:* Use of pile dikes by California brown pelicans was restricted to the five pile dikes in the lower estuary (pile dikes 3.00 - 6.37). These pile dikes are near East Sand Island, a major post-breeding night roost site for the species. Brown pelican use of pile dikes was greatest on pile dike 4.47 (one of two pile dikes not fitted with excluders; Table 1), even when adjusted for differences in pile dike length (Figure 11). Pile dike 6.37 had the lowest average number of perching pelicans (Figure 11), in agreement with observations in 2000; this pile dike is the furthest of the five lower estuary pile dikes from the pelican roost at the west end of East Sand Island (Figure 2). The mean number of pelicans observed perching on or foraging near each pile dike during study period ranged from 0.1 to 5.6 (Figure 11), representing a very small percentage of the total number of pelicans using East Sand Island as a roost during the study period (up to nearly 4,000 individuals; S. Wright, OSU, unpublished data). Pelican use of pile dikes was much less than cormorant use of these same structures. Pelicans began perching on and foraging near pile dikes in early to mid-June (Figure 12). Thereafter, pelican activity at pile dikes increased until mid-September, after which pelican activity at pile dikes began to decline (Figure 12). The great majority of pelicans observed at pile dikes were perching, although a few pelicans were observed foraging near pile dikes (Figure 11). Numbers of pelicans perching and foraging among the three segments of each pile dike are presented in Figure 13.

There was a decline in the average number of pelicans perching on pile dikes from 2000 to 2001, regardless of whether bird excluders were installed on the pile dike (Figure 14). Average total number of pelicans perched on pile dikes with excluders declined by 77%, while average total number of pelicans perched on pile dikes without excluders declined by 46% (Figure 14).

Average total numbers of foraging pelicans near pile dikes were similar in the two years,

regardless of whether the pile dikes were fitted with bird excluders or not (Figure 14). Unlike cormorants, pelicans do not typically use pile dikes as a staging area for foraging. Because cormorants often perch on pile dikes between foraging bouts near the dike, bird excluders on pile dikes are more likely to affect cormorant foraging near dikes, compared to pelicans. Unlike cormorants, we occasionally observed pelicans perched on top of newly installed bird excluders, which could potentially cause foot injuries to pelicans.

### **Distribution of Radio-Tagged Cormorants in the Columbia River Estuary**

#### Methods

Off-colony movements of radio-tagged double-crested cormorants were monitored from May through July 2001. These cormorants were radio-tagged during May at the East Sand Island colony site as part of another study (C. Anderson, OSU, unpublished data). Radio-tagged individuals were detected during biweekly aerial tracking surveys from a fixed-winged aircraft flying at low air speeds over the Columbia River Estuary from the mouth to Tenasillahe Island (river mile 35). Transects were flown such that the entire estuary was covered. A mobile tracking receiver was programmed with the radio frequencies of all radio-tagged cormorants believed to be within the survey area. As transects were flown, the receiver scanned through each radio frequency at a rate of one frequency every 2-3 seconds. When a signal was detected, the receiver was fixed on that frequency so that the exact location of the radio-tagged cormorant could be determined. Bird locations were determined by listening to signal strength and signal direction based on antennas located on the left and right wing struts of the aircraft. Once a bird was boxed in (i.e., signal remained on same side of aircraft while circling), the Global Positioning System (GPS) coordinates were recorded. Radio-telemetry flights were discontinued at the end of July because most tags had been dropped when cormorants molted their tail

feathers. The relocations of all radio-tagged cormorants were plotted on digitized maps using GIS software (ArcView). Relocations of radio-tagged adults had an error ellipse of ca. 500 m. To evaluate use of pile dikes by radio-tagged cormorants we calculated the proportion of all off-colony detections that were within a one-kilometer radius of each pile dike within the study area.

### Results and Discussion

A total of 43 different radio-tagged double-crested cormorants were detected off-colony during the study period. Thirty (70%) of these 43 radio-tagged cormorants were detected more than once, with each radio-tagged individual detected on an average of 3.2 different flights. There was a total of 138 off-colony detections of radio-tagged cormorants within and just outside the study area (Figure 15). Radio-tagged cormorants were detected off-colony between the mouth of the Columbia River and the Astoria Bridge (36%), between the Astoria Bridge and Rice Island (25%), above Rice Island (36%), and outside the study area in Willapa Bay (3%). Off-colony detections were concentrated around East Sand Island, Desdemona Sands, Tongue Point, and Rice Island (Figure 15), places where large numbers of cormorants were often seen foraging and loafing. Most of these areas are either open embayments that are shallow, especially during low tide (e.g., Baker Bay and Willapa Bay), or high energy open water with back eddies that presumably concentrate and disorient migrating fish (e.g., Tongue Point and near pile dikes). Overall, 10% of off-colony detections of radio-tagged cormorants were within a one-kilometer radius of pile dikes within the study area (Figure 15). All of the detections plotted in Figure 15 are thought to be from live, radio-tagged cormorants, but it is possible that a few of the detections could have been either from radio-tags that had dropped during tail feather molt or from radio-tagged cormorants that had died.

## Conclusions

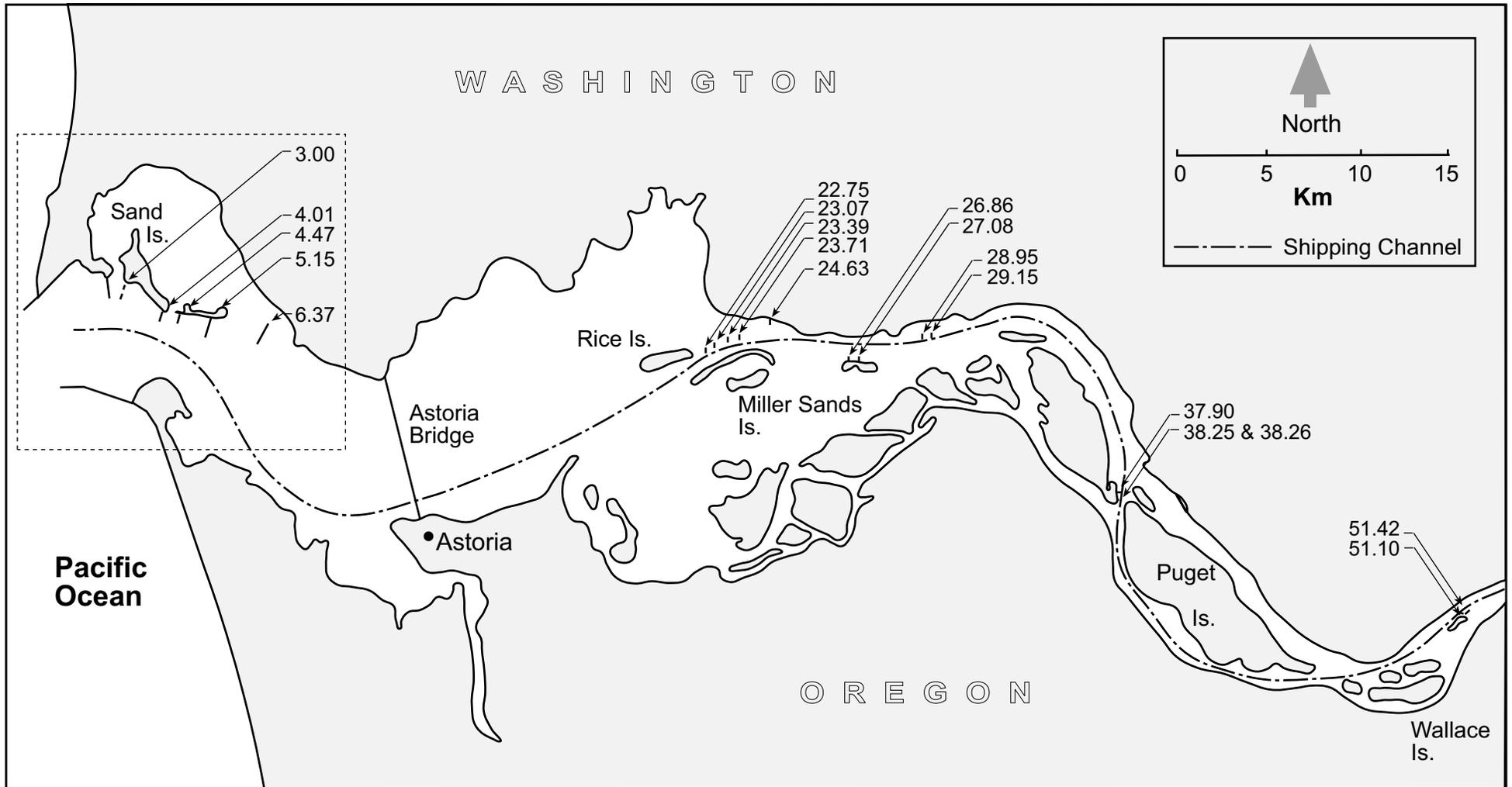
Installation of bird excluders on portions of some of the pile dikes in the lower estuary (pile dikes 3.00 – 6.37) does not appear to have been effective in reducing the total number of foraging double-crested cormorants near the five pile dikes in the lower estuary. It appears that cormorants readily shifted from pile dikes fitted with bird excluders to those pile dikes or pilings in the area that did not have bird excluders. Installation of bird excluders on all pile dikes and pilings in the lower estuary is probably not desirable because of the existence of a small Brandt's cormorant colony on pile dike 4.47 and the use of all five pile dikes, especially pile dikes 4.01, 4.47, and 5.15, as perching sites by endangered California brown pelicans. Also, the observations of some brown pelicans perching on top of recently installed bird excluders suggests that pelicans could potentially injure their feet on the spike strips, although we have no evidence of such injuries. Finally, there is no direct evidence to suggest that cormorants and pelicans foraging near pile dikes in the lower estuary are keying in on out-migrating juvenile salmonids; any enhancement of foraging efficiency near pile dikes may involve other types of forage fish.

Bird excluders appear to be effective in reducing numbers of foraging cormorants near pile dikes in the upper estuary, particularly at pile dikes near Miller Sands Island (pile dikes 22.75 – 23.71) and Pillar Rock (pile dikes 26.86 and 27.08). California brown pelicans do not use these pile dikes, no nesting by non-target species occurs on these pile dikes, and double-crested cormorants have been repeatedly observed foraging on juvenile salmonids in the immediate vicinity of the Miller Sands Island pile dikes. It should be emphasized that the efficacy of bird excluders in reducing cormorant predation on salmonids in the vicinity of these pile dikes has not been

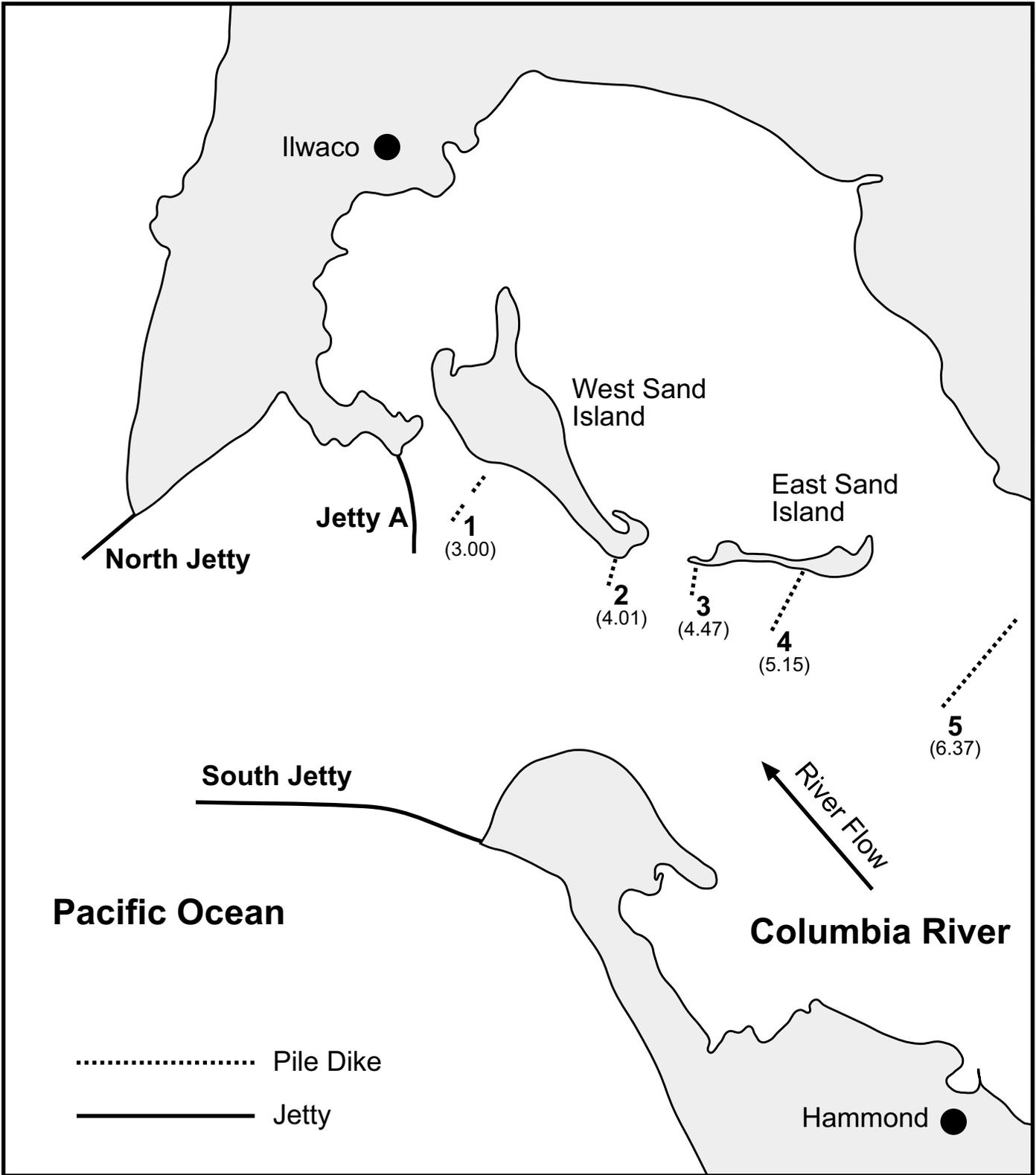
demonstrated, but instead has been inferred from the change in numbers of perching and foraging cormorants on or near pile dikes after excluder installation.

Other factors clearly influence the numbers of cormorants using particular pile dikes in the upper estuary, such as proximity to active nesting sites, local availability of forage fish compared to other potential foraging sites, and numbers of juvenile salmonids reaching the estuary. For example, the decline in numbers of cormorants foraging near pile dikes in the upper estuary during 2001 compared to previous years may be explained in part by large numbers of marine forage fishes in the lower estuary. The efficacy of bird excluders in reducing the use of pile dikes for perching and foraging will depend on regular maintenance of spike strips on all potential perching surfaces on pile dikes and nearby pilings and dolphins. Although all pile dikes in the Miller Sands area are fitted with bird excluders, there are many pilings and dolphins in the vicinity that lack excluders and are used extensively by cormorants. Effective maintenance will likely require annual replacement of most or all spike strips, as wear and tear on the strips tends to flatten the spikes and reduce their deterrence for perching birds. Finally, to be most effective, excluder installation or replacement should be completed by mid-April, prior to the arrival of most breeding cormorants in the estuary. During 1998-2000, cormorant counts at pile dikes in the upper estuary were highest in late April and May (D.E. Lyons and C.D. Anderson, unpubl. data). Peak out-migration of juvenile salmonids in the Columbia River estuary normally occurs in May (Fish Passage Center, unpubl. data).

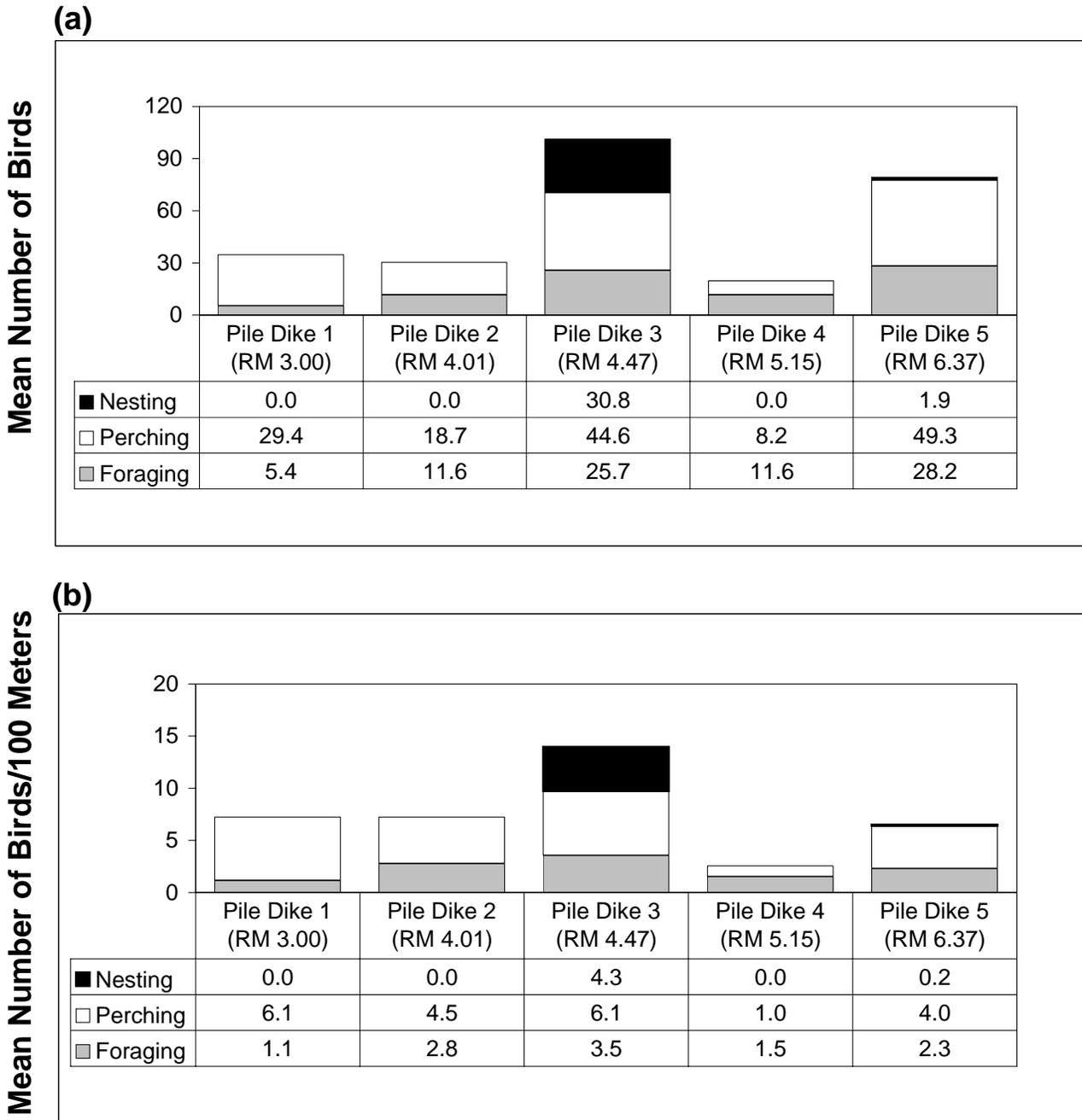
**FIGURES**



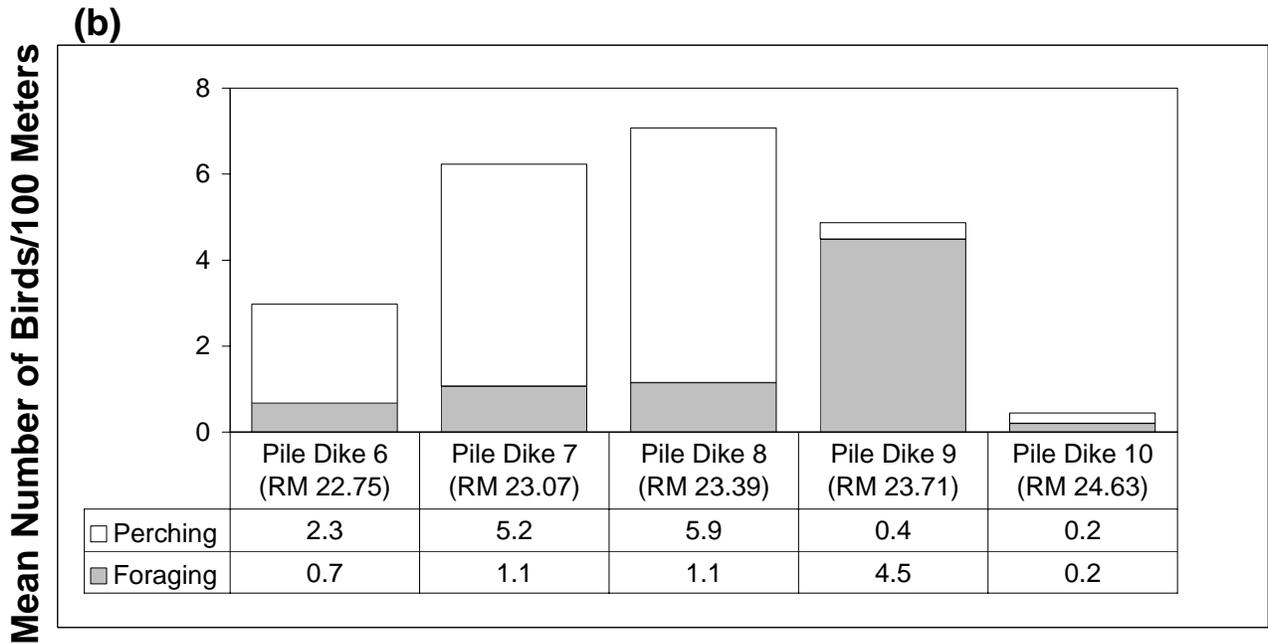
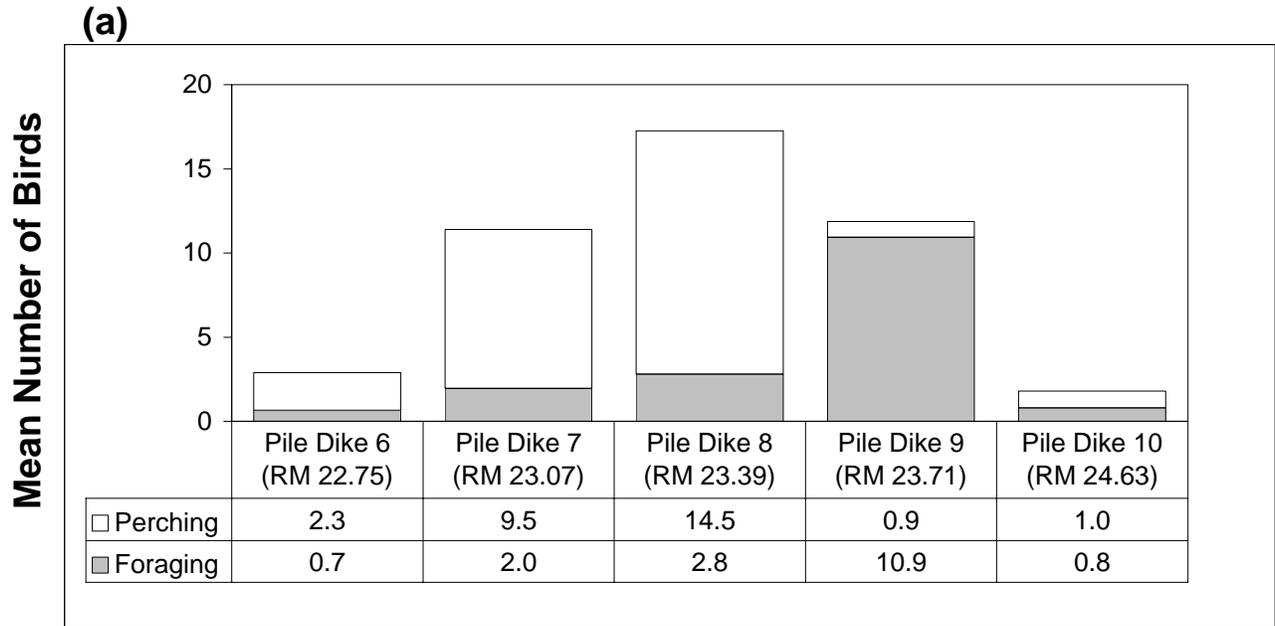
**Figure 1.** Location of pile dikes (in river miles) and the shipping channel (dashed line) in the Columbia River Estuary. Area within the dashed line box is shown in greater detail in Figure 2.



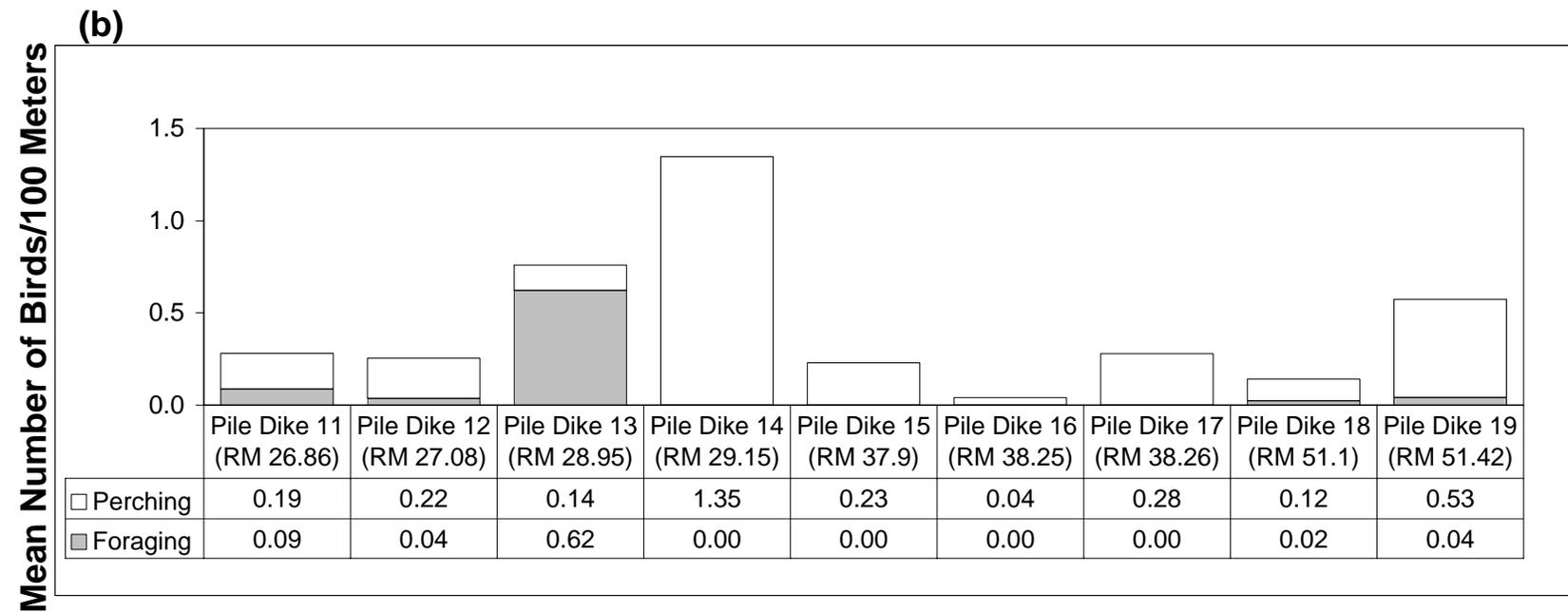
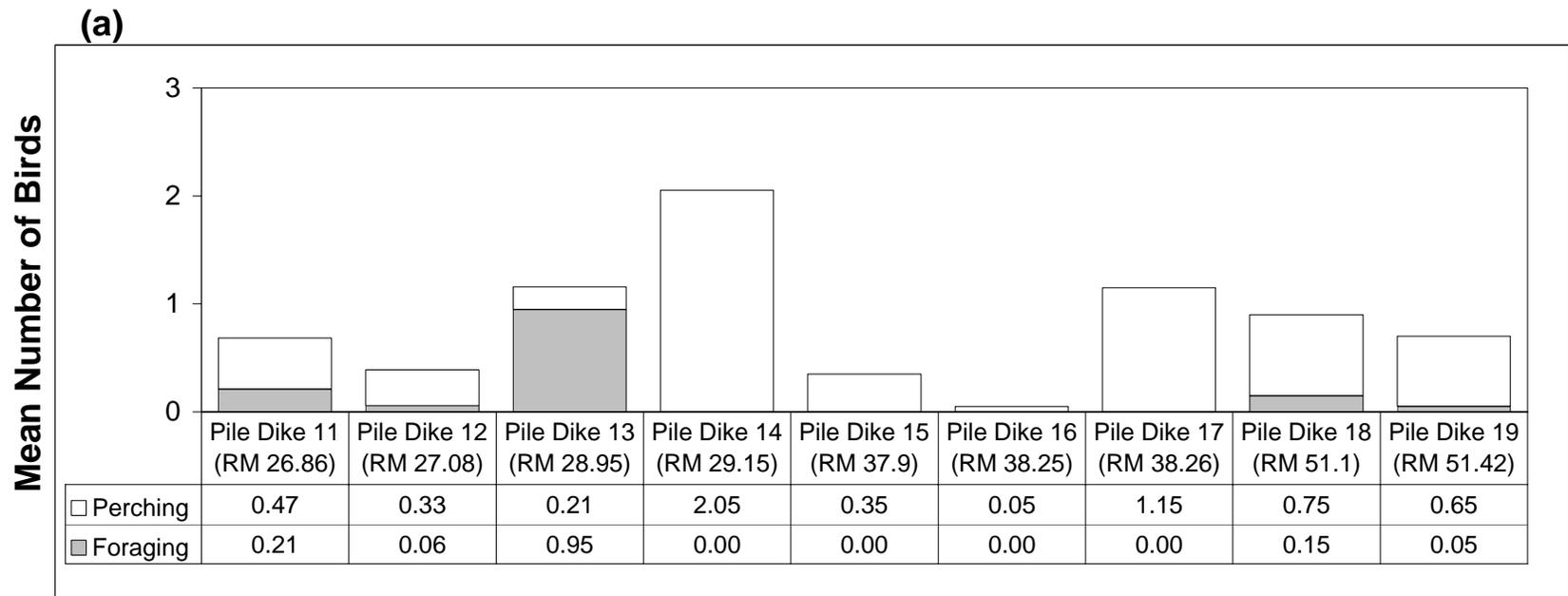
**Figure 2.** Location of pile dikes in the lower Columbia River (near the mouth of the river). The river mile for each pile dikes is shown in parentheses under the dike number.



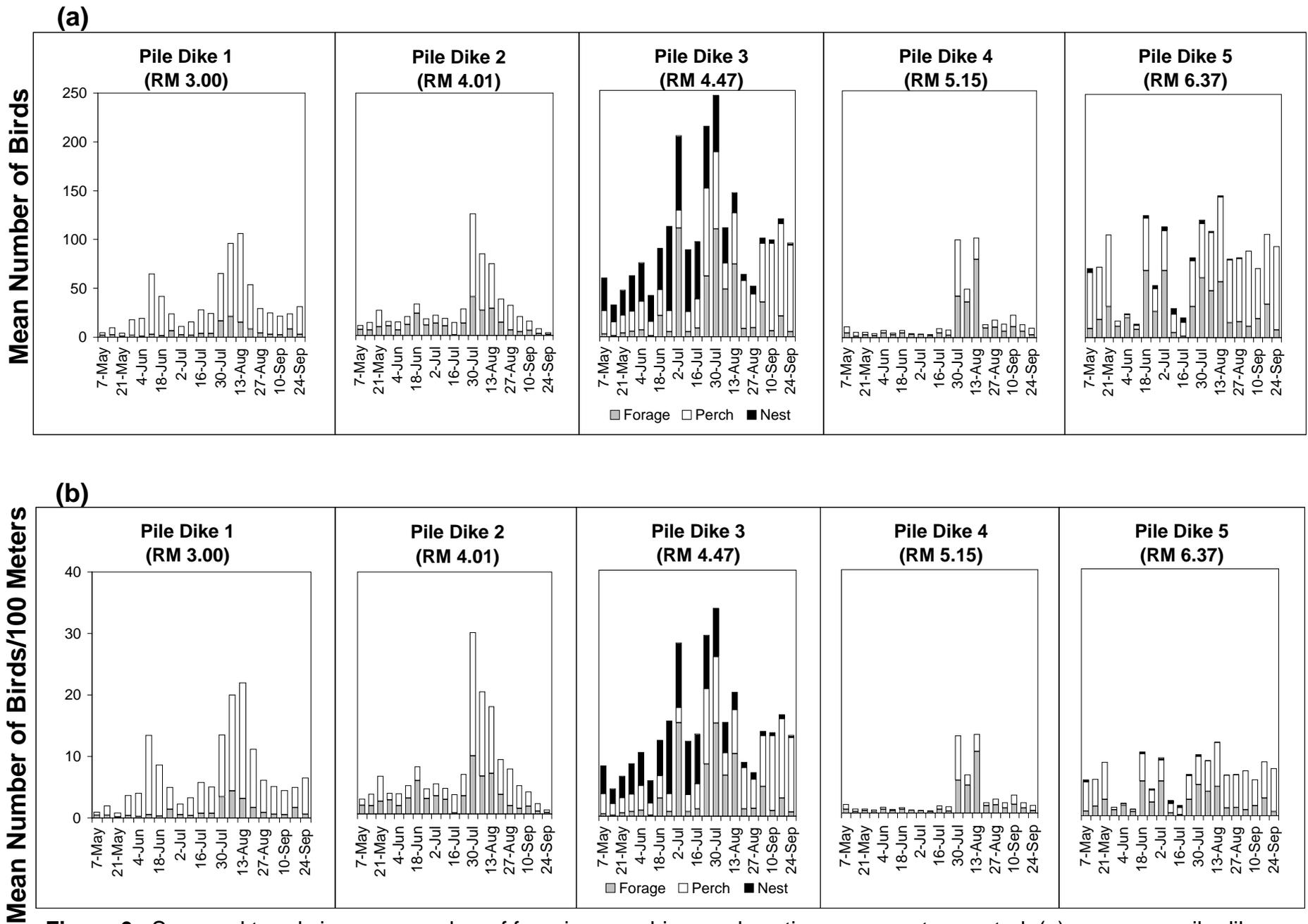
**Figure 3.** Mean number of foraging, perching, and nesting cormorants counted (a) on or near pile dikes and (b) per 100 meters of pile dike in the Columbia River Estuary near East Sand Island, 07 May - 30 September 2001.



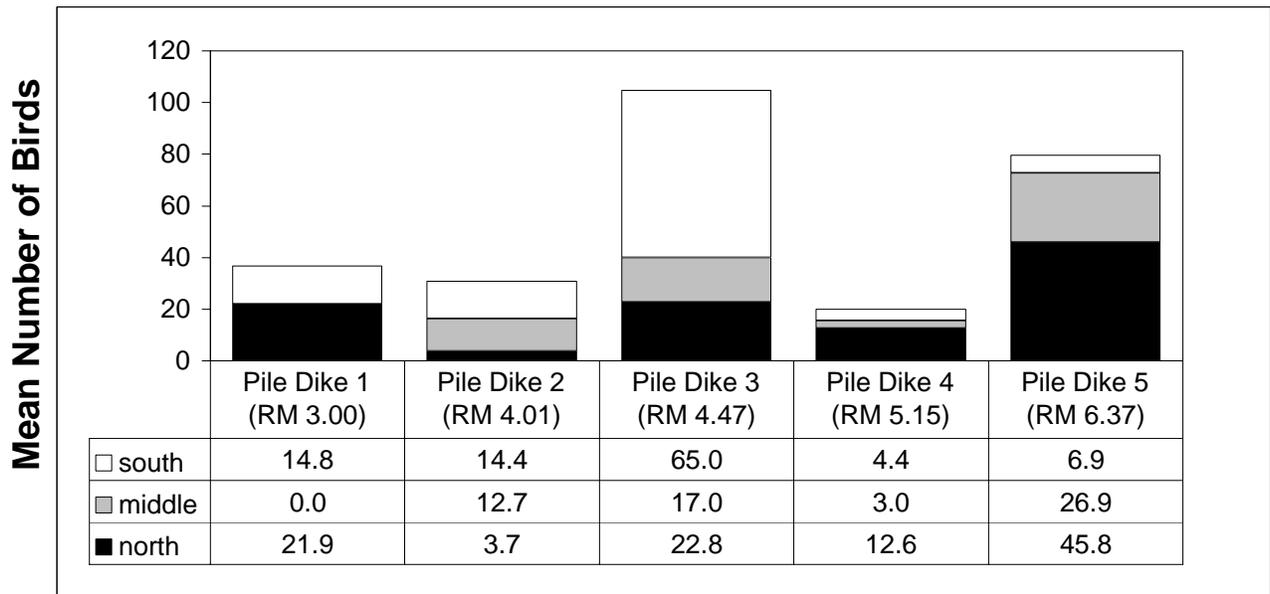
**Figure 4.** Mean number of foraging and perching cormorants counted (a) on or near pile dikes and (b) per 100 meters of pile dike in the Columbia River Estuary near Miller Sands Island, 14 May - 30 September 2001.



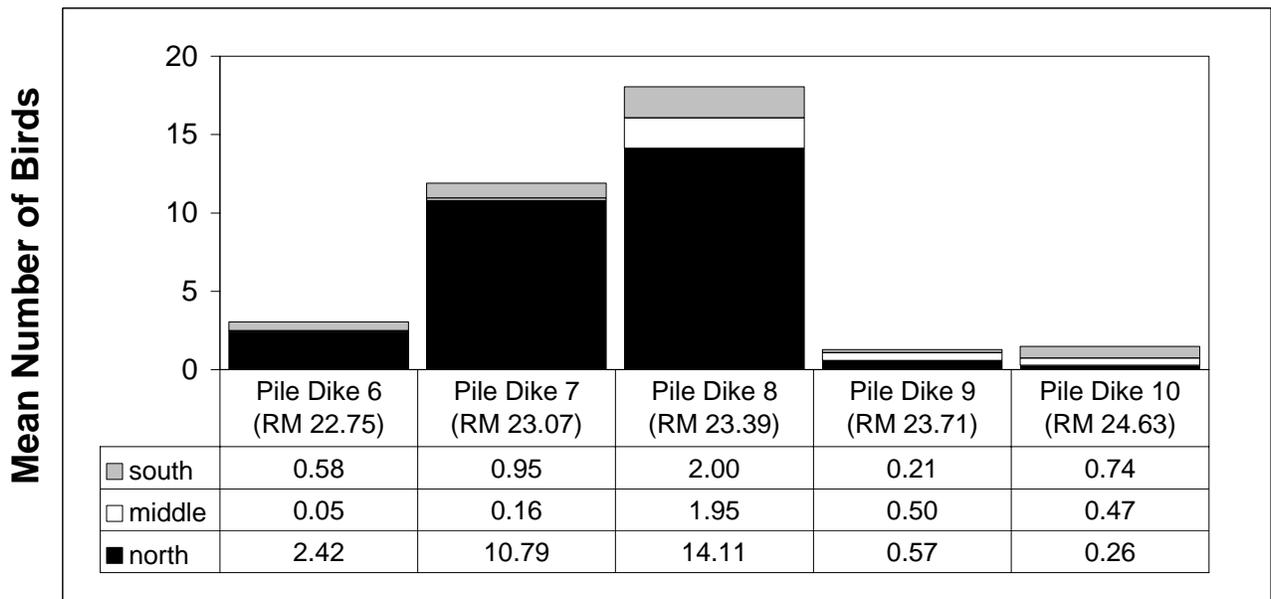
**Figure 5.** Mean number of foraging and perching cormorants counted (a) on or near pile dikes and (b) per 100 meters of pile dike in the Columbia River Estuary above Miller Sands Island, 14 May - 30 September 2001.



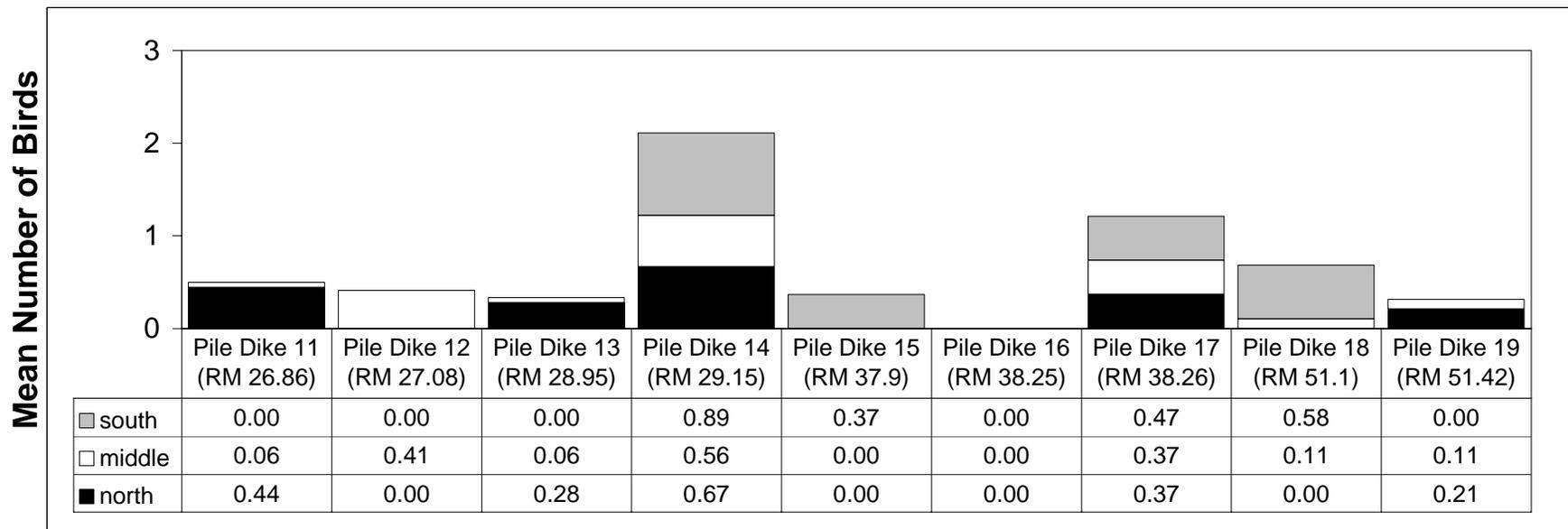
**Figure 6.** Seasonal trends in mean number of foraging, perching, and nesting cormorants counted (a) on or near pile dikes and (b) per 100 meters of pile dike in the Columbia River Estuary near East Sand Island, 07 May - 30 September 2001. Bird excluders were partially installed on pile dikes 4.01, 5.15, and 6.37 during the third week (week beginning 21 May) of the



**Figure 7.** Mean number of cormorants counted on or near pile dikes in the Columbia River Estuary near East Sand Island that were located on the north (nearshore), middle, and south (offshore) portions of the pile dike, 14 May - 30 September 2001. There was no middle portion for Pile Dike 1 (RM 3.00, see Figure 2).



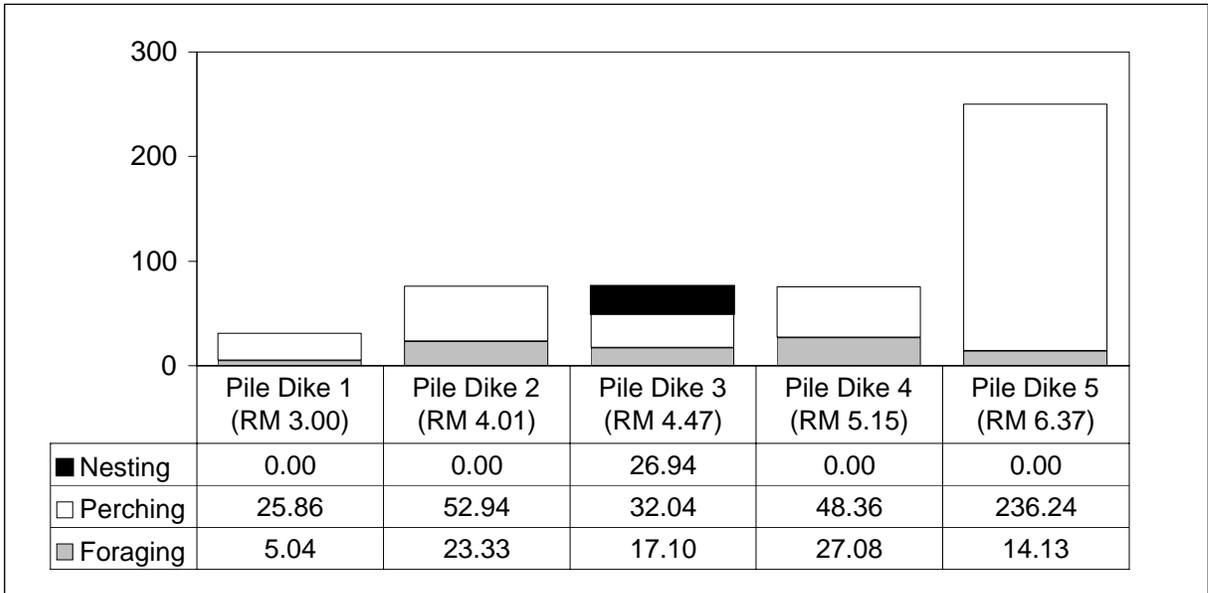
**Figure 8.** Mean number of cormorants counted on or near pile dikes in the Columbia River Estuary near Miller Sands Island that were located on the north, middle, and south portions of the pile dike, 21 May - 30 September 2001.



**Figure 9.** Mean number of cormorants counted on or near pile dikes in the Columbia River Estuary above Miller Sands Island that were located on the north, middle, and south portions of the pile dike, 21 May - 30 September 2001. For pile dikes 15 - 19, the south portion of the pile dike was the closest to land.

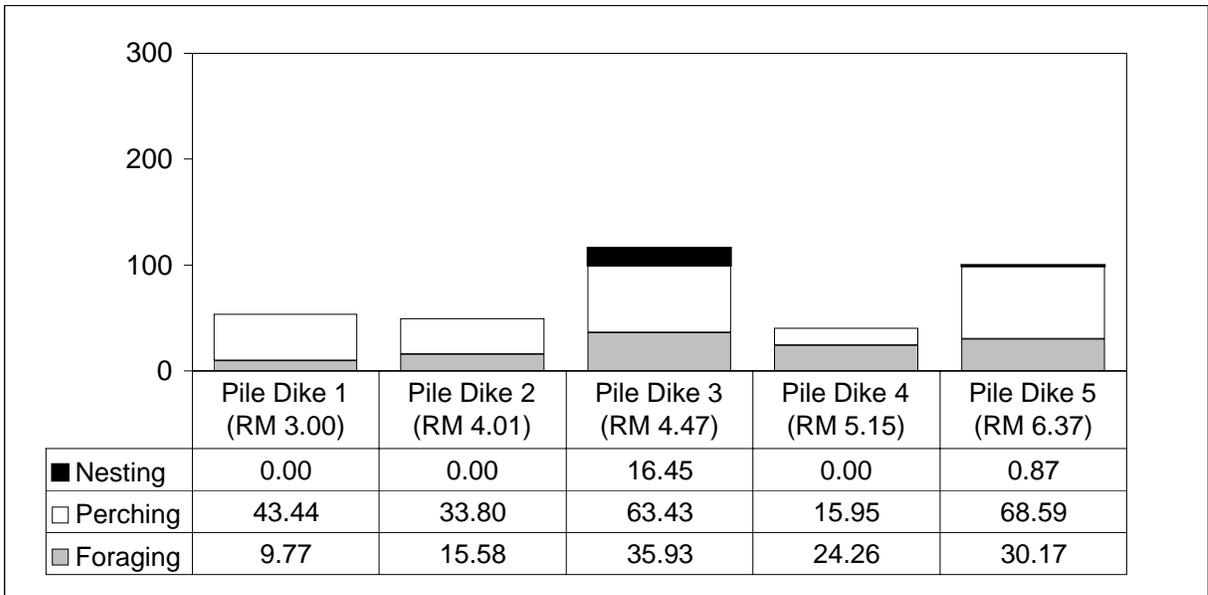
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Mean Number of Birds

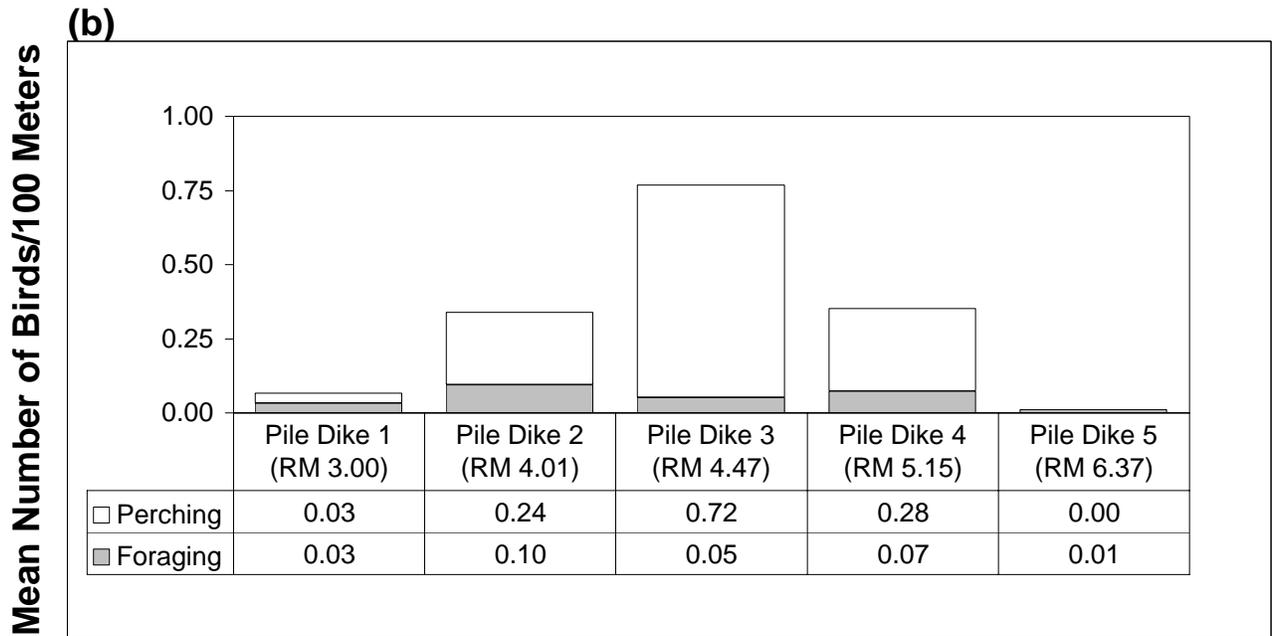
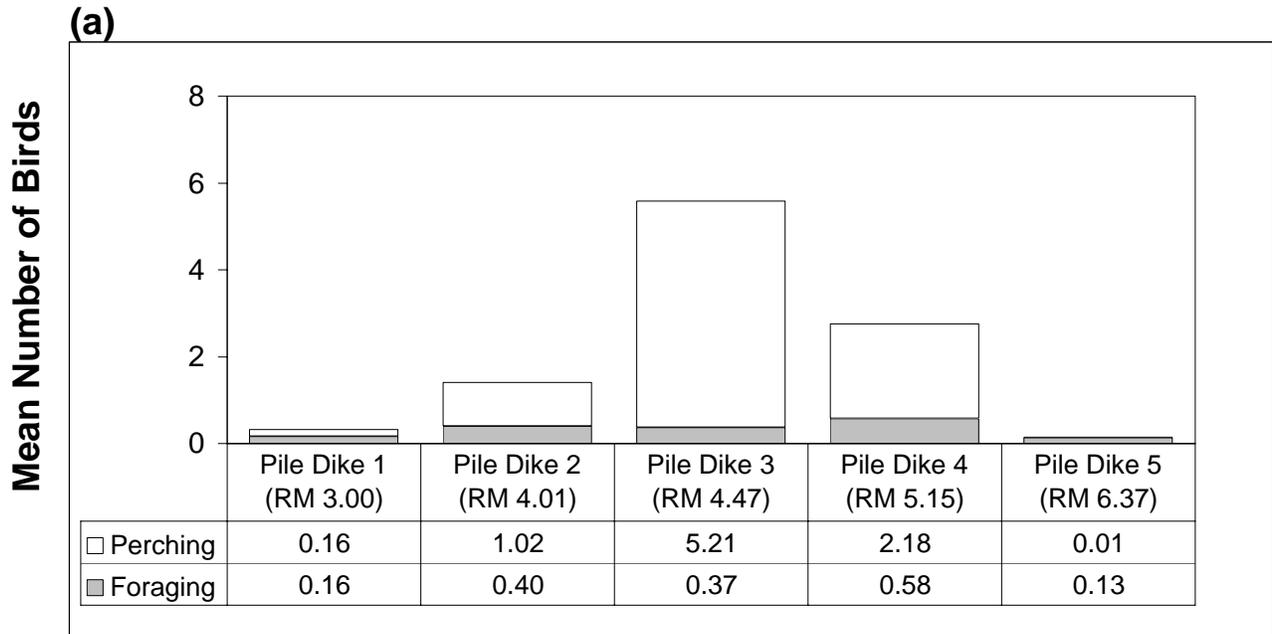


**2001**

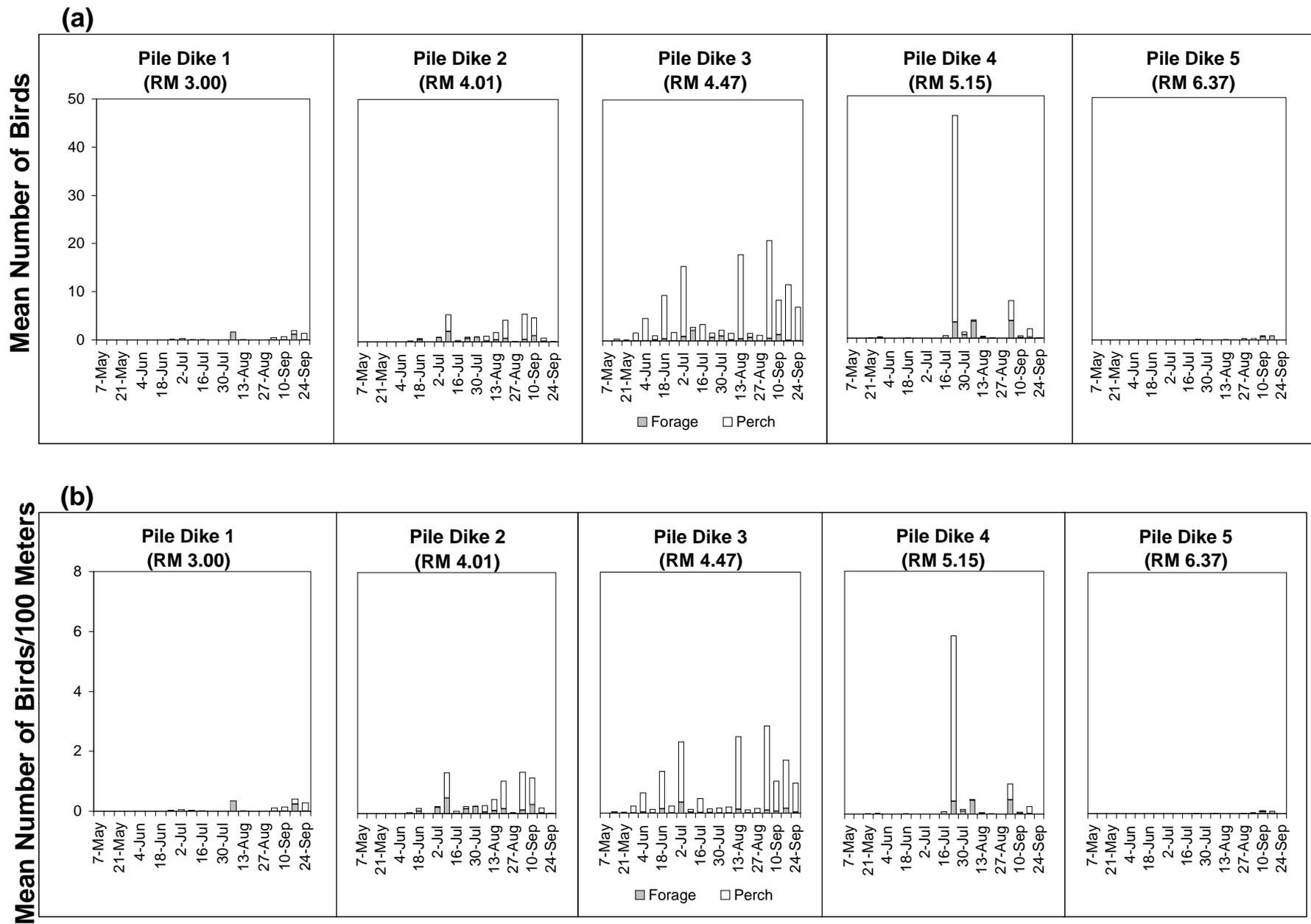
Mean Number of Birds



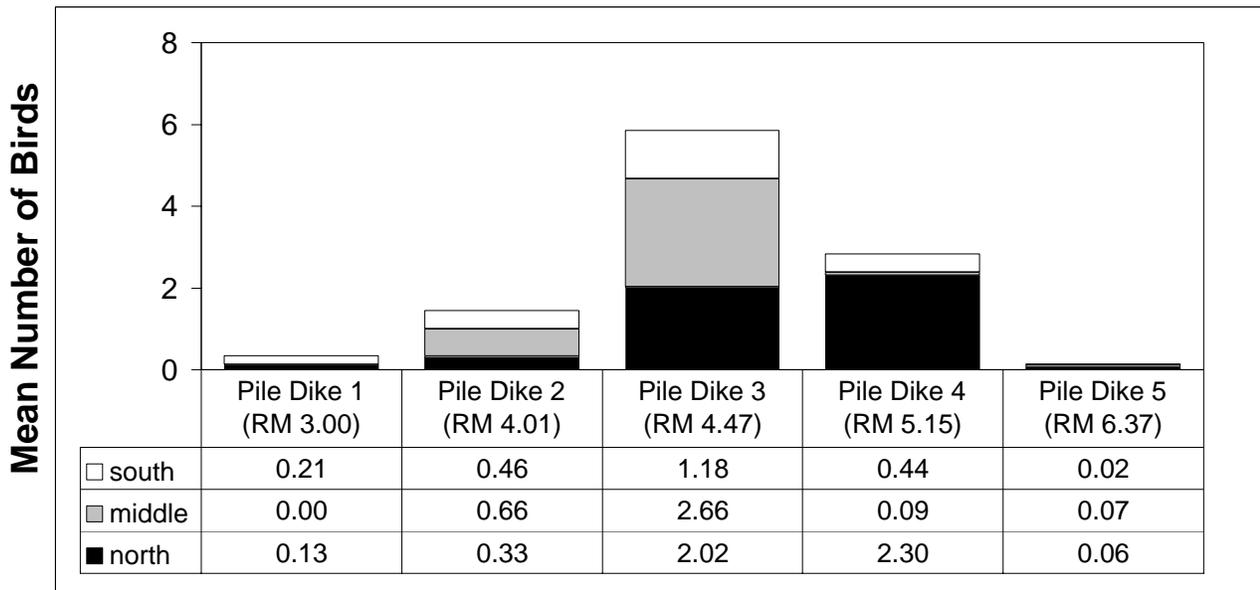
**Figure 10.** Mean number of foraging, perching, and nesting cormorants counted on or near pile dikes in the Columbia River Estuary near East Sand Island, August - September 2000 and 2001.



**Figure 11.** Mean number of foraging and perching brown pelicans counted (a) on or near pile dikes and (b) per 100 meters of pile dike in the Columbia River Estuary near East Sand Island, 07 May - 30 September 2001.

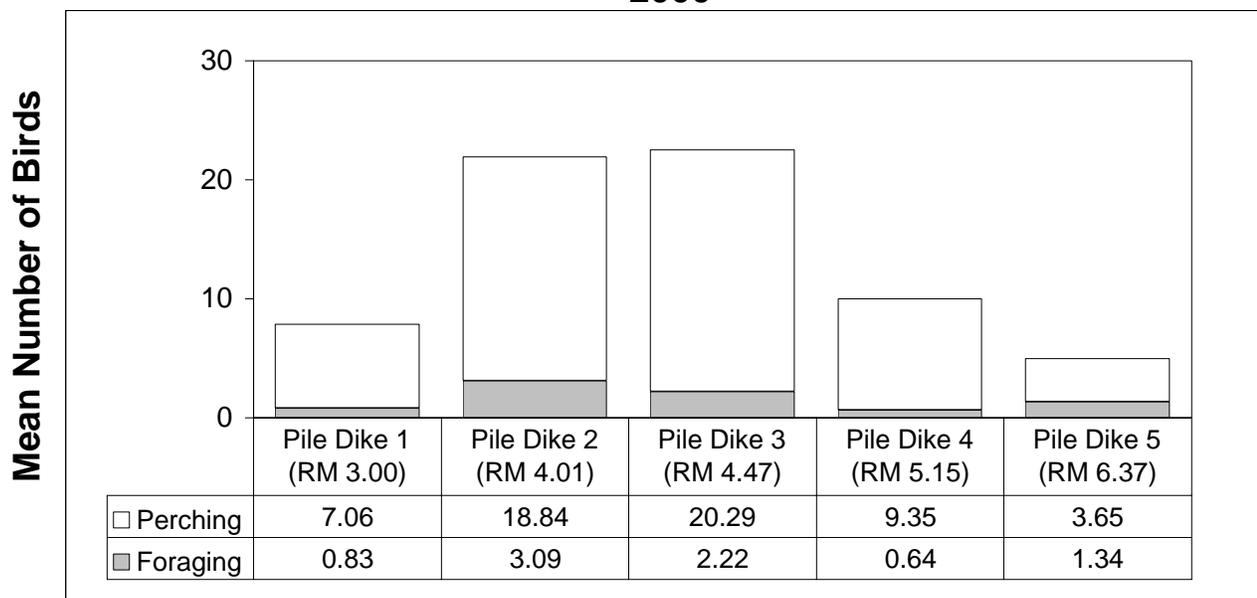


**Figure 12.** Seasonal trends in mean number of foraging and perching brown pelicans counted (a) on or near pile dikes and (b) per 100 meters of pile dike in the Columbia River Estuary near East Sand Island, 07 May - 30 September 2001. Bird excluders were partially installed on pile dikes 4.01, 5.15, and 6.37 during the third week (week beginning 21 May) of the study

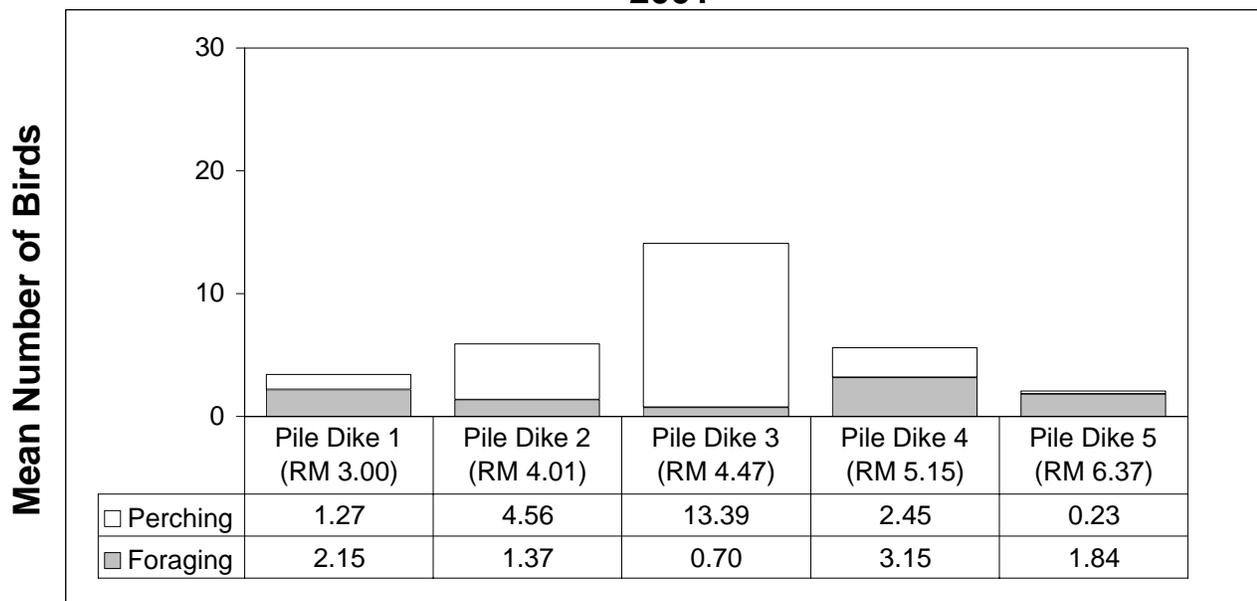


**Figure 13.** Mean number of brown pelicans counted on or near pile dikes in the Columbia River Estuary near East Sand Island that were located on the north (nearshore), middle, and south (offshore) portions of the pile dike, 14 May - 30 September 2001. There was no middle portion for Pile Dike 1 (RM 3.00, see Figure 2).

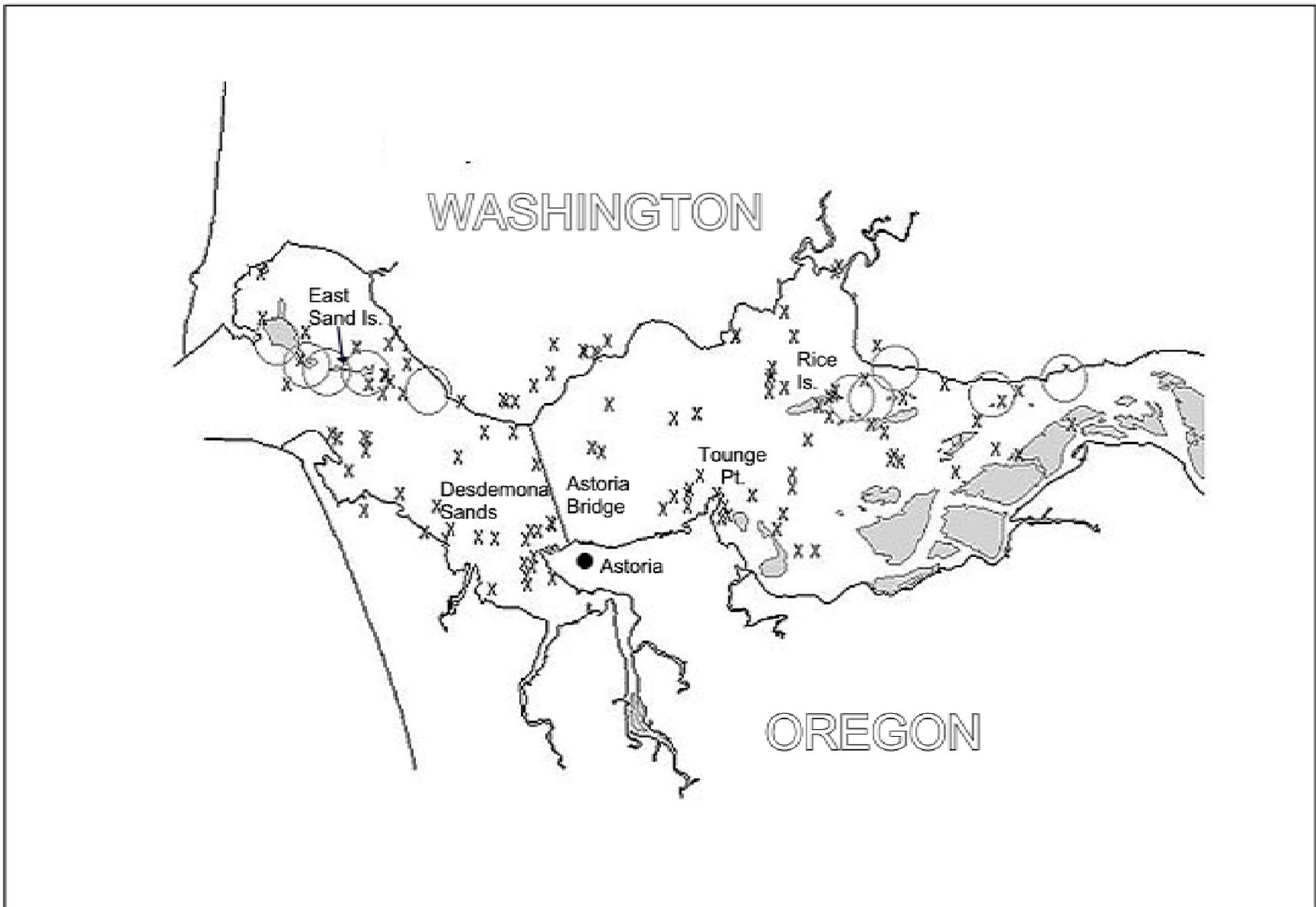
### 2000



### 2001



**Figure 14.** Mean number of foraging and perching brown pelicans counted on or near pile dikes in the Columbia River Estuary near East Sand Island, August - September 2000 and 2001.



**Figure 15.** Off-colony detections of radio-tagged double-crested cormorants in the Columbia River Estuary, May - July 2001. Circles with a one kilometer radius have been drawn at the location of each pile dike within the study area. Four radio tagged cormorants were detected outside the study area in Willapa Bay (Willapa Bay is located on the Washington Coast just north of the Columbia River Estuary.)

## **TABLES**

**Table 1.** Pile dike location and bird excluder installation information for dikes investigated in May – September 2001.

<b>Dike Number</b>	<b>Excluders (Yes/No)</b>	<b>Installation (New/Repair)</b>	<b>Approx. Date Excluders Installed/Repaired</b>	<b>Location of Excluders</b>
1 (RM 3.00)	No			
2 (RM 4.01)	Yes	New	25 – 27 May	1/3 of pile dike (south or offshore end)
3 (RM 4.47)	No			
4 (RM 5.15)	Yes	New	29 – 30 May	4/5 of pile dike (south or offshore end)
5 (RM 6.37)	Yes	New	30 – 31 May	5/6 of pile dike (south or offshore end)
6 (RM 22.75)	Yes	Repair	5 – 6 June	Entire pile dike
7 (RM 23.07)	Yes	Repair	5 – 6 June	Entire pile dike
8 (RM 23.39)	Yes	Repair	5 – 6 June	Entire pile dike
9 (RM 23.71)	Yes	Repair	5 – 6 June	Entire pile dike
10 (RM 24.63)	Yes	New	5 – 6 June	Entire pile dike
11 (RM 26.86)	Yes	New	6 – 7 June	Entire pile dike
12 (RM 27.08)	Yes	New	6 – 7 June	Entire pile dike
13 (RM 28.95)	Yes	Repair	6 – 7 June	Entire pile dike
14 (RM 29.15)	Yes	Repair	6 – 7 June	Entire pile dike
15 (RM 37.90)	Yes	Repair	7 – 8 June	1/3 of pile dike (north or offshore end)
16 (RM 38.25)	Yes	Repair	7 – 8 June	2/3 of pile dike (north or offshore end)
17 (RM 38.26)	Yes	Repair	7 – 8 June	Entire pile dike
18 (RM 51.10)	Yes	New	12 – 13 June	Entire pile dike
19 (RM 51.42)	Yes	New	12 – 13 June	Entire pile dike

**Table 2.** Number of foraging and perching cormorants counted on or near pile dikes in the Columbia River Estuary, 14 May - 30 September 2001. Counts were not conducted for a given week if we determined that boat or dike maintenance activities affected the distribution of birds at the dike (denoted by missing values). Counts in shaded cells were conducted prior to the installation/repair of bird excluders.

Foraging																						
Dike	7-May	14-May	21-May	28-May	4-Jun	11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	27-Aug	3-Sep	10-Sep	17-Sep	24-Sep	Mean
1 (RM 3.00)	2	2	1	2	1	3	2	7	3	2	4	4	17	21	15	8	4	3	2	8	3	5.41
2 (RM 4.01)	6	6	9	10	6	11	23	11	12	10	0	12	40	26	28	13	6	4	5	2	1	11.55
3 (RM 4.47)	3	1	4	5	7	1	21	5	110	5	8	62	109	48	74	8	9	35	6	21	5	25.67
4 (RM 5.15)	4	2	3	2	5	3	5	3	3	2	5	3	42	36	79	9	10	7	11	7	3	11.62
5 (RM 6.37)	9	19	32	12	20	8	69	27	69	9	2	32	61	48	57	15	16	11	19	34	8	28.22
6 (RM 22.75)	-	0	0	0	0	0	1	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0.65
7 (RM 23.07)	-	0	1	0	0	0	0	0	0	3	12	5	6	1	8	3	0	0	0	0	0	1.95
8 (RM 23.39)	-	2	0	0	0	0	6	3	0	10	9	4	7	2	5	1	5	2	0	0	0	2.80
9 (RM 23.71)	-	160			0	0	0	0	0	0	1	0	3	0				0	0	0	0	10.93
10 (RM 24.63)	-	7	0	1	0	0	0	0	0	0	0	0	7	0	0	0	0	1	0	0	0	0.80
11 (RM 26.86)	-	2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0.21
12 (RM 27.08)	-	0	0	1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0.06
13 (RM 28.95)	-	15	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0		0	0	1	0.95
14 (RM 29.15)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
15 (RM 37.90)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
16 (RM 38.25)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
17 (RM 38.26)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
18 (RM 51.10)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0.15
19 (RM 51.42)	-	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
<b>Mean</b>	4.8	13.3	0.1	0.2	0.0	0.2	0.5	0.2	0.0	0.9	1.6	0.6	1.6	0.2	2.1	0.3	0.5	0.4	0.0	0.1	0.1	1.3

Perching																						
Dike	7-May	14-May	21-May	28-May	4-Jun	11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	27-Aug	3-Sep	10-Sep	17-Sep	24-Sep	Mean
1 (RM 3.00)	3	7	3	16	18	62	40	17	8	14	24	21	48	75	91	45	25	22	19	16	28	29.37
2 (RM 4.01)	4	8	17	5	8	9	10	7	8	8	13	15	85	59	46	24	25	16	10	5	2	18.71
3 (RM 4.47)	24	14	18	21	29	14	27	21	18	20	30	89	78	26	52	49	34	60	89	94	88	44.58
4 (RM 5.15)	6	4	3	2	3	2	3	1	0	1	5	5	57	13	22	4	8	7	12	7	7	8.17
5 (RM 6.37)	58	54	74	5	3	4	54	24	41	24	14	47	56	60	87	64	65	77	52	72	86	49.28
6 (RM 22.75)	-	0	0	0	1	0	2	1	2	2	3	2	9	4	15	1	1	0	1	0	1	2.25
7 (RM 23.07)	-	2	26	0	2	2	0	0	23	15	11	19	5	52	11	13	4	2	0	0	0	9.45
8 (RM 23.39)	-	0	48	1	4	11	12	4	1	34	19	11	18	25	47	7	20	16	5	4	2	14.45
9 (RM 23.71)	-	0			1	2	1	1	0	0	2	2	3	1				0	1	0	0	0.93
10 (RM 24.63)	-	1	1	1	1	1	1	1	0	2	1	0	1	0	6	0	1	1	1	0	0	1.00
11 (RM 26.86)	-	2	0	0	0		0	1	1	0	0	1	1	1	0	0	1	0	0	0	1	0.47
12 (RM 27.08)	-	0	0	4	0	0	0	0	0	0	0	0	0			0	0	1	1	0	0	0.33
13 (RM 28.95)	-	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0.21
14 (RM 29.15)	-	1	2	2	5	4	0	1	2	4	1	2	1	3	1	1	1	4	2	2		2.05
15 (RM 37.90)	-	0	0	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	2	1	0.35
16 (RM 38.25)	-	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05
17 (RM 38.26)	-	0	1	1	1	1	1	2	0	1	0	0	0	0	0	5	4	2	0	2	2	1.15
18 (RM 51.10)	-	5	0	1	1	2	0	0	2	0	0	1	0	0	0	0	0	0	1	0	2	0.75
19 (RM 51.42)	-	8	0	1	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0.65
<b>Mean</b>	19.0	1.5	6.0	0.9	1.4	1.9	1.4	0.8	0.6	4.8	2.9	2.1	3.7	3.1	10.1	2.1	3.2	2.2	1.0	0.7	0.7	2.4

**Table 3.** Sample sizes of counts of cormorants and brown pelicans on pile dikes, 07 May - 30 September 2001.

<b>Dike Number</b>	<b>Cormorant</b>	<b>Brown Pelican</b>
1 (RM 3.00)	649	649
2 (RM 4.01)	665	665
3 (RM 4.47)	627	676
4 (RM 5.15)	662	663
5 (RM 6.37)	647	647
6 (RM 22.75)	20	-
7 (RM 23.07)	20	-
8 (RM 23.39)	20	-
9 (RM 23.71)	15	-
10 (RM 24.63)	20	-
11 (RM 26.86)	19	-
12 (RM 27.08)	18	-
13 (RM 28.95)	19	-
14 (RM 29.15)	19	-
15 (RM 37.90)	20	-
16 (RM 38.25)	20	-
17 (RM 38.26)	20	-
18 (RM 51.10)	20	-
19 (RM 51.42)	20	-

Table 4. Mean ( $\pm$  SE) number of foraging and perching (combined) cormorants counted on or near pile dikes in the upper Columbia River estuary near Miller Sands Island (pile dikes 22.75, 23.07, 23.39, and 23.71) and Pillar Rock (pile dikes 26.86 and 27.08) in June and July, 1998 - 2001. In 1998 and 1999, counts were of cormorants in the general area surrounding those dikes; however, a great majority was on or immediately adjacent to the dikes.

	Pile dikes near Miller Sands Is.			Pile dikes near Pillar Rock		
	Excluders (Yes/No)	N	Mean $\pm$ SE	Excluders (Yes/No)	N	Mean $\pm$ SE
1998	No	11	164.1 $\pm$ 34.7	No	11	17.5 $\pm$ 8.6
1999	No	7	86.4 $\pm$ 19.3	No	7	3.7 $\pm$ 1.8
2000	Yes	6	9.5 $\pm$ 6.0	No	6	31.2 $\pm$ 25.9
2001	Yes	8	28.4 $\pm$ 9.9	Yes	8	0.4 $\pm$ 0.2