MARINE BIRDS OF THE NEAR SHORE WATERS OF CLATSOP SPIT: AN ASSESSMENT OF COMPOSITION, ABUNDANCE, AND POTENTIAL EFFECTS FROM DREDGE SPOIL DEPOSITION ADJACENT TO THE SOUTH JETTY OF THE COLUMBIA RIVER.

Prepared for

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May 2005

SUMMARY

Marine bird abundance and composition in the vicinity of South Jetty, Columbia River, OR, are described from 3 data sets encompassing 13 years. The bird assemblage was dominated by Common Murres and Surf Scoters, and included 42 marine species. Species listed under the Endangered Species Act found in the area of interest were Brown Pelican and Marbled Murrelet. Potential impacts from proposed dredge spoil deposition included displacement during dredge operation, loss of benthic prey resources, and turbidity effects. Displacement of marine birds was considered to be a minor impact due to the short duration of operations. Loss of benthic prey may affect a few species, and effects of increased turbidity are not well known, but of short duration. A monitoring program to quantify these potential impacts is proposed.

ACKNOWLEDGEMENTS

I thank Renee Davis-Born and the Institute for Natural Science, Oregon State University, and the Nearshore Working Group for supporting this analysis. Thanks to Mike Patterson (Celata Research Associates, Astoria OR), who provided a large amount of important survey data to this effort, and to Jeanette Zamon and Troy Guy (NOAA Fisheries, Point Adams) who contributed offshore survey data from their work.

INTRODUCTION

Migrating and resident (local nesting) marine birds can be found in great numbers and with high diversity in the vicinity of the Columbia River mouth. Availability of nesting and roosting habitat
on islands, and localized concentrations of prey within the river and in the plume of river waters extending many kilometers seaward contribute to the diversity and abundance of seabirds. This paper focuses on the avifauna found in a local area bounded by the south jetty of the Columbia River at the north end, and extending 20 km south down the coast and 5 to 37 km seaward of the beach. The purpose of this study is to describe the seabird community south of the south jetty, Columbia River (hereafter referred to as South Jetty) and address potential impacts of dredge spoil deposition immediately south of South Jetty on the abundance, composition and habitat use of the avifauna. Also included are recommendations for monitoring marine birds and environmental variables before, during, and after the dredge operations period. With a effective monitoring program, effects of the dredge operations on seabirds can be quantitatively described and it may be possible to minimize any negative impacts.

The near shore area of interest has three habitat features of import to marine birds. 1) The extensive sandy beach south of the jetty and running approximately 25 km south to Tillamook Head is characterized by a depth gradient of less than 1:100 out to shelf waters. This gradient is found north of the Columbia River in southern Washington, but is less than that found along the rest of the Oregon coast. It does not appear to be an important location for foraging seabirds in general, though large feeding flocks are occasionally present in late summer. 2) The South Jetty itself creates a protective buffer from northwest winds that are typically strongest in spring and summer, and it is a barrier to longshore transport of water and sediment. Loons and grebes that are often concentrated in bays and on the leeward side of headlands may use the jetty for the same effect of providing calmer waters on its leeward side. Water brought onshore in the surf zone exits the beach via a permanent rip current that runs along the south side of the inner jetty, and this may provide prey resources to some species. The rocky intertidal habitat created by the jetty structure may provide further feeding opportunity to seabirds foraging on benthic species. 3) The Columbia River plume represents a massive and dynamic habitat feature which often extends to over 50 km seaward. Guy et al. (2005) described concentrated seabird foraging along the northern boundary of the plume in the near shore habitat, but the southern boundary is usually offshore (>5 km) of the waters bounded by the South Jetty. Tidal state, river volume, and the net longshore current movement affect the location of the plume.

Three data sources on bird use of habitats in the study area were accessed (see methods below). In addition, aerial surveys focused on Marbled Murrelets were conducted in 1994 and 1995 by Varoujean and Williams (1996), and a small amount of near shore transect data collected by Washington Dept. of Fish & Wildlife (unpubl.) comprise all the known sources of quantified bird data for the study area. Large scale aerial and shipboard transects have been completed offshore from the area of interest (Briggs et al. 1992, Ainley et al 2005, Zamon and Guy pers. comm.), but the broad scale and offshore location of these efforts would not contribute to our knowledge within the study area.

METHODS

Near Shore Transect Data.

Near shore seabird transects have been carried out in the study area during the summer season from 1992 to1996 and from 2000 to 2004. The purpose of the transects was to monitor Marbled Murrelet population size, but strip transect data were collected for all seabird species. From 1992 to 1996, transects around the South Jetty were conducted at 300 to 500 m (depth range 7.5 – 12 m) from the rocks, and transects down the coast were conducted at 400 to 800 m offshore (depth range 3.0 – 5.5 m). From 2000 to 2004 transects were conducted at 350 to 1500 m offshore (depth range 5.0 – 27 m, 'inshore transects'), and also at 1500 to 5000 m offshore (depth range 30 – 92 m, 'offshore transects', see Fig. 1) using a randomized selection process for exact transect placement (further detail in Miller et. al 2005).

Vessel surveys were made from 6 to7 m boats equipped with a marine radio, compass, Global Positioning System receiver (GPS), and digital sonar depth finder, which also relayed sea surface temperature (SST). Other equipment included binoculars, digital watches, and micro tape recorders for each person, maps covering planned transect lines, and a lazer range finder. The deck of the boat is about level with the waterline; so standing observer viewing height was about 2 m above water.

Two observers and a vessel driver were on board for all transects. Each observer scanned a 90^{o}

arc between the bow and the beam continuously, only using binoculars to confirm identification Search effort was directed primarily towards the bow quarters and within 50 m of the vessel. All seabirds within 50 m of the boat and on the water were recorded, and all Marbled Murrelets, Brown Pelicans, and marine mammals sighted at any distance were recorded.

Data were recorded on cassette tapes and later transcribed to forms and entered on computer. At the beginning and end of each 5 km transect segment the time, location, water temperature and depth, weather and observing conditions were recorded. Observing conditions as they related to bird detectibility were rated excellent, very good, good, fair, and poor corresponding approximately with beaufort sea states of 0 to 4, respectively.

The vessel driver maintained a speed of 10 knots, monitored the transect route, and watched for navigational hazards. Transects were paused sometimes to rest, make observations, or for equipment reasons, and resumed at the same approximate location where they left off. A break from duties was taken at least every 3 hours. This protocol has been used consistently for all surveys. Further detail on methods can be found in Strong (2003).

Offshore Surveys

Surveys conducted by NOAA fisheries personnel Jeanette Zamon and Troy Guy in the summers of 2003 and 2004 provide information on the avifauna offshore from the south jetty, Columbia River. Each year, two transect lines were run perpendicular to shore from 36.7 to 3.7 km off Clatsop Spit, ending about 4 km south of the South Jetty (Fig. 1). A single observer identified and counted all species detected within 300 m of the vessel on one 90^0 quadrat and summed for each of 4 transects (May and June of 2003 and 2004). A second person logged all sightings into a computer concurrently. Observer height on the 127 ft. vessel was about 7 m above water, and vessel speed was maintained at 9 knots.

Shore-based Surveys

From 1997 to 2001, Mike Patterson (Celata Research Assoc.) conducted avifaunal surveys from the south jetty Columbia River. Time-delimited counts (between 25 and 75 minutes) of all visible birds were carried out with a 20-60X spotting scope and binoculars between March and November at weekly or less frequent intervals, for a total of 73 censuses. With an approximate 1.8 km survey range, censuses overlapped near-shore vessel transect routes and the area of proposed dredge spoil deposition (Fig. 1). Data were edited to separate flying birds from those on the water, and only included counts at sea south of South Jetty. Counts over all years were averaged by month and by season.

Because the shore based surveys and near-shore transects occurred over 5 and 9 seasons, respectively, I considered that year effects could be minimized by using the average over all years for each month or season.

RESULTS AND DISCUSSION

Seabird Count Data

A total of 42 marine bird species were recorded among the 3 data sets. This assemblage was dominated by Common Murre, Surf Scoter, Pacific Loon, and Brandt=s Cormorant (Table 1, Fig. 2). White-winged Scoter, Brown Pelican, Western Grebe, and Red-throated Loon were also important among birds on the water. When flying birds are included, Sooty Shearwater dominated, followed by Common Murre, Pacific Loon, Caspian Tern, gulls, Brandt=s Cormorant, and Brown Pelican (data in Table 2). Flying birds were either in transit (ie; not using the area) or, in the case of some pelicans, terns, and gulls, searching for feeding opportunities. Flying birds necessarily rank of lower importance in terms of area use and potential impacts of activities in the study area.

In all 3 data sets, Common Murres were numerically dominant and occurred with high frequency (Tables 1, 2, 3). There was a strong seasonal cline in murre numbers, however. The spring season is considered to be February-April; summer, May-August; and fall September-November. Murres were virtually absent in spring, highest during summer and at moderate abundance in the fall (Table 2, Fig. 3). Murres can occur in large and mixed species flocks, but more typically are dispersed over shelf waters. Though murres occur out to near the shelf break, in Oregon they are concentrated within 10 km of shore (Ainley et al. 2005, Strong unpubl. data). From mid July through September, parent/fledgling pairs concentrate within 5 km of shore, where both father and young are flightless for some weeks when the adult is undergoing complete wing molt and the young is still growing flight feathers. The flightless period of murre father/fledgling pairs overlaps entirely with the proposed timing of dredge operations (see following sections for potential impacts). Murres forage primarily on mid water schooling fish, though euphausiid krill are an important prey in winter. Flying common murres were extremely abundant in the El Nino seasons of 1993, 1997, and 1998, when frequent, large flocks were seen moving north, presumably in search of more favorable foraging areas.

Surf Scoters, the second most abundant species, were much more evident in the shore-based surveys. Scoters were consistently present throughout the seasons. Large concentrated flocks (120-600 birds) of Surf Scoters or mixed Surf and White-winged Scoters occur on the water within 1 km of shore, but flock locations are sporadic along the coast. No such flocks were recorded in the near-shore transect data, but they were from shore adjacent to South Jetty (Fig 3). The relative frequency of scoters in the shore-based surveys suggests an association of these birds with habitat created by the jetty itself. Scoters are largely benthic foragers, preying on both invertebrates and fish.

Pacific Loons occurred in high numbers during their spring migration north, and were present throughout the year at low numbers near-shore (Fig. 3). Western Gulls are ubiquitous throughout the year, and in fall and winter are mixed with Glaucous-winged, California, and Ring-billed Gulls, among others. Sooty Shearwaters were consistently present in the offshore transects, and were by far the most abundant seabird when flying birds were included (Table 2).

This was due to huge flocks that occurred in late summer and fall; they were absent or occasional in spring and early summer. Brandt=s Cormorants are local breeders, and like the Common Murres, numbers peaked in summer, but at much lower numbers (Fig. 3).

Brown Pelicans migrate north to the area from May through August. Numbers peak between August and October, when about 10,000 birds have been present in the Columbia River in recent years (D. Jaques unpubl. data). Tens to hundreds of pelicans are present daily in the study area between July and October, but most of these birds are flying in transit to foraging areas farther south down the coast, and only a few were present on the water in the study area (Fig. 3). Near-shore transects have exaggerated counts since flying and distant pelicans (and murrelets) were reported in the near-shore transect data.

Marbled Murrelets are quite scarce in the region, however, they occurred around the South Jetty (both north and south sides within 500 m of the structure, at depths of 6 to 20 m) with a higher consistency and density than adjacent near-shore waters down the coast (Table 3). Because this species is small and dark, it was probably under-represented in the shore count data. Conversely, because it was the primary study species in the near-shore transects, and all detections were reported (flying and at over 50 m from the vessel) it was over-represented in those data. Like other alcids, Marbled Murrelets are pursuit divers, and some evidence suggests they forage near or at the bottom. Evidence includes Sandlance (*Ammodytes hexapterus*) prey, solitary or paired foraging groups, and a distribution concentrated in waters less than 25 m deep. Murrelets were never found in mixed foraging groups.

Species that favored the habitat near the South Jetty relative to waters south down Clatsop Spit included Pelagic Cormorants, Pigeon Guillemots, and Marbled Murrelets (Table 3). Guillemots and Pelagic Cormorants are known to forage in rocky, benthic habitats (such as provided by the rip-rap of the jetty), and additionally jetty rip-rap may provide some crevice nesting habitat for the guillemots, though nesting has not been confirmed there (USFWS in prep.). It is unknown what factors concentrate Marbled Murrelets near South Jetty, but their density close to the jetty was about 3 times higher than that along the beach of Clatsop Spit (Table 3).

In spite of the seemingly high seabird numbers in our area of interest, comparison of the South Jetty and north Clatsop spit seabird densities with other coastal areas of Oregon indicate that it is not an important location for seabirds in terms of overall density. Mean density of alcid species for the entire northern Oregon coast were 81.8, 18.0, 8.9, and 1.0 birds per square km for Common Murre, Pigeon Guillemot, Marbled Murrelet, and Rhinoceros Auklet, respectively (from Strong and Carten 2000). Except for the Rhinoceros Auklet, these values are much higher than found for this study area specifically (Table 3). Though data are not yet summarized for other seabirds, this was true of virtually all species groups[1]. Qualitatively, this was apparent during our surveys; and the Clatsop Spit area came to be known as >the desert= of coastal seabird abundance.
No information exists that may explain low seabird numbers along Clatsop Spit, but several

1 Data for other species is scheduled for analysis and will be available in 2006.

speculative assessments can be made. The low gradient and monotonous bathymetry along the spit may not allow any mechanism for concentrating prey species. If better foraging conditions in adjacent waters of the Columbia River, along the river plume, and off Tillamook Head exist, them seabirds may simply be selecting these accessible, adjacent habitats. Finally, the low gradient combined with the Columbia River outflow may limit or displace the local upwelling current pattern which provides for high primary productivity elsewhere in the California Current system.

In spite of relatively low densities, shore based surveys of M. Patterson indicate a high diversity immediately adjacent to the seaward (south side) of the South Jetty (Table 2), as may be expected in this habitat transition zone. In addition to seabirds, raptors which prey on seabirds (Peregrine Falcon) or surface fish prey (Bald Eagle, Osprey) were also noted near the South Jetty by Patterson (Unpublished data and Table 2).

A summary of seasonality and foraging characteristics of the more common and important species described above is included in Table 4.

Bias and Differences Between Data Sets

Each of the data sets has a different bias in the abundance and diversity reported. Shore observations were made for a long period (usually 60 minutes) a one point, and the observer was keen to note new or unusual species. Thus the diversity in this data set was far higher than the at-sea transects (45 species vs, 23 in the near-shore transects). With an unlimited range and looking out over the surf, the shore based observer was more likely to report large and flying birds, and the smaller species were more often missed.

Abundance and composition was at its most precise and accurate within the narrow survey strip of the near-shore transects, but flying birds and rare species were generally not reported. Flying birds were not included because 1) they were not considered to be actively using the habitat (except terns and pelicans, which were included), and 2) methodology was focused on detecting all Marbled Murrelets, and we didn=t want to excessively >dilute= the murrelet search effort by identifying and enumerating all flying birds. An exception to this is that Marbled Murrelets and Brown Pelicans were reported when flying and at distances beyond the 50 m wide strip, so these species are over-represented relative to other birds. Surf scoters, Pacific Loons, and some Brandt=s Cormorants could have some negative bias in the near-shore transects since these species sometimes flush from approaching boats at great distances. Double-crested Cormorant numbers were biased high due to a single survey where an unusual flock of 240 of these birds were foraging at sea (Double-crests more often inhabit estuaries and inland water habitat).

The offshore transects included birds on the water as well as flying, and so are not easily compared with near-shore transects, particularly for the Sooty Shearwater, the Caspian Tern, and gulls. The 300 m wide strip search used in the offshore surveys also likely underestimated small species that are not easily detected at over 120 m (Strong 1996).

Effects of Dredge Spoil Dumping.

Factors of the proposed dredge spoil deposition that can affect seabirds include
1) Displacement by the dredge vessel during operations.
2) increase in water turbidity with effects on foraging success.
3) smothering or displacement of benthic prey.

These potential impacts are addressed separately below

1) *Displacement During Operations.*
During the period in which the dredge is operating (1 - 2 days for the demonstration project), seabirds will have some lost foraging opportunity close to the vessel due to displacement, and a moderate expenditure of energy in evading the dredge vessel. For most species, this would not be anticipated to have any significant impact. Shearwaters, gulls, terns, pelicans, and phalaropes are largely aerial foragers and so the energy spent in relocating would be negligible in the context of their usual activities. Common Murres are fairly tolerant of close vessel approaches, and only those in the path of the dredge and within 50 m would be expected to move. Flightless parent/fledgling murre pairs avoid vessels by swimming at the surface or diving, and are capable of easily evading slow-moving vessels (< 6 kts). Loons, scoters, Brandt's Cormorants, and Marbled Murrelets show higher sensitivity to vessel approaches, and, if any were present, would either be displaced from the area of operations throughout the active deposition period, or would be repeatedly flushed, with some minor increase in their energy expenditure. In the context of commercial and sport vessel activity in the study area and throughout the near-shore coastal region, the direct effect of dredge vessel presence is considered to be a minor impact on all species.

2) *Increase in Turbidity*
Conclusions are mixed among the few studies that have examined turbidity effects on seabird foraging. Haney and Stone (1988) found aerial plunge divers were more common in turbid waters, counter to the hypothesis advanced by Ainley (1977) which considered that water clarity would be an advantage to this guild. However, Haney and Stone did not address water depth, distance from shore, or prey densities in their study. Turbidity, water depth, and distance from shore were highly correlated in their study area along the Atlantic seaboard, and prey abundance is typically higher in the near-shore habitats, so the direct relation between seabirds and water clarity was not available. Ainleys (1977) analysis was based on large scale latitudinal gradients in the distribution of plunge versus pursuit diving seabirds, and his conclusions are not likely to pertain to the microscale turbidity gradient caused by dredge sediment deposition.

Among pursuit divers, such as murres, higher turbidity may confer an advantage in that fish are not alerted to the presence of predators (Eriksson 1985). This would be a density dependent factor, requiring the prey to be relatively abundant so that the birds would have a high likelihood of encountering prey in turbid waters. The same "concealing" effect is likely true of plunge divers. Brown Pelicans, for example, often forage in estuaries and very close to the surf zone, where tidal mixing and waves render the water turbid relative to farther offshore. Terns and cormorants (both Brandt=s and Double-crested) have also been seen foraging successfully in very turbid waters, though there are no data to compare their foraging success or selection of turbid waters relative to clear. Through the process of monitoring seabirds during the proposed sediment deposition project, there may by a rare opportunity to quantify direct impacts of water turbidity on foraging among the guilds of seabirds.

The gradient between disturbed, turbid waters where dredge dumping occurs and adjacent waters may itself have an effect. It is well known that seabirds and their prey concentrate along marine fronts between water types, including river plumes, convergence (downwelling) and divergence (upwelling) zones, and in tidal and wind-driven currents (Hoefer 2000, Zamon and Guy 2005). An abrupt turbidity gradient may initially attract birds to this visual cue even if there is no concentration of prey. If schooling prey species avoid a sediment plume created by spoil deposition (Pearcy, 2005), then an actual increase in prey availability to seabirds may occur, with commensurate impacts on the local fish numbers.

Loss or Displacement of Benthic and Infaunal prey.
Even in a limited demonstration project, dumping of approximately 30,000 cy of material will likely smother many infaunal species and will eliminate food resources and displace most mobile benthic species (eg; crabs, flatfish, sharks, sandlance, etc). Physical effects of extreme turbidity during deposition may clog gills and cause disorientation among the mobile species. For the most part, seabirds will be affected by loss of foraging opportunity where benthic prey is eliminated. This may be particularly true of benthic foragers including scoters, Pelagic Cormorants, Pigeon Guillemots, Marbled Murrelets, and possibly loons. Other species may experience a temporary boost in prey availability if prey species are disoriented or lose visual cues of predator approach (see turbidity above). Depending on the amount of deposition, the loss of infaunal biomass as a prey resource would have a much longer recovery period (months to several years) than turbidity effects (hours to weeks) of the deposition. In the context of the expanse of sandy benthic habitat in the littoral cell of northern Oregon and southern Washington, the loss of infauna in the subject area is very small (Braun 2005).

MONITORING EFFECTS OF DREDGE OPERATIONS ON SEABIRDS

A series of surveys of marine bird composition and abundance before, during, and after dredge spoil deposition are suggested as an effective means of assessing impacts of this activity. Three replicate at-sea transects during each phase of the operation (before, during, and after) are recommended as a minimum necessary to provide a quantitative comparison between treatments. There is no equivalent control area with which to compare the project area, since the South Jetty habitat differs from the open coast farther south down Clatsop Spit. Surveys conducted immediately prior to deposition, and, to some extent, south of the deposition area, will serve as controls. Shore-based surveys, which are less expensive and logistically simpler than marine transects, are recommended to corroborate transect results and assess immediate effects during deposition.

At-sea transects will follow the same basic protocol as the near-shore transects described above, but with a fixed strip width of 150 to 200 m (75 to 100 m on either side of the vessel). The larger strip width is advised since our interest will include all species (rather than just the small murrelets) and a larger strip will provide a greater representation of the avifauna. The 300 m strip as used in the offshore surveys of Zamon and Guy (2004) results in loss of precision due to scanning such a large area, and a tendency to miss small species at the surface.

Two Transect lines are proposed parallel with the south jetty and down the coast to 10 km south of south jetty. A near-shore line (ca 800 m out, at a depth of 7-8 m) and an offshore line (approximately 2 km out, at a depth of 20 – 25 m) will overlap the deposition area and should provide an accurate representation of the near-shore avifauna (fig. 4). This route can be completed in a half day using a small vessel. One transect line would be conducted going out from port, and the other on the return trip, with a random selection of which is first. Transect routes would be loaded into a GPS memory and logged into GIS software so that they can be repeated. Data categories collected on the lines are to include.
A) Weather and observing conditions (transects will only be conducted in good conditions at Beaufort sea states of 3 or less).
B) Sea surface temperature, water clarity (secchi disk depth), depth, and tidal state.
C) Species and number of all seabirds. Seabird detections will be limited to the strip width although unusual records, flocks, or concentrations beyond the strip will also be noted.
D) Behavior of marine birds in context of how the habitat is being used: Flying by in transit, forage flying, rafting at the water surface, or forage diving. Transects will be paused where large or multi-species foraging flocks occur so that composition and behavior can be accurately recorded, and to measure water clarity.
E) All marine mammals recorded at any distance with an estimate of their perpendicular distance from the transect line.

Because sechhi disk readings require stopping, it is suggested that these readings be made every 2 km or where water characteristics show a sudden visible change at the surface (unless a continuous recording transmissometer is available). These secchi stations will be located by GPS, and other environmental parameters will be updated concurrently (weather, SST, depth). By maintaining fixed secchi stations, the transect segments between stations may be used as strata if the transects are to be subdivided for statistical analysis. Moored instruments which log water characteristics (turbitidy, sediment load, SST, ChlA, etc.) and which are integrated with other monitoring efforts for the deposition would also contribute to assessment of impacts on seabirds.

This sampling program is designed for seabirds and marine mammals, but it can be modified to complement, incorporate, or provide vessel support to other components of monitoring the depositions effects. In particular, it may be important to locate transect lines more precisely relative to the deposition area, or to use randomized transect lines bounded by the area of interest.

Shore-based surveys are recommended as a means of efficiently tracking immediate effects of the dredge activity, and for comparison with marine transects for longer temporal effects (ie, days to weeks). Time delimited shore based surveys using the methods of M. Patterson (Celata Res. Assoc, unpubl. notes) should be conducted 2 or 3 times prior to the deposition. During the dredge deposition, a continuous watch is recommended through the days, with periodic time delimited counts of all species and their behavior. A 30 minute time delimiter should be adequate for the marine area south of south jetty (Patterson typically surveyed for 60 min., but his effort included species on shore and north of the jetty).

Results of this monitoring program should allow a quantitative determination of effects using ANOVA on before, during and after treatments. It is expected that different foraging guilds or species groups will have different responses, so there will be multiple analyses.

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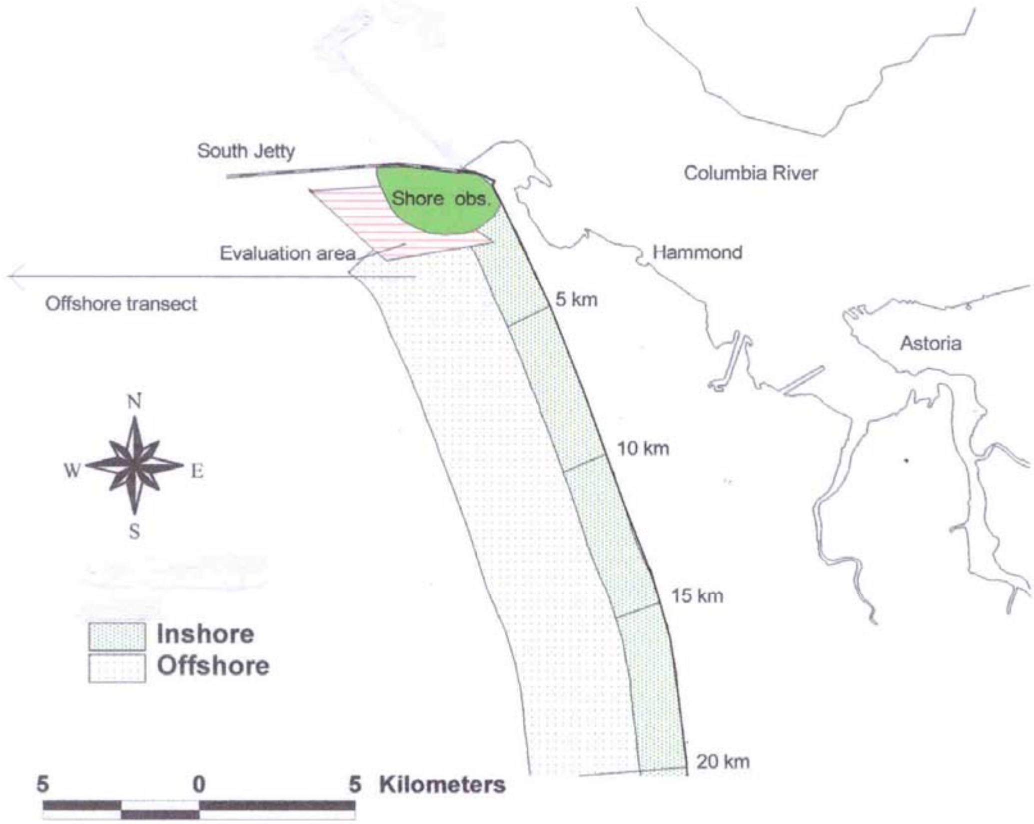

Figure 1. Clatsop Spit and the south jetty Columbia River showing areas of prior survey coverage from which data were used to assess seabirds in the study area. 'Evaluation area' is an approximation of the dredge spoil deposition area, Inshore and Offshore refer to divisions in the near shore survey effort (note that Inshore surveys extended around the jetty beyond that indicated in this figure).

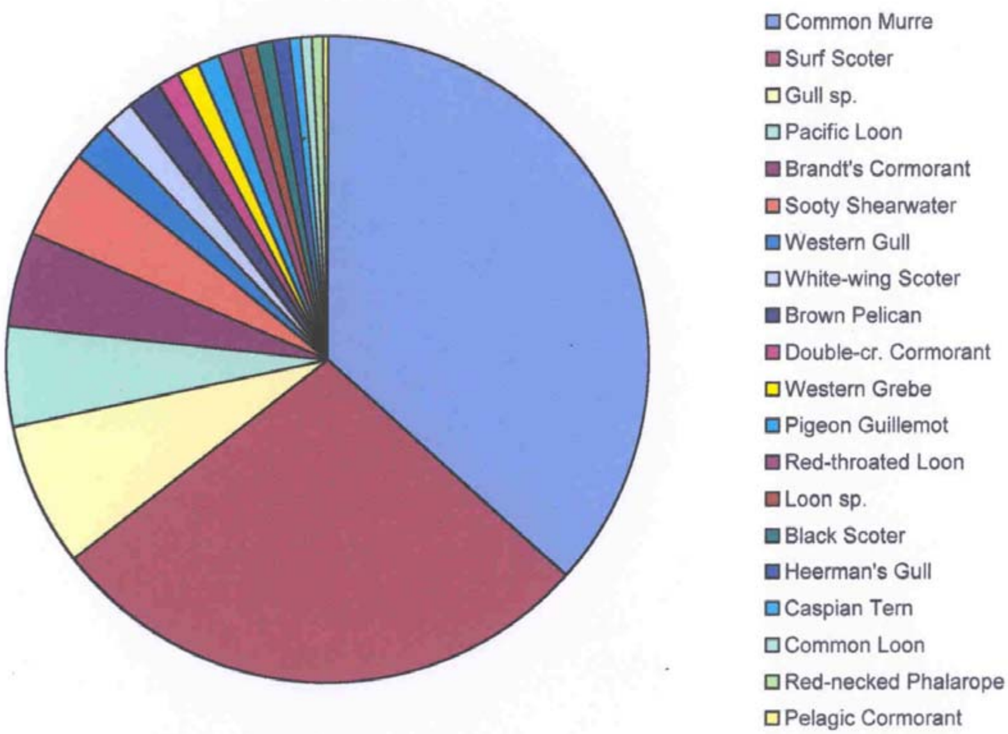

Figure 2. Relative abundance of the 20 most common seabirds in the vicinity of the south jetty, Columbia River, based on the mean summer abundance from combined data sources (Offshore transects, near shore transects, and shore-based surveys).

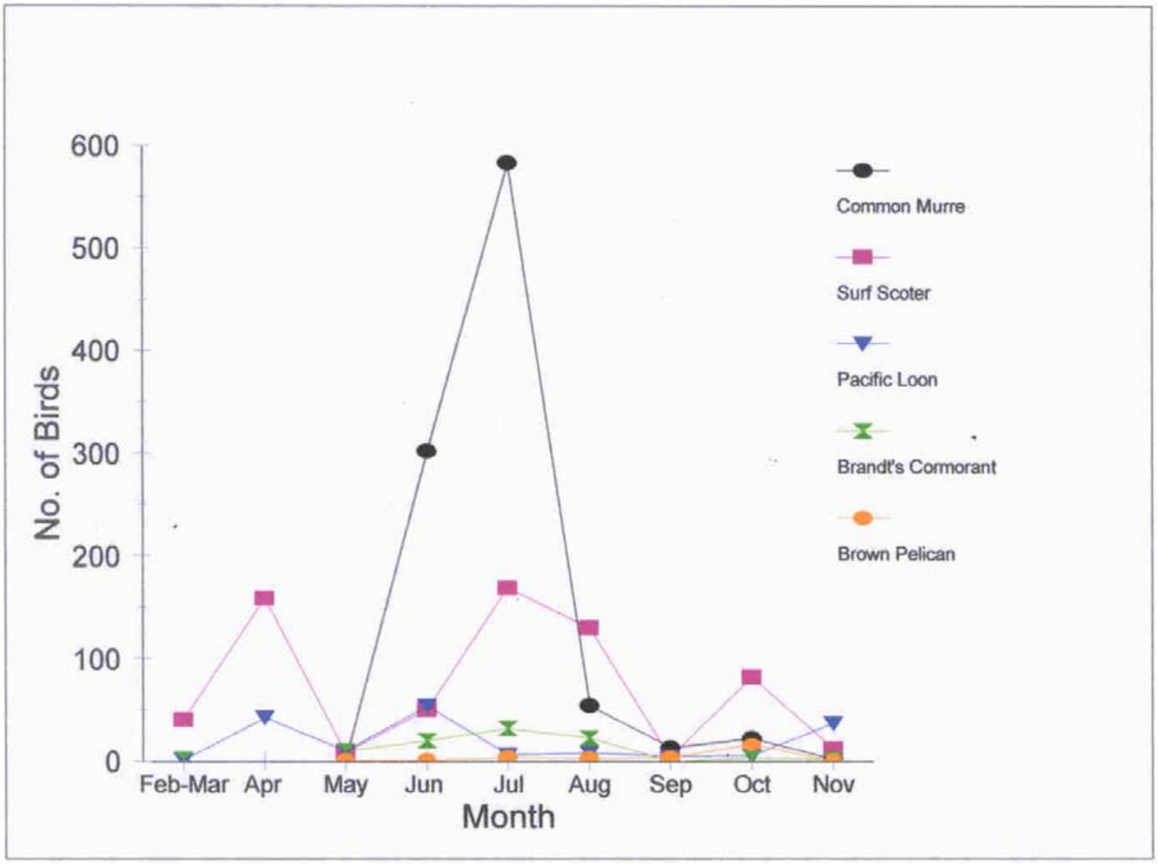

Figure 3. Seasonal abundance of selected seabirds at the south jetty Columbia River based on monthly averages of shore-based surveys.

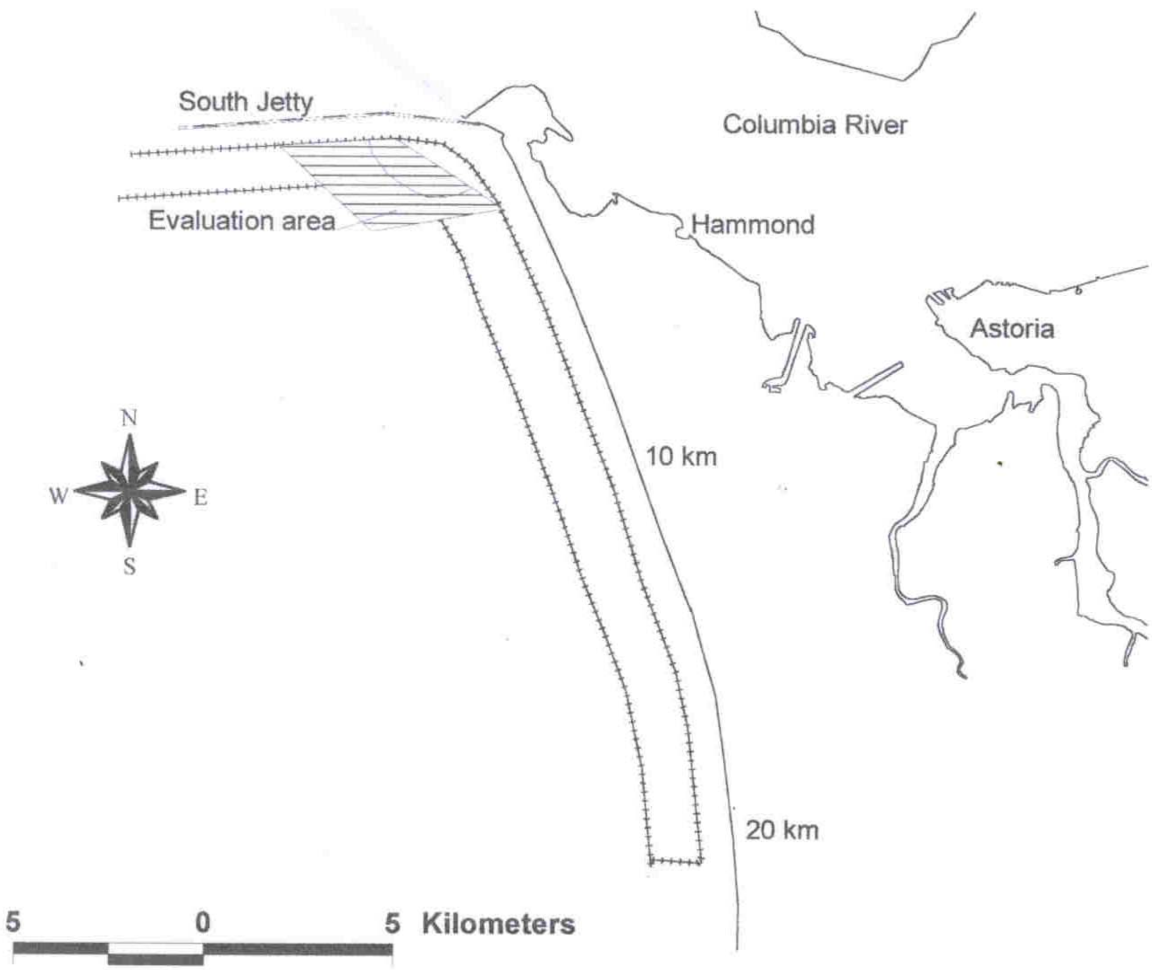

Figure 4. Clatsop Spit and the south jetty Columbia River showing suggested transect lines (hatched lines) for assessing impacts of dredge spoil deposition ('Evaluation area' in horizontal lines).

Table 1. Summary of marine bird survey data by season in the vicinity of the south jetty, Columbia River. Species are ordered by mean abundance. See methods for a description of survey methods. Near-shore data include surveys from 300 to 5,000 m offshore.

		Spring, Feb - Apr		Summer, May - Aug						Fall, Sep - Nov.		All seasons	
		Shore		Shore		Near shore		Offshore		Shore		TOTAL	
	AOU	6 surveys		48 surveys		17 surveys		4 surveys**		15 surveys			
Species	Code*	Avg.	% Freq.	Avg.	% Freq.	Avg.	% Freq.	Avg.	% Freq.	Avg.	% Freq.	Avg	% Freq.
Common Murre	COMU			148.8	83.3	38.82	94.12	172.5	100	14.07	40	96.7	63.48
Surf Scoter	SUSC	99.3	100	111.7	87.5	2.24	29.4	0.25	25	42	80	73.63	64.38
Gull sp.	GULL	5	33.3	32.24	22.9	0.12	11.76	21	100	5.4	13.3	19.38	36.25
Pacific Loon	PALO	21.5	66.7	17.1	85.4	1.47	29.41	1	25	13.2	60	13.08	53.3
Brandt's Cormorant	BRCO	0	0	22.97	54.2	0.47	41.2	0.25	25	1.47	13.3	12.6	26.74
Sooty Shearwater	SOSH	0	0	6.16	6.25	0.18	11.8	76.5	100	30	26.7	11.72	28.95
Western Gull	WEGU	13.67	66.7	4.33	27.1	1.88	35.29	22.25	100	1.13	33.3	4.75	52.48
White-wing Scoter	WWSC	5.69	33.3	2.1	0.5	2.18	29.4			15.47	66.7	4.49	25.98
Brown Pelican	BRPE	0	0	2.1	45.8	9.12	76.47	0.5	25	8.07	33.3	4.21	36.11
Double-cr. Cormorant	DCCO	0	0	0.98	25	14.05	11.8	0.75	25	0.2	20	3.24	16.36
Western Grebe	WEGR	1.5	50	1.79	41.7	0.06	5.9			11.87	73.3	3.04	34.18
Pigeon Guillemot	PIGU	0.33	16.7	4.38	66.7	2.88	82.35	0.25	25	0.07	6.7	2.92	39.49
Red-throated Loon	RTLO	0	66.7	0.5	33.3	0	0	0	0	14.2	86.7	2.63	37.34
Loon sp.	LOON	17	33.3	0.06	2.1	0	0	0	0	7.13	20	2.35	11.08
Black Scoter	BLSC	1.85	33.3	1.98	31.25	0	0	0	0	6.8	33.3	2.31	19.57
Heerman's Gull	HEEG	0	0	1.9	18.75	1.18	23.53	0	0	6.27	13.3	2.28	11.12
Caspian Tern	CATE	0	0	0.18	4.2	1.47	35.29	25.75	50	0	0	1.52	17.9
Common Loon	COLO	4	50	1.63	66.7			0.25	25	2.13	66.6	1.5	41.66
Red-necked Phalarope	RNPH	0	0	0.16	4.2	0.12	11.76	21.75	50	0	0	1.08	13.19
Pelagic Cormorant	PECO	0.17	16.7	1.12	47.9	0.24	17.6	0.5	50	1.8	20	0.98	30.44
WxGW Gull	WEGW	0	0	1.53	12.5			1.25	59	0	0	0.87	14.3
Rhinoceros Auklet	RHAU	0	0	0.6	37.5	1.24	41.18	3.75	75	0.2	13.3	0.76	33.4
Black-legged Kittiwake	BLKI	0.83	50	0.2	4.2	0.06	5.88	0	0	3.13	40	0.7	20.02
Marbled Murrelet	MAMU	0	0	0.33	20.8	2.47	47.06	0	0	0	0	0.64	13.57
California Gull	CAGU	0	0	0.45	8.3	0.53	23.53	0	0	1	13.3	0.51	9.03
Bonaparte's Gull	BOGU	0.17	16.7	0.44	4.2	0	0	0	0	0	0	0.24	4.18
Ring-billed Gull	RBGU	0	0	0.45	10.4	0	0	0	0	0	0	0.24	2.08
Red Phanarope	REPH	0	0	0	0	0	0	5	25	0	0	0.22	5
Red-necked Grebe	RNGR	0.17	16.7	0.14	6.25	0	0	0	0	0.27	20	0.13	8.59
Glaucous-wing. Gull	GWGU	0.83	50	0.06	4.2	0.12	11.76	0	0	0	0	0.11	13.19

Mew Gull	MEGU	0	0	0	0	0	0	0	0	0.4	6.7	0.07	1.34

Table 1 continued.

		Spring, Feb - Apr		Summer, May - Aug						Fall, Sep - Nov.			
		Shore		Shore		Near shore		Offshore		Shore		TOTAL	
	AOU	6 surveys		48 surveys		17 surveys		4 surveys**		15 surveys			
Species	Code*	Avg.	% Freq.	Avg.	% Freq.	Avg.	% Freq.	Avg.	% Freq.	Avg.	% Freq.	Avg	% Freq.
Common Murre	COMU			148.8	83.3	38.82	94.12	172.5	100	14.07	40	96.7	63.48
Sabine' Gull	SAGU	0	0	0	0	0	0	1.5	25	0	0	0.07	5
Small Alcid sp.	SMAL	0	0	0	0	0.25	17.65	0	0	0	0	0.05	3.53
Black-footed Albatross	BFAL	0	0	0	0	0	0	1	50	0	0	0.04	10
Horned Grebe	HOGR	0.33	16.7	0	0	0	0	0	0	0.13	6.7	0.04	4.68
Arctic Tern	ARTE	0	0	0	0	0	0	0.75	25	0	0	0.03	5
Parasitic Jaeger	A11 PAJA	0	0	0	0	0.12	5.88	0	0	0	0	0.02	1.18
Herring Gull	HERG	0	0	0	0	0	0	0.25	25	0.07	6.7	0.02	6.34
Shrt-tailed Shearwater	STSH	0	0		0	0	0	0	0.5	25	0	0	0.025
Eared Grebe	EAGR	0.33	16.7	0	0	0	0	0	0	0	0	0.02	3.34
Scoter sp.	SCOT	0	0	0.04	6.25	0	0	0	0	0	0	0.02	1.25
Clark's Grebe	CLGR	0	0	0.02	2.1	0	0	0	0	0	0	0.01	0.42
Ancient Murrelet	ANMU	0	0	0	0	0	0	0	0	0.07	6.7	0.01	1.34
Cassin's Auklet	CAAU	0	0	0	0	0.06	5.88	0	0	0	0	0.01	1.18
Fork-tailed Storm Petrel	FTSP	0.17	16.7	0	0	0	0	0	0	0	0	0.01	3.34
Pink-foot Shearwater	PFSH	0	0	0	0		0	0.25	25	0	0	0.01	5
Common Tern	COTE	0	0	0	0	0	0	0.25	25	0	0	0.01	5

"* Codes for species groups (Loon, Gull, Scoter) were generated for this report "

** Flying and sea surface birds were combined in the offshore data.

Table 2. Summary of shore survey counts conducted from 1997 to 2001, averaged by month. Data are divided by flying birds and birds on the surface south of south jetty.

	Feb-March		April		May		June		July		August		September		October		November	
Number of surveys:	3		3		8		10		18		13		4		7		4	
Species and AOU code	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea
Common Loon COLO	3	0.33	0.33	7.67	1.75	5.13	0.5	0.2	0.44	1.5	0.15	0.39	0.75	1.5	0.72	2.86	1.5	1.5
Pacific Loon PALO	2.33	1	434.3	42	122	10.13	295.4	53.2	3.67	5.61	2.54	8	2.25	4.75	57	4.86	6.5	36.25
Red-throated Loon RTLO		2.33	6	37.67	0.88	0.88		0.3	0.06	0.44	0.15	0.31	0.33	6.75	4	4.86	4	38
loon sp. loon		0.67		33.33	0.13							0.23				14.29	7.3	1.75
West Grebe WEGR		1	0.33	2		5.75		1.1		0.22		0.62	0.22	0.25	0.43	23.14		3.75
Clark's Grebe CLGR				0.67			0.2								0.57			
Eared Grebe EAGR				0.67											0.14			
Horned Grebe HOGR				0.67												0.29		
Red-necked Grebe RNGR				0.33	0.13	0.63	0.1	0.2								0.57		
Northern Fulmar NOFU															0.14		1	
Sooty Shearwater SOSH					0.5		180	0.1	2.1	0.06	3121.23	23.08	9030.89	87.5	3009.43	14.29	0.25	
Shrt-tail Shearwater STSH															0.86			
Pink-foot Shearwater PFSH									0.06		0.15		0.33		0.43			
Buller's Shearwater BUSH															0.29			
Fork-tailed Storm Petrel FTSP		0.33																
Brandt's Cormorant BRCO		1.67	3.67		16	9.75	68.6	19.4	89.33	31.44	70.92	22	25.78		52	2.29	8.5	1.5
Pelagic Cormorant PECO				0.33	1.5	0.75	1.9	0.6	1.44	1.61	3.77	1.08	1.56	6	2.14	0.29	0.5	0.25
Double-cr. Cormorant DCCO					19		17.1	0.3	44.67	0.72	12.15	2.46	0.44	0.5	5.71	0.14	0.5	
Brown Pelican BRPE					5.38	0.5	37.3	0.4	36.56	3.5	42.46	2.46	5.56	2.75	61.57	15.71	8.5	
Brant BRAN			32		12.5		1		0.06								0.5	
Surf Scoter SUSC	23	40	78.67	158.67	41.63	8.13	26.9	49.9	6.28	168.44	4	129.77	5.78	3.25	27.71	81.57	1.5	11.5
White-wing Scoter WWSC	13.67	4.33	5.33	7	7.63	1.25	8.8	0.9	3.83	2.61	1.46	2.54	2.11	1	14.43	3.43	1.25	51
Black Scoter BLSC	1.33	1	1.33	2.67	1.75	2	1.3	3.2	0.61	1.78	0.39	0.77	0.44		0.43	11.43	2.75	5.5
scoter sp. scot	3		15		5.63							28.39						
Long-tailed Jaeger LTJA															0.29		0.25	
Parasitic Jaeger PAJA					0.25	0.25	0.5		0.06		0.85		0.11		1.57			
Pomarine Jaeger POMA											0.15				0.43			
jaeger sp. JAEG	0.33										0.23		0.22					
Western Gull WEGU	5.67	1.33	11.67	26	18.88	7.25	20.5	3.8	27.5	4	21.23	3.39	8.89	0.5	20.29	1.71	8.5	0.75
Glaucous-winged Gull GWGU	5	0.67	5.33	1	2.63		3.2		1.28	0.11	4.08	0.08			3.14		7	
Western/Glaucous hybrid	1.67		0.67		5.38	6.25			3.94	0.56	3.23	1.15	3.33		1.43	0.14	3	
Glaucous Gull GLGU	0.33						3											
Herring Gull HERG	2.33						0.1			0.39	0.08		0.22		0.14		2.5	
Ring-billed Gull RBGU	0.33				0.25	0.38	3.1	0.7	0.78	0.06	0.31	0.15	0.78		1.57		0.5	
California Gull CAGU							4		2.61		12.31	1.69	21.67	15	34.86	4.29	13.75	
Mew Gull MEGU	7														0.57		3	1.5
Heerman's Gull HEEG					0.13		5.5	0.3	35.61	2.61	19.92	3.31	36.67	10.5	35	7.43	0.5	
Sabine' Gull SAGU															0.86			
Franklin's Gull FRGU															0.14			
Bonaparte's Gull BOGU			13	0.33	22.88	2.63					0.08				0.14			
Bl-legged Kittiwake BLKI	3	0.33	12	1.33	9.38	0.13	1.9		0.06	0.06	0.08		0.11	0.75	12.14	1	39	9.25
gull sp. Gull	46.67	10			30	33.75	30	43	35	37.78	80	15.39	36.67	10.25	135.71	5.71	15	

Table 2. Summary of shore survey counts, continued.

	Feb-March		April		May		June		July		August		September		October		November	
Number of surveys:	3		3		8		10		18		13		4		7		4	
Species and AOU code	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea	Flying	At sea
Caspian Tern CATE			1		83.13	0.38	394		415.28		135.77	0.46	0.22					
Elegant Tern ELTE									0.11									
Arctic Tern ARTE					0.63						2.77							
Common Tern COTE					0.5	0.38							0.11					
Red-necked Phalarope RNPH					4.75	0.5	0.1	0.2			4.08	0.15	14.67		0.14			
Common Murre COMU	2		5		1482.63	3.5	2940	302	1330.28	583.44	423.54	54	1.11	12.75	35.86	22	0.5	1.5
Pigeon Guillemot PIGU			2.33	0.67	1.25	1.88	3.8	4.1	4.06	2.78	7.08	1				0.14		
Rhinoceros Auklet RHAU						0.5	2	0.5	1.22	0.56	1.39	0.69		0.5		0.14		
Marbled Murrelet MAMU					0.25	0.13	1.5	0.4	0.33	0.61	0.39				0.29			
Xantus' Murrelet XAMU							0.1											
Ancient Murrelet ANMU																		0.25
Cassin's Auklet CAAU							0.5		0.94		0.39							
Tufted Puffin TUPU							0.2											
alcid sp. alcid											0.46							
Bald Eagle BAEA							0.1		0.06									
Osprey OSPR																		
Peregrine PERE									0.06									

Table 3. Mean seabird number and density (birds per square km) from strip transects in areas near the south jetty, Columbia River. Surveys took place during summers 1992-1996 and 2000-2004. Data include transects from 350 to 1500 m offshore

	North side jetty 6 surveys, 39 km		South side jetty 8 surveys, 51.5 km		Jetty to 5 km south 18 surveys, 127 km		5 to 10 km south 19 surveys 113 km		10 to 15 km south 21 surveys 142 km		15 to 20 km south 18 surveys, 111 km	
Species	Number	Density	Number	Density	Number	Density	Number	Density	Number	Density	Number	Density
Pacific Loon			7	1.359	18	1.423	11	0.840	5	0.351	6	0.540
loon sp.							1	0.076		0.000	3	0.270
Western Grebe			1	0.194			3	0.229	2	0.140	1	0.090
Sooty Shearwater			3	0.583			167	12.748	51	3.581	11	0.990
Brandt's Cormorant	4	1.026	3	0.583	10	0.791	8	0.611	42	2.949	8	0.720
Pelagic Cormorant	1	0.256	3	0.583								
Double-cr Cormorant	6	1.538			239	18.893			1	0.070		
Cormorant	3	0.769			7	0.553	4	0.305	3	0.211	1	0.090
Brown Pelican	43	11.026	1	0.194	152	12.016	82	6.260	47	3.301	51	4.590
Surf Scoter			10	1.942	28	2.213	11	0.840	5	0.351	3	0.270
White-winged Scoter					37	2.925	15	1.145			10	0.900
scoter sp.							8	0.611	2	0.140		
Parasitic Jaeger			2	0.381								
Pomarine Jaeger									2	0.140	1	0.090
Western Gull	11	2.821	6	1.165	26	2.055	29	2.214	44	3.090	29	2.610
Glaucous-winged Gull					1	0.079			3	0.211	3	0.270
California Gull	30	7.692			9	0.711	4	0.305	1305	91.643	46	4.140
Heermann's Gull					20	1.581	2	0.153	29	2.037	5	0.450
Black-legged Kittiwake					1	0.079					1	0.090
gull sp.					1	0.079					4	0.360
Caspian Tern	10	2.564	7	1.359	19	1.502	12	0.916	15	1.053	9	0.810
Red-neck Phalarope		0.000	7	1.359								
Common Murre	47	12.051	157	30.480	377	29.802	830	63.359	1103	77.458	539	48.515
Pigeon Guillemot	8	2.051	24	4.660	22	1.739	1	0.076	3	0.211	9	0.810
Marbled Murrelet	16	4.103	29	5.631	13	1.028	24	1.832	33	2.317	26	2.340
Rhinoceros Auklet	2	0.513	13	2.524	9	0.711	9	0.687	7	0.492	12	1.080
Cassin's Auklet					1	0.079	1	0.076	1	0.070		
Small alcid			1	0.388	3	0.237					1	0.090

Table 4. Seasonality and foraging characteristics of selected seabird species found off South Jetty, Columbia River, ordered by approximate abundance on the water.

Species

Species	Seasonality in abundance at south jetty and local nesting status	Foraging method and habitat
Common Murre	Strong peak in numbers during summer. Scarce late fall and winter. Local breeder	Pursuit diver singly or in flocks on midwater schooling prey
Surf Scoter	Year round, numbers higher summer, fall Not a local breeder	Pursuit diver for benthic fish and invertebrates. Can form large flocks
Pacific Loon	Strong migratory peak in spring (most flying) Year round presence, not a local breeder	Pursuit diver on fish. Usually solitary foraging
Brandt's Cormorant	Year round resident breeder. Abundance peak near-shore in summer	Pursuit diver on schooling fish, usually in flocks
White-winged Scoter	Year round, numbers may be higher fall through spring. Not a local breeder	Pursuit diver for benthic fish and invertebrates. Can form large flocks
Western Gull	Common year round. Local breeder	Surface seize/ scavenge. Opportunistic in all aspects.
Brown Pelican	Migrant. Present May - Nov with peak Jul - Sep. Not a local breeder	Plunge diver on schooling fish. Solitary or in flocks
Western Grebe	Present year round. Peak numbers at sea fall and spring. Not a local breeder	Pursuit diver on small fish and invertebrates. Sometimes in flocks
Pigeon Guillemot	Present Mar - Sep, peak in summer Local breeder, possibly nesting in south jetty	Pursuit diver for benthic fish, some midwater fish. Solitary foraging
Pelagic Cormorant	Present year round. Highest abundance late summer & fall. Local Breeder	Pursuit diver primarily for benthic fish, also midwater fish. Solitary
Marbled Murrelet	Present Mar- Oct, possible year round. More from Jul-Sep. Local breeder	Pursuit diver, possibly near bottom. Solitary or very small groups
Sooty Shearwater	Present year round, usually offshore. Strong peak in late summer-fall. Not a local breeder	Surface seize & pursuit diver on surface to midwater prey. Usually in flocks
Caspian Tern	April - September, peak in summer. Local breeder	Plunge diver on surface fish. Usually Solitary or in scattered flocks
Red--throated Loon	Migrant with peaks in fall and spring. Not a local breeder	Pursuit diver. Can occur in large, loose flocks.