BLACK OYSTERCATCHER HABITAT MODELING IN PRINCE WILLIAM SOUND

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Introduction

We created a GIS model to locate habitat in Prince William Sound that has the potential to support Black Oystercatchers (*Haematopus bachmani*). It is hoped that by identifying shoreline used by oystercatchers in the Sound, that we will be able to determine the amount of available habitat, and determine areas where this species may be at risk to human disturbance. The queries used in this project were completed almost entirely with the use of Arcinfo and Arcview. A number of GIS coverages were produced for each step of the model and details about their creation are offered in an attached file under Appendix I.

Andres developed a model for black oystercatcher habitat based largely on fieldwork from Green and Knight Islands for EVOS projects during the summers of 1991-93. He determined that oystercatchers in the Sound use two different types of shoreline, gradual beach areas as well as rocky shores in close proximity to islets and sea stacks. In 1998 we created a model that selected out areas of these two different types but we were not completely satisfied with the results. Based on known nest locations and some of Andres' field impressions we began looking at ways to further define shoreline used by oystercatchers. We developed four separate queries that delineate oystercatcher habitat. Andres went back to his field data from the early 90's and looked at several habitat characteristics that were associated with oystercatcher nests. Using regression trees, created by the software package SPLUS, he was able to come up with value estimates for the relative importance of these characteristics. Based on these values we came up with density estimates, pairs per km, for oystercatchers on each type of shoreline selected by the model.

Our data for shoreline types are based on a coverage created for the south coast of Alaska by NOAA in 1991 which classifies substrates based on their sensitivity to oil spills. The substrates included in this coverage for Prince William Sound are found in Table 1. The items in the table are linked to a NOAA web site that provides example pictures of each substrate. Appendix II offers a text description of each substrate.

Table 1.

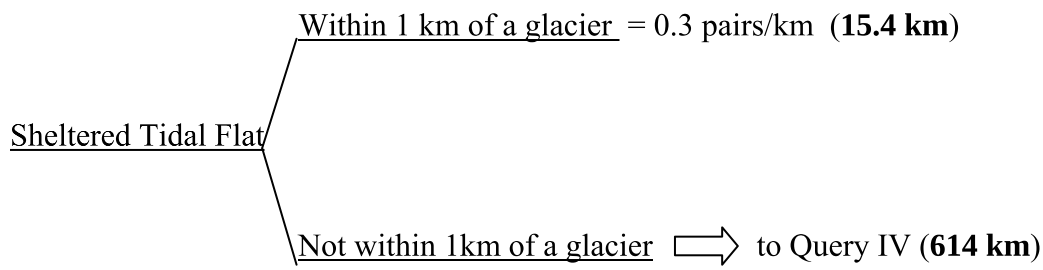
Exposed Rocky Shores	Gravel Cobble Boulder Beaches
Exposed Rocky Platforms	Exposed Tidal Flats
Fine-grained Sand Beaches	Sheltered Rocky Shores
Coarse-grained Sand Beaches	Sheltered Tidal Flats
Mixed Sand and Gravel Beaches	Marshes*

*The Marshes substrate was not used in any of our queries. It occurs in the shoreline coverage as a secondary shoreline, above mean high tide, and there is always another shoreline type between Marshes and the ocean.

Query I.

It is known that oystercatchers nest in relatively high densities in Glacier Bay National Park on moraines associated with tidewater glaciers (Andres and Falxa 1994). Andres conducted fieldwork in Harriman Fiord during the summer of 1999 and noted that many of the oystercatchers there, were using similar areas. Harriman Fiord, as well as other fiord and bays in the northern part of the Sound, have a number of moraines adjacent to the shoreline that were left behind by retreating glaciers. Many of these moraines show up in association with sheltered tidal flats. However, there are vast expanses of sheltered tidal flat, especially in the eastern half of the Sound, that do not host moraines and are not used by oystercatchers. Our first query looked for sheltered tidal flat that was within 1 km of a glacier. It was thought that by using this distance our model would include moraines left behind by recently retreating glaciers, as well as moraines associated with tidewater glaciers.

I.



After running this query we came up with about 15.4 km of sheltered tidal flat within 1 km of a glacier. Using the 0.3 pairs/km density figure results in 4 to 5 pairs of nesting oystercatchers associated with this type of shoreline. The remaining 614 km was run through Query IV to determine if its proximity to small rocky islets makes it useful oystercatcher habitat.

Query II.

The shoreline substrate in Prince William Sound most frequently used by oystercatchers is sand and gravel beaches (Andres 1998). There is approximately 1550 km of sand and gravel beach in the Sound. These beaches often supports mussels and other invertebrate prey. In addition, this substrate is ideal for the creation of the scrape nests used by oystercatchers. However not all of these beaches provide ideal habitat. The formation of mussel beds and an extensive area above high tide for nesting, are more likely to occur on sand and gravel beaches in areas sheltered from wave action. From his work on Knight and Green Island Andres believes that the highest densities of oystercatchers would likely occur on this type of shoreline (Andres pers. com.). Surveys in the eastern part of the Sound, Port Gravina, Sheep Bay and Simpson Bay, had similar findings (Bishop 1999). This query selects sand and gravel beaches that are in close proximity to other sheltered shoreline (ie. sheltered rocky shores and sheltered tidal flat).

II.

Adjacent to any sheltered habitat > 0.3 pairs/km **(891.1 km)**

Sand and Gravel

Not adjacent to sheltered habitat → To Query IV **(658.9 km)**

Based on a density value of at least 0.3 pairs per km, Query II estimates some 267 pairs of oystercatchers using this substrate type. The remaining 658.9 km of sand and gravel shoreline that is not adjacent to any sheltered shore will be run through the rocks query. Figure 1 displays the location of shoreline selected by Query II.

Query III.

The oceanic side of Montague and Hinchinbrook are directly exposed to wave action from the Gulf of Alaska. The result of this exposure is miles of rocky sea cliffs with little or no exposed inter-tidal area. In addition, the shoreline on the sound-ward side of both islands was uplifted by the 1964 earthquake. This also resulted in tall sea cliffs in some areas. The steep shoreline of these islands will cause oystercatchers to be more closely associated with shoreline gradient than substrate type (Andres pers com). The slope of the shoreline was determined to be gradual if after 300 m inland the elevation did not raise above 60 m. This translates to a slope of less than 20% (Andres 1998).

Though slope was the primary consideration in this Query, we also limited it to the "beach" substrates available on these islands that oystercatchers are known to use. **Beach substrates include;** exposed wavecut platforms, coarse gained sand beaches, mixed sand and gravel beaches and gravel cobble boulder beaches. Of the gradual shoreline selected by our query, the majority fell into one of the above substrate types. A noted exception was 22 km of fine-grained sand beaches and 2.4 km of exposed tidal flat. These areas are known to be of little use to oystercatchers (Andres 1998) and were thus excluded.

III.

Slope less than 20% = 0.3 pairs/km (**336.7 km**)

Beach substrates

Slope greater than 20% → to Query IV (**361.5 km**)

The 336.7 km of shoreline translates into about 101 pairs of oystercatchers based on the 0.3 pairs per km density value. As with the previous queries any shoreline not selected was sent to Query IV. Figure 2 displays the location of shoreline selected by Query III.

Query IV.

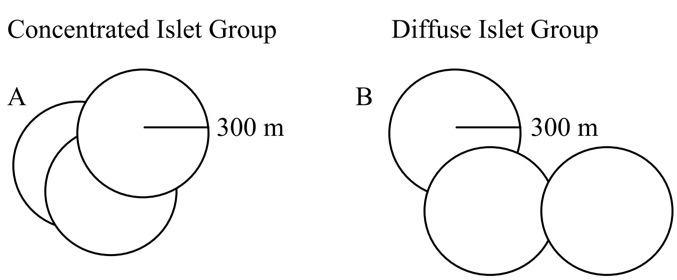
The final query selects segments of shoreline that are valuable oystercatcher habitat because of the their proximity to small rocky islets. With the exception of segments already assigned to the preceding 3 queries, all shoreline segments were considered. Islets were located using a shoreline coverage of the Prince William Sound area, created by the USFS in 1996.

Oystercatchers rely on large intertidal areas that are exposed at low tide to provide proper feeding habitat. The area between groups of rocky islets, as well as islets that are adjacent to shoreline, often provide such habitat. Oystercatchers are also known to nest on small off-shore rocks and sea stacks (Andres 1998). Islets less than or equal to 100 m in diameter, and within 300 meters of shore were determined to be the most important. Shoreline segments in association with greater densities of islets are more likely to be used by oystercatchers (Andres pers com).

In order to come up with an accurate continuous indicator for the "density" of islets, associated with a segment of shoreline, we created a 300 m buffer around each rock islet. We used this distance in part because oystercatchers regularly travel 300 m and greater to different feeding locations (Andres and Falxa 1994) but also because groups of islets that are closer to one another offer more exposed intertidal and thus provide better feeding habitat.

With a circular 300 m buffer around a single islet, the area enclosed in that buffer, or polygon, is 282690 m^2. However when islets are closer together, their buffers overlap creating multi-islet polygons and their areas become variable. Using Arcinfo, we were able to count the number of islets within these multi-islet polygons and then multiply that number by the ideal area for a single islet. This number was then divided by the actual area of the multi-islet polygon. The number produced, 0-1, served as an indicator for the amount of overlap between islets. These values were then assigned to two potential distribution classes using the natural breaks function in Arcview. Those with more overlap were assigned to the concentrated class and those with less were placed into the diffuse class. Islets without overlap were also placed into the diffuse classification.

Example:



Each islet has an area of 282690 m^2 squared and when multiplied by the number of islets, 3, their resulting ideal area is 848070 m^2 . Since each islet buffer has some overlap they are combined into mult-islet polygons. The actual area of these polygons, 500000 m^2 for A , and 800000 m^2 for B, are then divided by the ideal area of 848070 m^2 . A= 0.58 and is assigned to concentrated, and B= 0.94 and becomes diffuse.

Any shoreline substrate not selected in a previous query, that intersected with islet polygons of a concentrated nature, were assigned to that group. The same was done for shoreline intersecting diffuse islet ploygons. Shoreline not selected by this fourth and final query is assumed to have no value for oystercatchers.

IV.

All Substrates
- Concentrated islets within 300 m of shore = 0.15 pairs/km **(878.5 km)**
- Diffuse islets within 300 m of shore = 0.04 pairs/km **(375.9 km)**
- No rocky islets within 300 m of shore = 0.00 pairs/km

The first branch of the query, for concentrated islets, offers shoreline for about 132 pairs of oystercatchers based on the given density value. The second branch translates to approximately 15 pairs living on shoreline associated with more diffuse concentrations of islets. Figure 1 displays the locations of shoreline segments selected by this query.

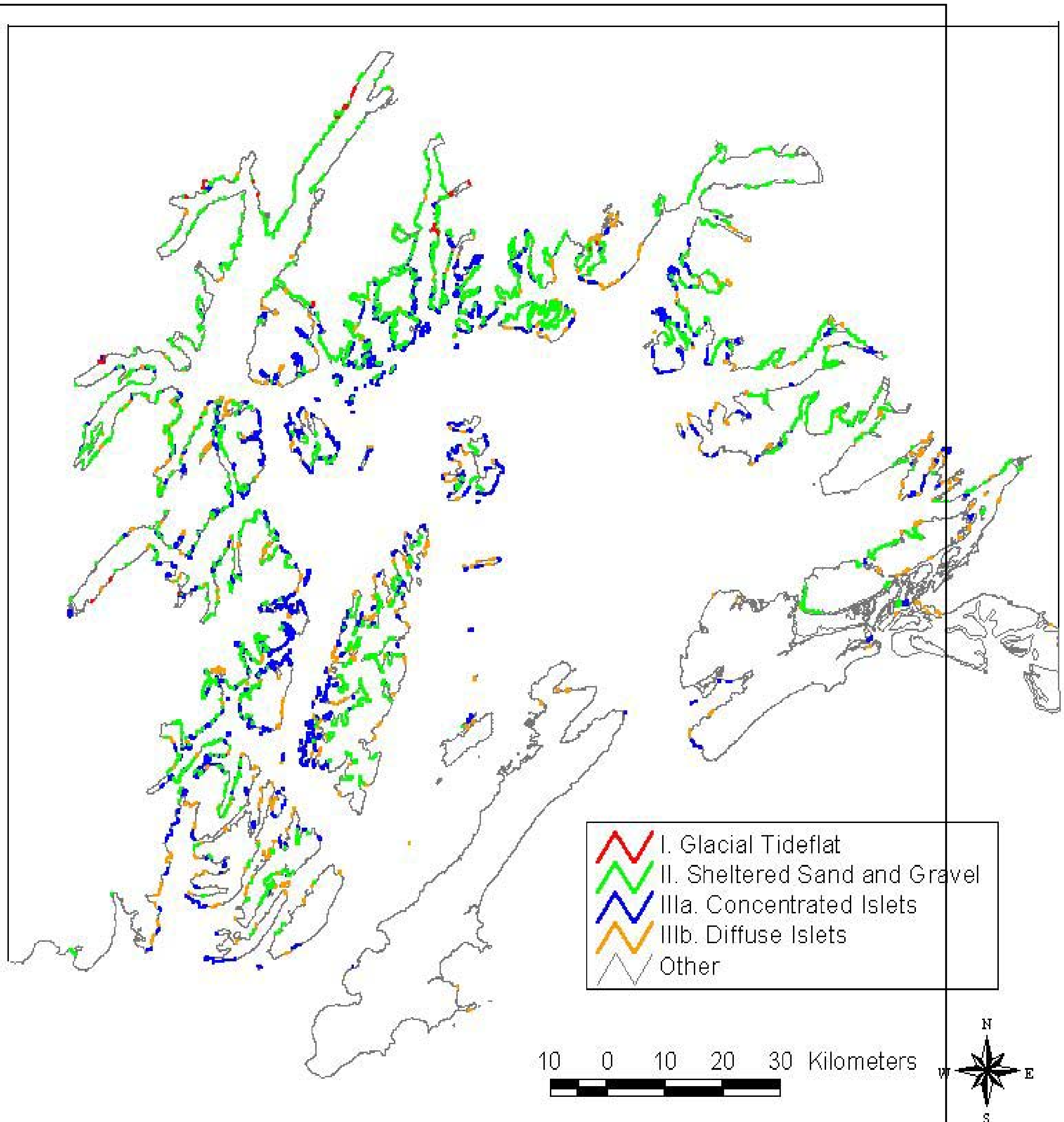

I. Glacial Tideflat
II. Sheltered Sand and Gravel
IIIa. Concentrated Islets
IIIb. Diffuse Islets
Other
10 0 10 20 30 Kilometers
N
W
E
S

Figure 1.

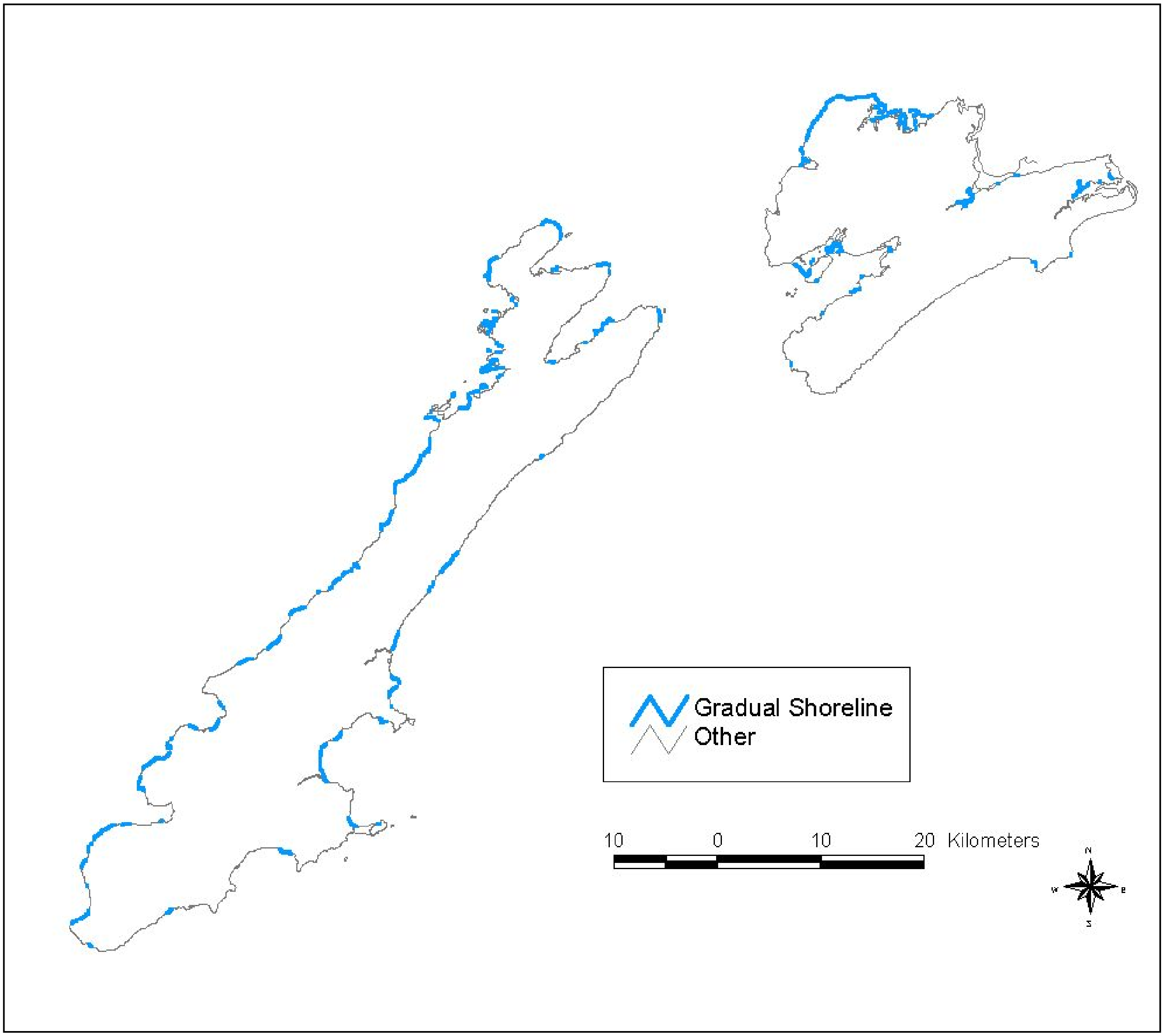


Figure 2.

Summary of Results

Table 2.

Shoreline Type	Shoreline (km)	Number of Pairs supported*
Glacial Sheltered Tide Flats	15.4	4-5
Sheltered Sand and Gravel	891.1	267
Gradual, Montague and Hinchinbrook	336.7	101
Concentrated Islet Shore	878.5	132
Diffuse Islet Shore	375.9	15

*These numbers are based on density values associated with each query.

When all shore types from Table 2 are combined, the model predicts that a total of 2497.6 km of suitable habitat is available to oystercatchers in Prince William Sound. This represents approximately 41% of the 6079 km of total shoreline in NOAA's substrate coverage. Assuming oystercatchers occupy all habitat selected by the model, at the proposed densities, this translates into about 520 breeding pairs of oystercatchers. When one considers that approximately ¾ of the population is breeders (Andres and Falxa 1995), our model estimates a population of approximately 1387 birds.

Additional Analysis

We gathered 238 known siting and nest locations for oystercatchers across the Sound. Almost 2/3 of the known locations were on Green, Montague and Knight Islands with others from bays north of Cordova and Harriman Fiord. These locations were put into a coverage so that they could be compared with shoreline data in hopes of testing the accuracy of the model. Oystercatchers are known to regularly travel 1 to 1.5 km from their nests while foraging (Andres and Falxa 1995). Based on this information, each of the points had a 1 km buffer placed around them. It was then determined if that buffer overlapped habitat selected by the model. Out of the 238 known locations, 186 or 78% were within 1 km of at least one segment of shoreline selected by the model as being important oystercatcher habitat.

Another query that was run is related to the impact of shoreline campsites on potential oystercatcher habitat. According to a coverage of recreation sites for the Chugach National Forest, there are approximately 330 campsites on the shores of Prince William Sound. Recent research found that oystercatchers in Kenai Fiords National Park were disturbed by humans when camps were set up within 150-200 m of a nest (Tetreau pers com). With this in mind, a 200 m buffer was placed around each shoreline campsite. Assuming the shoreline selected by the model is oystercatcher habitat, table 3 presents the amount of shoreline likely to be affected by beach campers. It also provides the likely number of nests disturbed based on the densities estimated for each shoreline type.

Table 3.

Shoreline type	**Amount affected**	**Estimated number of nests affected**
Glacial Sheltered Tide Flat	0.94 km ~ 6%	Less than 1
Sheltered Sand and Gravel	40.6 km ~ 5%	12
Montague, Hinchinbrook	0.00 km 0%	None*
Concentrated Islets Shore	40.4 km ~ 5%	6
Diffuse Islets Shore	9.5 km ~ 3%	Less than 1

***** There were only 2 campsites shown in the recreation sites coverage for these two islands. This is a short-coming of that particular coverage, as there are other campsites on these islands.

The total number of nesting pairs disturbed by beach campsites is likely to be between 18 and 19. This represents about 38 to 40 individuals and potentially more as non-breeding oystercatchers are likely to occupy some of these locations as well. Locations of particular concern are Serpentine Cove, in Harriman Fiord and Hell's Hole, in Port Gravina. Some of the Sound's highest densities of oystercatchers are in direct contact with multiple beach campsites in both of these areas (Andres pers com and Bishop 1999).

Sheltered sand and gravel occurred with relative frequency near areas of concentrated rocky islets. A coverage was created that shows the areas of overlap between these two habitat types. Though it has not been tested, one might reason that these areas represent the best possible habitat for oystercatchers because of the presence of both types of habitat features. A few areas in Prince William Sound known for high oystercatcher densities, including Serpentine Cove and Hell's Hole correlate with this coverage. Figure 3 displays the areas were sheltered sand and gravel occur in association with concentrated rocky islets.

Discussion

Query I.

Although not a large number of nesting birds appear to depend on this substrate, one should consider that in some locations (ie. Harriman Fiord), this shoreline type makes up a large percentage of the nesting and feeding habitat available to oystercatchers (Andres per com). Their presence in some of these areas is dependent on the availability of this glacially influenced sheltered tidal flat.

Query II.

This query produced the largest amount of habitat available to oystercatchers. The density value for this substrate is likely to be a little high. Surveys in a few bays in the eastern part of the sound produced densities closer to 0.15 or 0.20 pairs per km. Using these values the number of pairs predicted for this type of substrate is approximately 175, about 100 pairs less than with a density value of 0.3 pairs per km. However, these lower densities come only from a limited study and were not used for the model. Further surveys on sand and gravel beaches throughout the Sound could help to better define the density value for oystercatchers living on this type of shoreline.

Known nest locations on Knight Island match very well with shoreline substrate predicted by this query. In addition a number of the sightings from Port Gravina and Simpson bay correspond with this shore type. Much of the sheltered sand and gravel selected by this query occurs in Eaglek Bay and Unakwik Inlet. Comprehensive survey data for these two locations was unavailable. One unexpected result of this query was its almost total omission of Green Island. Though much of the northwest side of the island, particularly Port Chalmers is indeed sheltered from wave action, and much of it is shore is composed of sand and gravel beach, it did not show up that way in NOAA's shoreline coverage. There are other locations in the Sound where the shoreline coverage does not appear to represent the substrate accurately. NOAA is producing another shoreline substrate coverage that will be available in summer of 2000 that is likely to correct some of these problems.

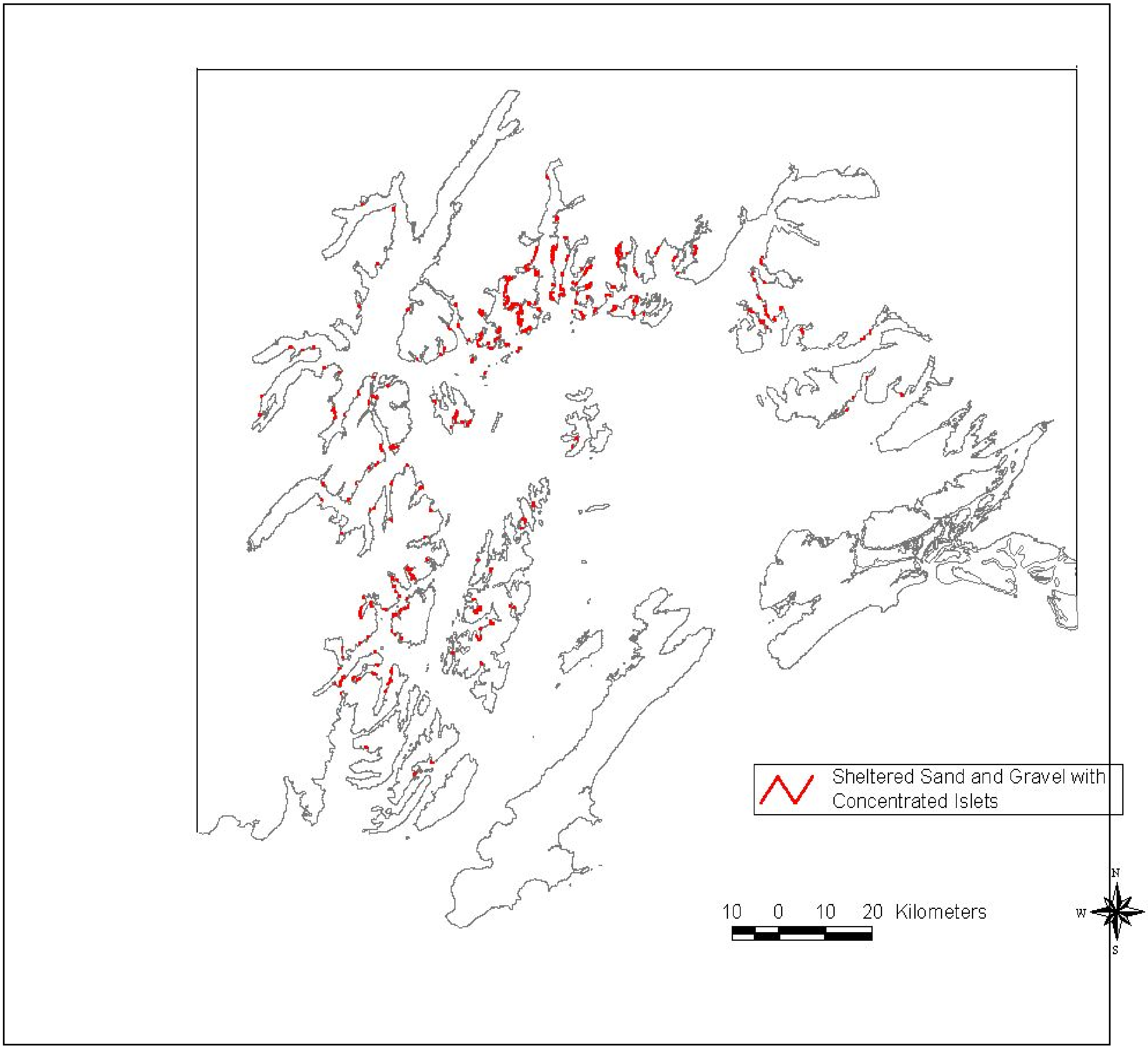

Sheltered Sand and Gravel with Concentrated Islets
10 0 10 20 Kilometers
N
W
E
S

Figure 3.

Query III.

According to the model almost half of the available land area for these two islands should be available for use by oystercatchers. A number of oystercatcher surveys have been done on the northwest side of Montague and these sightings correlate well with shoreline selected by this query. However a lack of survey data for Hinchinbrook and other locations on Montague made it impossible to determine if areas selected on that island are indeed used by oystercatchers.

Query IV.

The two separate types of islet concentrations produced a total of 1254 km of shoreline supporting some 147 pairs of oystercatchers. Nest locations on Green and Knight Island, as well as survey points from Sheep Bay, correspond well with shoreline selected by this query. However, similarly to Query II, a large percentage of shoreline associated with both concentrated and diffuse islet groups occurs in bays and inlets between Port Wells and Valdez Arm. There is little survey information for these areas.

The distribution of nests and known locations were compared for correlation between concentrated and diffuse islet shore. Approximately 65% of locations thought to be associated with islet supported habitat, showed up closer to areas with concentrated islet distributions. This finding is similar to the difference in predicted density values for each of the two islet shore habitats, 0.15 and 0.04 respectively. However, the kilometers of concentrated islet shore are about 3 times those of diffuse islet shore. So it is possible that oystercatchers are not selecting concentrated islet habitat over diffuse islet habitat.

Summary

Current estimates of Oystercatcher numbers in Prince William Sound range from 750 to 950 individuals (Andres per com). Even assuming the greater value of 950, or 356 pairs, the model over estimates the number of oystercatchers thought to live in the Sound by approximately 164 pairs, or about 437 birds. Our estimate assumes that birds occupy each shoreline type at the predicted density, and that all sections of each shore type are used by oystercatchers.

Our density estimates were generated from habitat data collected on Montague, Knight and Green Islands and oystercatchers may occur in higher densities on these islands when compared to mainland shore. Thus, one might consider lowering the density estimates, however comprehensive surveys of mainland shoreline are not available to predict new density values.

It is also possible that oystercatchers do not occupy all available habitat in the Sound at carrying capacity. The population could be limited by some factor other than the availability of suitable habitat. A relatively low reproduction rate, availability of prey and predation could all have important effects on the populations of these birds. Andres (1998) discusses the affect of predators and human disturbance on the presence of oystercatchers and these relationships, which are not considered in the model, may be limiting the available habitat in the Sound.

The other alternative is that the model does not correctly identify all habitat characteristics required for shoreline to be oystercatcher habitat. However, with 78% of known nest and sighting locations occurring within 1 km of oystercatcher habitat, one can assume that we have at least identified several important characteristics of shoreline used by oystercatchers.

Conclusion

This model serves as our best estimate about the location and amount of habitat that is available to Black Oystercatchers in Prince William Sound. The shoreline selected by this model is not necessarily habitat used by oystercatchers, rather, it serves as an indicator of potential habitat for this species. The density values presented for the shoreline selected by each query are also estimates. Surveys in some of the selected areas have produced similar density values however, it is unlikely that all areas off each shore type actually support the given density of oystercatchers.

Sources Cited

Andres, B. A., and G. A. Falxa. 1995. Black Oystercatcher (*Haematopus bachmani*). The Birds of North America, No. 155. Acad. Nat. Sci., Philadelphia, and The American Ornithologists' Union, Washington, D. C.

Andres, B. A. 1998. Shoreline habitat use of Black Oystercatchers breeding in Prince William Sound, Alaska. Jour. of Field Ornith. Vol. 69.

Bishop, M. A. 1999. Status of Seabird Colonies in Northeast Prince William Sound, Restoration Project Final Report. Prince William Sound Science Center. Cordova, AK.

APPENDIX I

Directory created by: Carl Madson & Aaron Poe, Glacier Ranger District
Date & Time: Started 11/11/99

bloy99.apr:
ArcView project
Created by apoe on 11/10/99

COVERAGES /fsfiles/fstmp/res/bloy99/

Andresbloy:
*created by Aaron Poe 12/2/99
*digitized from 1:63360 maps of field observations of oystercatchers made by Brad Andres (USFWS)in June of 1999

bloynests:
*Brad Andres of USFWS
*UTM coord. from a GPS unit, collected from 1991 - 1993 15th May - 31st July
*Black Oystercatcher nest locations collected from shoreline in the vicinity of Green, Montague and Knight Islands only.

fsbloy1:
*Created by Aaron Poe based on field observations from:
*GRD rec. crew over the period of (1997-1999)
*Mary Ann Bishop from USDA PNWRS Copper River Delta Institute (CRDI). with surveys in Northwest Orca Inlet (June 1996 - May 1997)
*Surveys collected for Shepard's point EA http://www.pwssc.gen.ak.us /~shepard/docs/reports/final/crdi/nearcrdi.html
*Digitized by hand by apoe
*These are not actual nest locations they are just observations by field crews

fsbloy2:
*Collected by Mary Ann Bishop of NWRS CRDI
*Coverage generated with points file fsbloy2.txt by apoe
*Collected for survey on Montague & Knight Island
*Year or other info unknown
*These are not actual nest locations they are just observations by field crews

fwsbloy:
*queried /fsfiles/ref/library/gis/outside_data/biologic/seabird column bloy > 0 by apoe 11/99 for observations of Black Oystercatchers
*contains data for the entire south coastal area of AK
*see /fsfiles/ref/library/gis/outside_data/biologic/seabird metadata for more information

fsbloy99:

*created by apoe on 12/5/99
*Points collected by Mary Ann Bishop formerly with NWRS CRDI during 6/99 surveys of bays north of Cordova (Orca Inlet, Simpson Bay, Port

Gravina)
*point locations were digitized from 1:63360 map
*locations include both nesting oystercatchers and apparently non-Nesting individuals

camps:

*created by apoe on 12/11/99
*these polygons represent campsite areas that are likely to have an impact on shoreline used by nesting black oystercatchers
*campsites and kayak beaches were queried from the /fsfiles/ref/library/gis/chugach/rec_sites coverage
*they were made into polygons by placing a 200 m buffer around each point selected by the query. They were then built as polygons

-glacstf, -s+gshelter, -shore++4, and -isletshore+3:

*created by apoe on 12/11/99
*these arcs represent sections of shoreline that are likely to be impacted by recreation activities at campsites
*they were created by clipping each coverage (glacstf, s+gshelter, isletshore+3. and shore++4) to the camps polygon coverage
*Montague and Hinchinbrook were omitted as no areas of shore overlapped with polygons in camps

best:

*created by apoe on 12/11/99
*these arcs represent areas where dense groups of islets and sand and gravel shoreline overlap one another.
*it was created by clipping s+gshelter with the polygon coverage bislets.

COVERAGES FOR QUERY I. /fsfiles/fstmp/res/bloy99/tideflat/

stf:
*stf = sheltered tidal flats
*created from /fsfiles/ref/library/gis/outside_data/physical/esi_pws by querying for shoretype1 = 9
*created by apoe on 11/10/99
*see /fsfiles/ref/library/gis/outside_data/physical/esi_pws metadata for more information

pwsglac1:

*created by apoe on 11/29/99
*a temp coverage created using arctools to clip polygons from /fsfiles/ref/library/gis/outside_data/physical/glac1mil that surround prince william sound.
*It was created only to speed up the commands that needed to be run on this subset of glaciers

bpwsglac1:

*created by apoe on 11/29/99
*a 1 km buffer was placed around all glaciers in pwsglac1
*buffer pwsglac1 bpwsglac1 # # 1000 # POLY

glacstf:

*created by apoe on 11/29/99
*a coverage created to show areas of sheltered tidalflat /fsfiles/fsmtp/res/bloy99/stf that were recently affected by retreating and tide water glaciers
*it was created by clipping stf with bpwsglac1
*clip sft bpwsglac1 glacstf
*the shoreline in this coverage is the final   result of Query I.

COVERAGES FOR QUERY II. /fsfiles/fstmp/res/bloy99/s+g/

s-g_beach:
*created by cmadson on 11/11/99
*created from /fsfiles/ref/library/gis/outside_data/physical/esi_pws by querying for shoretype1 = 5
*s-g_beach is a Sand & Gravel beach of esi type 5

bs-g_beach:
*created by cmadson on 11/11/99
*created by buffering s-g_beach out 1000m
*buffer s-g_beach bs-g_beach # # 1000 # LINE # #

shelter:

*created by apoe on 11/18/99
*shows areas of sheltered tide flat and sheltered rocky shore in PWS
*queried /fsfiles/ref/library/gis/outside_data/physical/esi_pws for shoretype1 with values of 8 or 9.

Pshelter:

*created by cmadson on 12/7/99

???:

???:

s+gshelter:

*created by apoe on 12/7/99
*shows only those areas of s-g beach that are immediately adjacent to shelter.
*created by joining tables in arcview of ??? and ??? that had the same attributes (area=perimeter??) then converted to a shape file, then converted to a coverage using shapearc and then built as a line.
*this coverage represents all of the shoreline selected by query II.

COVERAGES FOR QUERY III. /fsfiles/fstmp/res/bloy99/m+h/

Esim+h:

*created by apoe on 12/2/99
*selected on those arcs from /fsfiles/ref/library/gis/outside_data /physical/esi_pws that make up Montague and Hinchinbrook using arctools

plus_plus:
*created by cmadson and apoe 12/6/98

mh++:

*created by apoe on 12/6/99
*selected those arcs from plus_plus that make up Montague and Hinchinbrook using arctools

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COVERAGES FOR QUERY IV. /fsfiles/fstmp/res/bloy99/rocks/

islets:

*created from /fsfiles/ref/library/gis/chugach/shoreline by querying for area < 7854
*created by apoe on 11/10/99
*see /fsfiles/ref/library/gis/chugach/shoreline metadata for more information

bislets:
*created by cmadson 11/11/99
*buffer islets bislets # # 300 # POLY ROUND
*creates a 300m buffer around islets

pislets:

*created by 12/9/99
*places a point and the center of each islet polygon
*using the command centroidlable
*arc and poly features were dropped so that only the label point remains

intersect:

*created by apoe on 12/9/99
*counts the number of points in pislets that intersect polygons in bislets and places this value under the column frequency in a table for bpislets.
* using the intersect command on pislets and bislets

bpislets:

*created by apoe on 12/9/99
*this is a polygon coverage created from bislets. It incorporates the frequency of islets (based on their centered label points) that occur within each polygon. This data is found in the Frequency column
*it also has a value for the ideal area of a circular polygon that is 600 m which is then multiplied by the corresponding Frequency value.

The resulting value is the column Ideal Area.
*The actual area of each polygon is then divided by the ideal area and placed in the column A/ia.
*Finally, this coverage was classified using the value in A/ia with Arcview natural breaks.

Islets+:

*created by apoe on 12/11/99
*these polygons have a lower degree of overlap based the natural breaks in the A/ia column in bpislets
*they were queried out of bpislets using acview and then shaparc was used to convert them to a coverage and built as a polygon

Islets++:

*created by apoe on 12/11/99
*these polygons have a higher degree of overlap based the natural breaks in the A/ia column in bpislets
*they were queried out of bpislets using acview and then shaparc was used
to convert them to a coverage and built as a polygon

Isletshore+:
*created by apoe on 12/11/99
*these arcs represent shoreline that is within 300 m of the rocky islet polygons in Islets+
*the clip command was used to clip the esi_pws coverage to islets+

Isletshore++:

*created by apoe on 12/11/99
*these arcs represent shoreline that is within 300 m of the rocky islet polygons in Islets++
*the clip command was used to clip the esi_pws coverage to islets++

******Each of the above Islet+ and Islet++ coverages were then erased by creating small 20 meter buffers around the line coverages; s+gshelter, glacstf, and mh++. Each of these buffers and erases was done as an iteration and temporary coverages are not disscussed since their methods of creation were identical. The final resulting coverages are:

isletshore+3:

*created by apoe on 12/11/99
*these arcs represent the shoreline that is within 300 meters of a diffuse or single rocky islet that is not already selected by one of the previous queries

shore++4:

*created by apoe on 12/11/99
*these arcs represent the shoreline that is within 300 meters of a condensed group of rocky islets that is not already selected by one of the previous 3 queries.

```
-----------------------------------FILES---------------------------------
fsbloy2.txt:
      * UTM coordinates of observed black oystercatchers.
      * see fsbloy2 under coverages for more info
```

APPENDIX II. (adapted from NOAA's Shoreline Assessment Manual pages pgs 87-103.)

Shoreline Descriptors, including Oil Behavior and Response Considerations

EXPOSED ROCKY CLIFFS ESI = 1A
- The intertidal zone is steep (greater than 30° slope), with very little width.
- Sediment accumulations are uncommon and usually ephemeral, because waves remove the debris that has slumped from the eroding cliffs.
- There is strong vertical zonation of intertidal biological communities.
- Species density and diversity vary greatly, but barnacles, snails, mussels, seastars, limpets, sea anemones, shore crabs, polychaetes, and macroalgae are often very abundant.

EXPOSED WAVE-CUT PLATFORMS ESI = 2
- The intertidal zone consists of a flat rock bench of highly variable width.
- The shoreline may be backed by a steep scarp or low bluff.
- There may be a beach of sand- to boulder-sized sediments at the base of the scarp.
- The platform surface is irregular and tidal pools are common.
- Small amounts of gravel can be found in the tidal pools and crevices in the platform.
- These habitats can support large populations of encrusting animals and plants, with rich tidal pool communities.

FINE-GRAINED SAND BEACHES ESI = 3A
- These beaches are generally flat and hard-packed.
- Though they are predominately fine sand, there is often a small amount of shell hash.
- There can be heavy accumulations of wrack present.
- They are utilized by birds and turtles for nesting and feeding.
- Upper beach fauna are generally sparse, although amphipods can be abundant; lower beach fauna can be moderately abundant, but highly variable.

MEDIUM- TO COARSE-GRAINED SAND BEACHES ESI = 4
- These beaches have relatively steep beach faces and soft substrates.
- Coarse-sand beaches can undergo rapid erosion/deposition cycles, even within one tidal cycle.
- The amount of wrack varies considerably.
- They are utilized by birds and turtles for nesting and feeding.

MIXED SAND AND GRAVEL BEACHES ESI = 5
- These beaches are moderately sloping and composed of a mixture of sand and gravel.
- Because of the mixed sediment sizes, there may be zones of pure sand, pebbles, or cobbles.
- There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms.

 Because of sediment desiccation and mobility on exposed beaches, there are low densities of attached animals and plants.
 The presence of attached algae and animals indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.

GRAVEL BEACHES ESI = 6A
 Gravel beaches are composed of sediments ranging in size from pebbles to boulders. The gravel-sized sediments can be made up of shell fragments.
 They can be very steep, with multiple wave-built berms forming the upper beach.
 Attached animals and plants are usually restricted to the lowest parts of the beach, where the sediments are less mobile.
 The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota.

EXPOSED TIDAL FLATS ESI = 7
 Exposed tidal flats are broad intertidal areas composed primarily of sand and minor amounts of shell and mud.
 The dominance of sand indicates that currents and waves are strong enough to mobilize the sediments.
 They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals; they are commonly associated with tidal inlets.
 Biological utilization can be very high, with large numbers of in fauna, heavy use by birds for roosting and foraging, and use by foraging fish.

SHELTERED ROCKY SHORES ESI = 8A
 These are bedrock shores of variable slope (from vertical cliffs to wide, rocky ledges) that are sheltered from exposure to most wave and tidal energy.
 Wide shores may have some surface sediments, but bedrock is the dominant substrate type
 Species density and diversity vary greatly, but biota are often very abundant.

SHELTERED TIDAL FLATS ESI = 9A
 Sheltered tidal flats are composed primarily of mud with minor amounts of sand and shell.
 They are present in calm-water habitats, sheltered from major wave activity, and are frequently backed by marshes.
 The sediments are very soft and cannot support even light foot traffic in many areas.
 They can be sparsely to heavily covered with algae and/or seagrasses.
 They can have very heavy wrack accumulations along the high-tide line.
 There can be large concentrations of shellfish, worms, and snails on and in the sediments.
 They are heavily utilized by birds and fish for feeding.

SALT- AND BRACKISH-WATER MARSHES ESI = 10A
 These marshes contain vegetation which tolerates water salinity down to about 5 ppt.
 Width of the marsh can vary widely, from a narrow fringe to extensive areas.
 Sediments are composed of organic-rich muds except on the margins of barrier islands where sand is abundant.
 Exposed areas are located along waterbodies with wide fetches and along busy waterways.

- Sheltered areas are not exposed to significant wave or boat wake activity.
- Resident flora and fauna are abundant with numerous species with high utilization by birds, fish, and shellfish.