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Geo 565 Spatial Analysis Final Project

Hot Spot Analysis of the Seasonal Distribution of Marbled Murrelets (*Brachyramphus marmoratus)* within the San Juan Islands

Introduction

The marbled murrelet (*Brachyramphus marmoratus*) is a small seabird found in the Pacific Northwest. While it forages exclusively in the marine environment, the seabird's nesting habitat is highly associated with old growth or late-successional forest stands (Ralph et al.1995). The marbled murrelet was classified as a threatened species within the states of Washington, Oregon, and California in 1992 (U.S. Fish and Wildlife Service 1992) and is protected under the Northwest Forest Plan.

The Pacific Northwest Research Station (PNW) out of Olympia, WA has been conducting at-sea population surveys of marbled murrelets within the San Juan Islands since 1995. The PNW has also recently finished a five year radio-telemetry study on the breeding ecology of marbled murrelets within the state of Washington (Bloxton and Raphael 2009) which applied radio-tags on marbled murrelets to locate and study their nesting sites. The results from this study demonstrated a low nest success rate. The majority of nest failures were due to apparent chick starvation or adults abandoning the egg before the end of its incubation period. A number of different factors are at play. Adults may abandon an egg if they are flushed out by something, such as a predator. However, Bloxton and Raphael detected low predation rates during the course of their study. Due to deforestation, marbled murrelets have to find nest sites farther inland and have further to fly from their nest to their feeding habitat. Are they now expending too much energy to successfully fledge a nest? There is the possibility that adults aren't getting enough food on their feeding grounds to support a chick and are either not feeding the chick enough or are abandoning the nest before the egg is finished incubating or the chick is ready to fledge.

While population surveys of marbled murrelets have been ongoing in Washington waters for fifteen years, little research has been done looking at the relationship between marbled murrelets and their environment or the changes that have occurred in their environment over time. With issues such as global climate change and overfishing becoming more influential on the marine environment, it would be an important step to assess how changes in their habitat affect marbled murrelet population numbers and distribution patterns.

As a first step to assess this relationship, marbled murrelets distribution patterns are analyzed using GIS within the San Juan Islands. It is hypothesized that marbled murrelet distribution demonstrates a spatial pattern. Population centers of both low and high concentrations will be identified for further analysis on key environmental factors contributing to marbled murrelet distribution.

Methods

Field Surveys

Marbled murrelet population surveys were conducted around the San Juan Islands from 1996 through 2010 starting on the 12th of May and ending on the 29th of August. Sixteen "core" transects were surveyed eleven times throughout the season during ten-day intervals (Table 1, 2). Each transect ranged from 4km to 22km in length, broken into 2 km segments (named 302, 304, 306, etc.), covering a total of 170km of the San Juan Islands surveyed each year.

Table 1: Ten Day Interval Numbers with their corresponding start date.

Interval	3	4	5	6	7	8	9	10	11	12	13
Start Dates	5/12	5/22	6/1	6/11	6/21	7/1	7/11	7/21	7/31	8/10	8/20

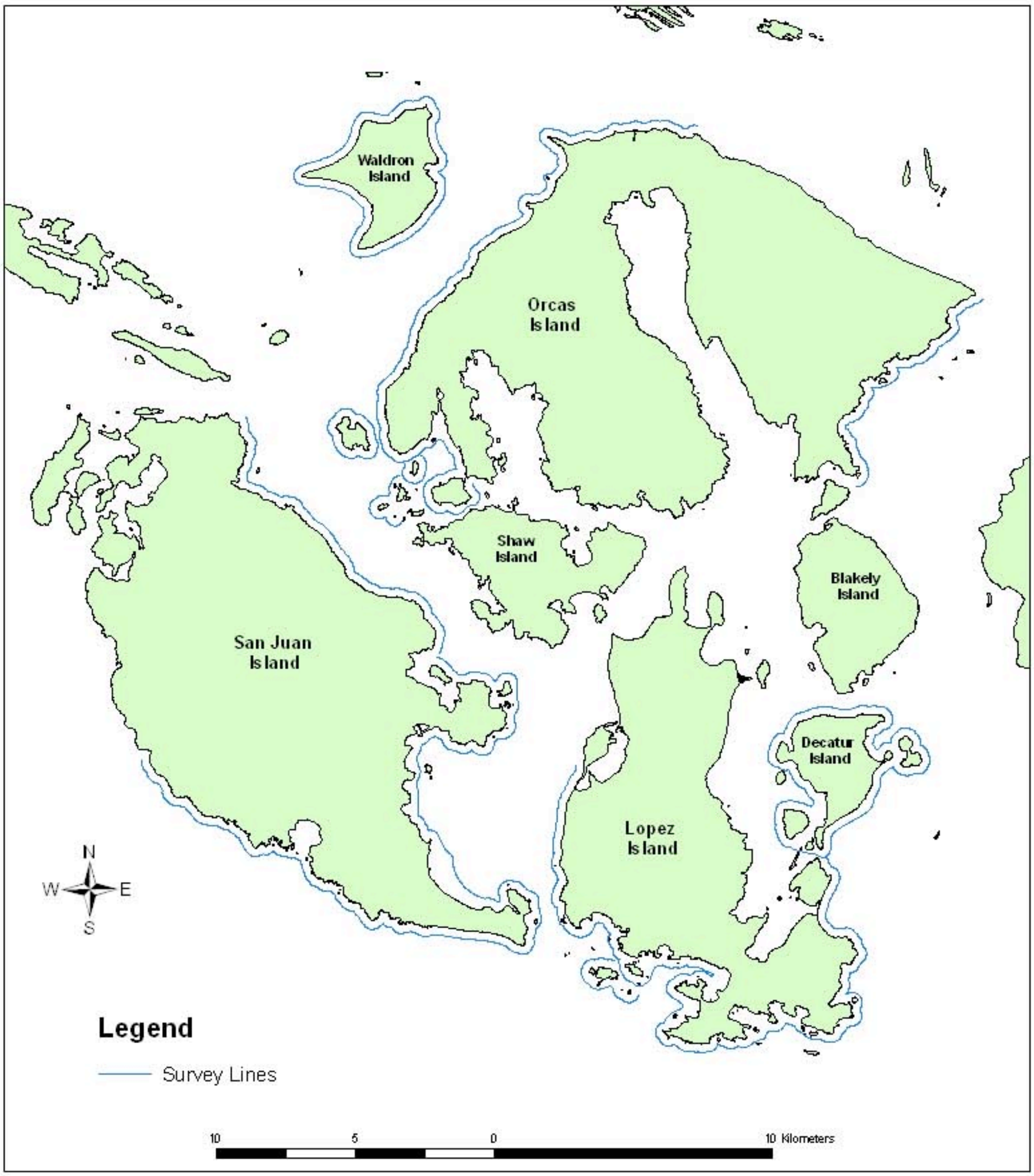
Table 2: Transect Names with their corresponding regions.

Transect Name	Area Surveyed	Segments Surveyed	Number of 2-km Segments	Total Distance Surveyed (km)
CRAN	Crane Island	302-304	2	4
JONE	Jones Island	302-306	3	6
DECA	Decatur Island	302-322	11	22
LOHA	Long and Hat Islands	302-304	2	4
LOSE	Lopez Southeast	302-308	4	8
LOSO	Lopez South	302-310	5	10
LOSW	Lopez Southwest	302-314	7	14
ORNO	Orcas North	302-306	3	6
ORSE	Orcas Southeast	302-308	4	8
ORSW	Orcas Southwest	302-304	2	4
ORWE	Orcas West	302-314	7	14
SJNO	San Juan North	302-312	6	12
SJSE	San Juan Southeast	302-318	9	18
SJSW	San Juan Southwest	302-318	9	18
WALD	Waldron Island	302-316	8	16
WASP	Wasp Islands	302-306	3	6
			Total	170

Surveys were conducted from a 17-ft Boston Whaler at a 300m distance from shore, as estimated by radar. Surveys occasionally deviated from the 300m distance to avoid shallows or hazardous conditions. One observer scanned from 90 degrees left to 90 degrees right of the bow. Numbers of marbled murrelets were recorded along with behaviors, distance to the transect line, time, temperature, and depth. The survey method is described by Ralph and Miller (1995). Surveys were conducted in sea states of 0 through 3 and were abandoned in rougher conditions due to poor visibility.

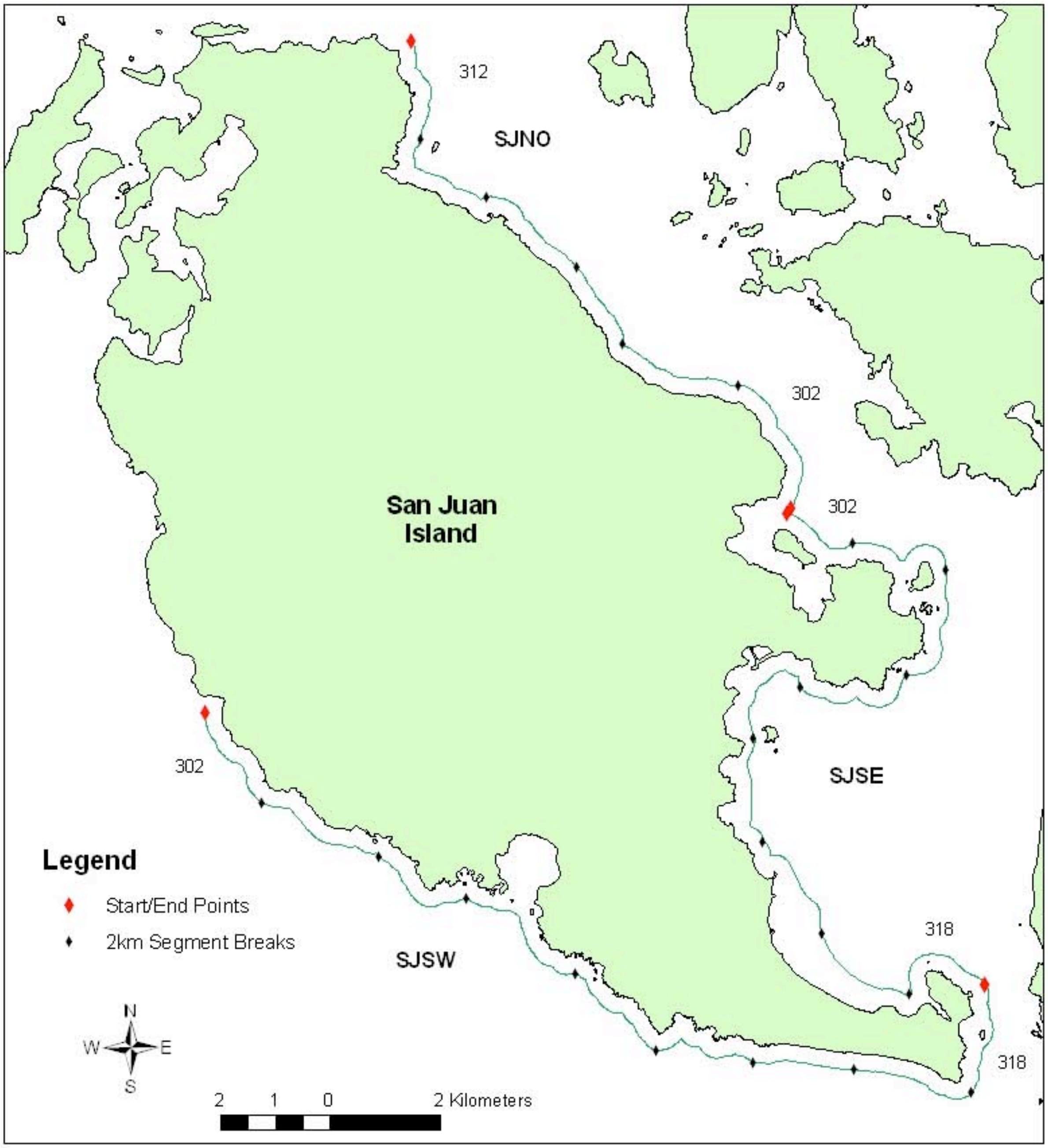
The survey season corresponds to the marbled murrelet nesting period which typically extends from the beginning of May until the end of July. In August, juvenile marbled murrelets begin to show up within the San Juan Islands. This data is used to determine an adult: juvenile ratio in order to assess breeding success rate from year to year.

San Juan Island Study Area



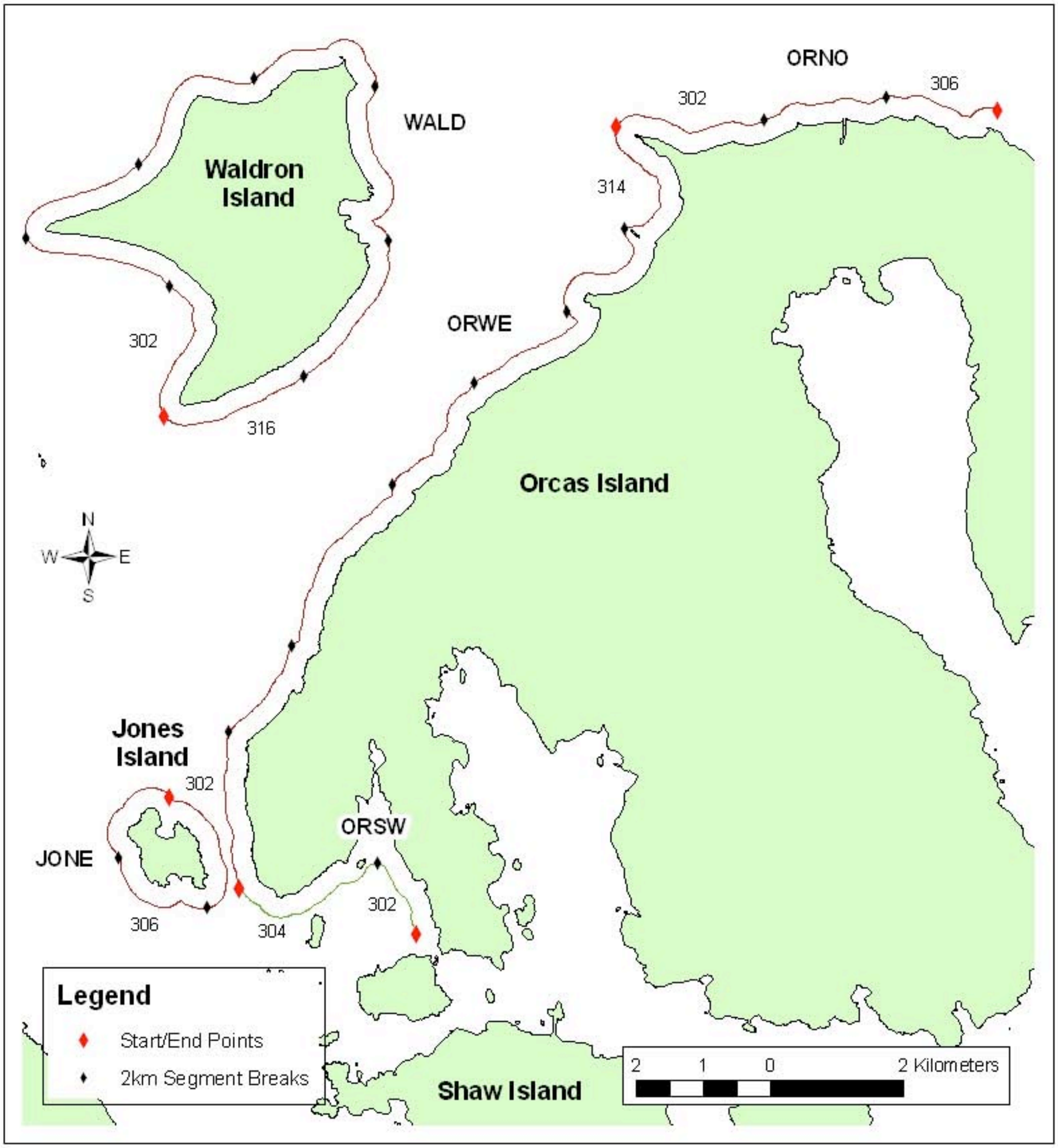
San Juan Island Surveys

SJNO - San Juan North
SJSE - San Juan Southeast
SJSW - San Juan Southwest



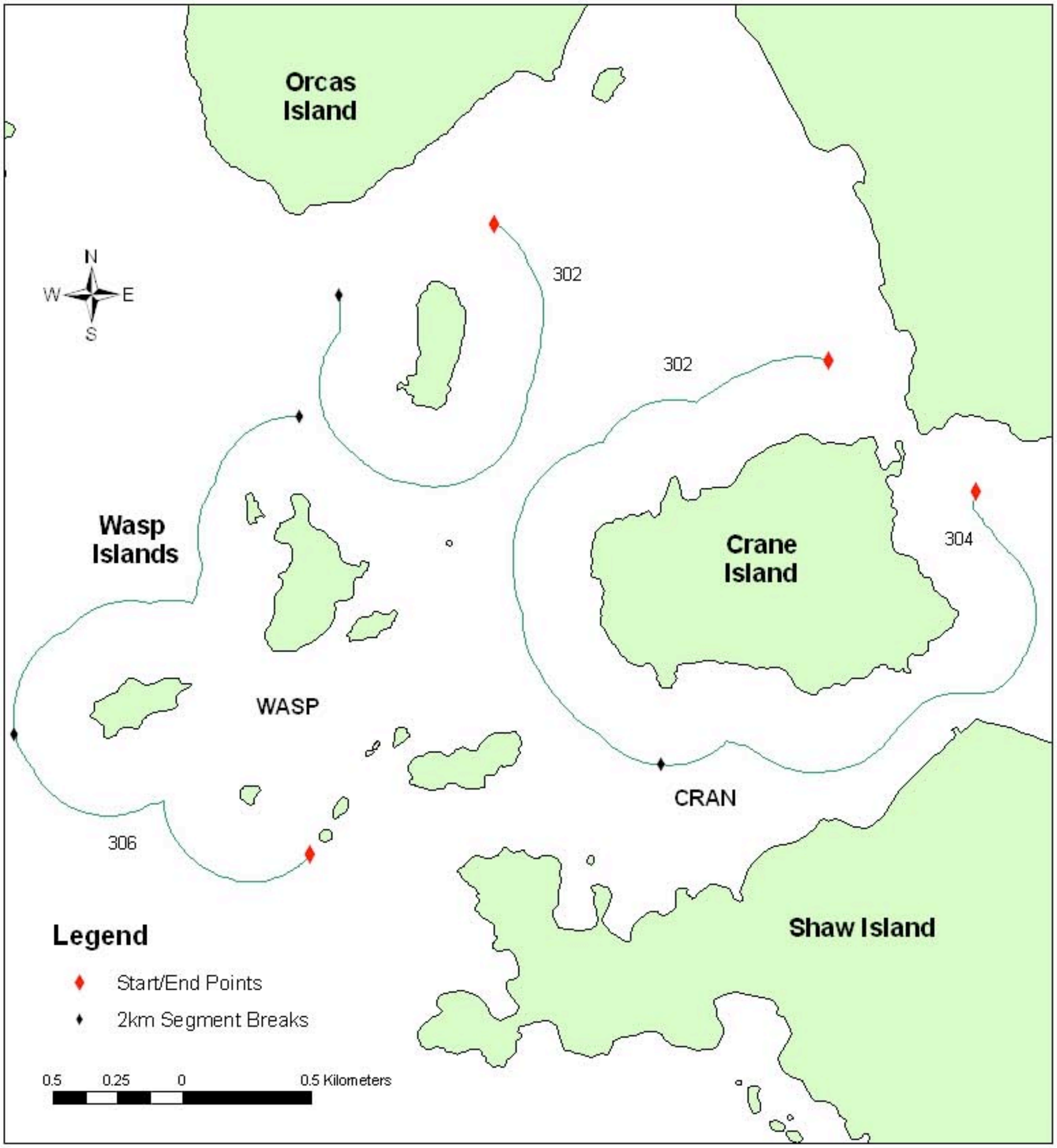
JONE - Jones
ORNO - Orcas North
ORWE - Orcas West
WALD - Waldron

Orcas, Waldron, and Jones Islands



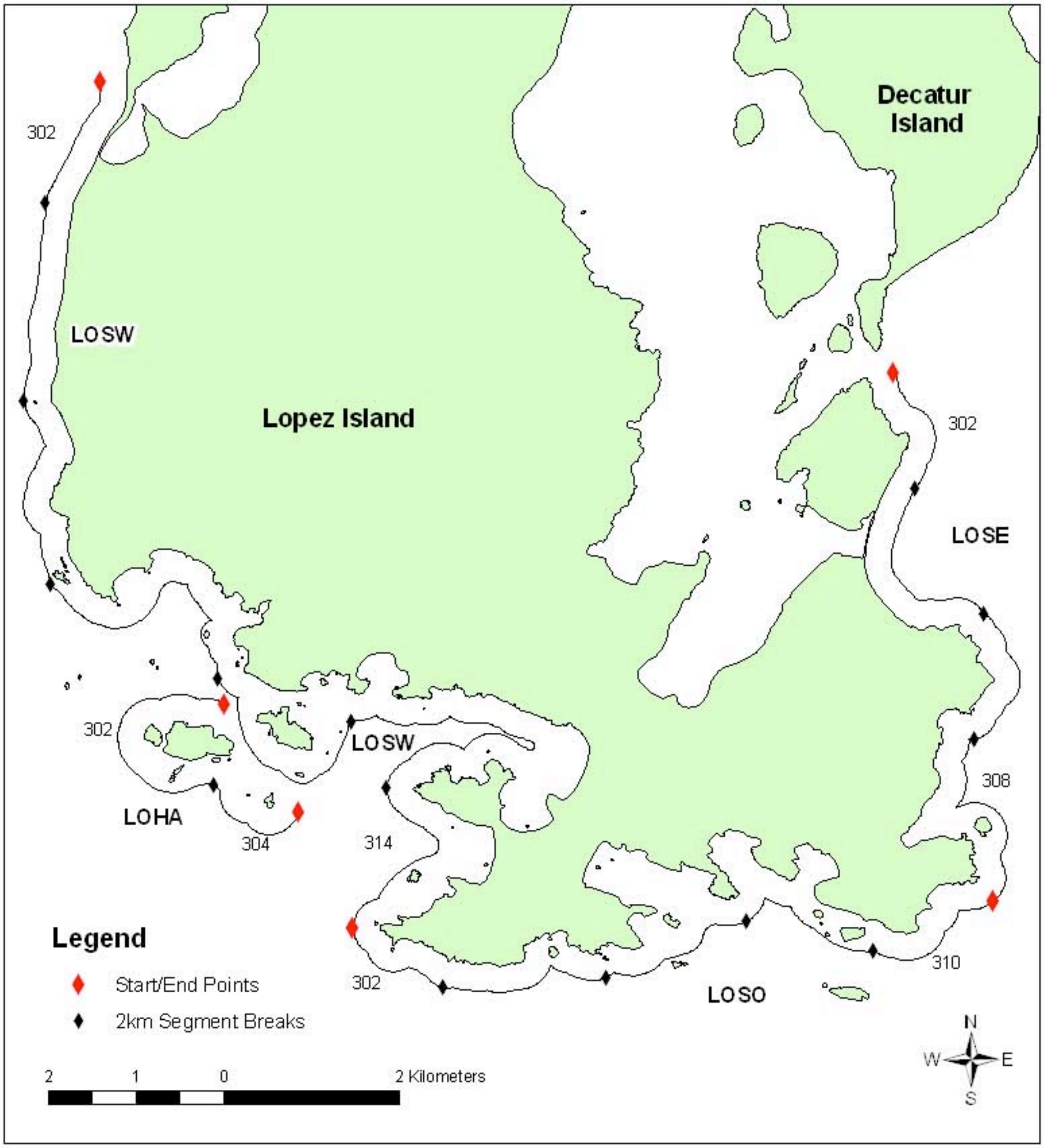
Crane and Wasp Islands

CRAN - Crane Island
WASP - Wasp Islands



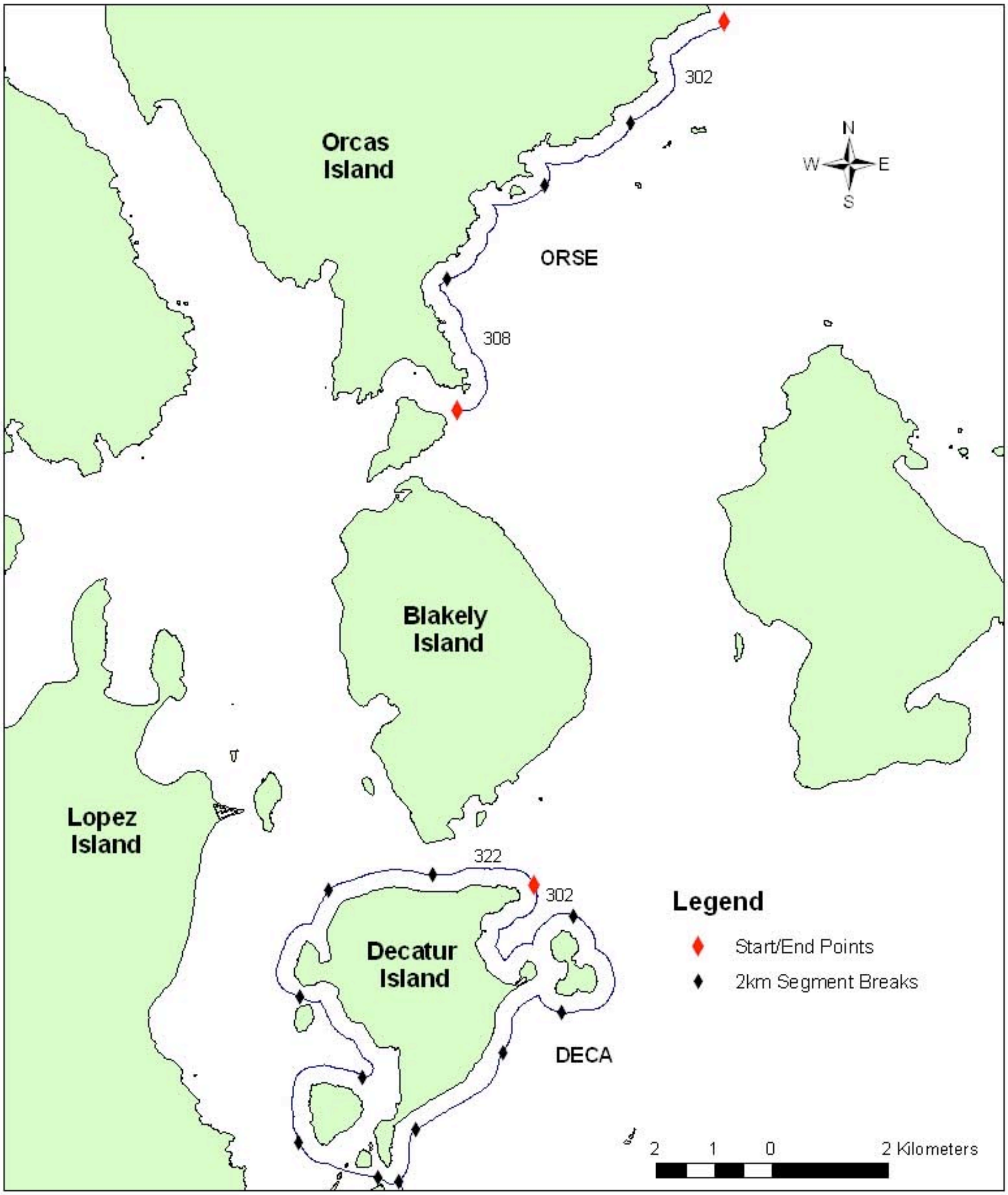
Lopez Island

LOHA - Long and Hat Islands
LOSE - Lopez Southeast
LOSO - Lopez South
LOSW - Lopez Southwest



Southeast Orcas and Decatur Islands

DECA - Decatur Island
ORSE - Orcas Southeast



Analysis

Due to variation in protocol, this study only investigated surveys conducted from 2002 onward. Not all intervals were completed in 2003, so data from that year was discarded as well. Marbled murrelet records from the PNW's "All Species" access dataset were exported and the data were complied according to interval. Eleven separate tables were constructed, one for each interval, listing each segment surveyed and the corresponding sum of marbled murrelets seen across years. This sum was divided by the number of years included in the analysis (8 years) to provide an average. It was then further divided by 2 to arrive at the average number of marbled murrelets seen per km of survey.

Shapefiles for segments were created in ArcMap from 300m Island buffers and "core" data points provided by the Pacific Northwest Research Station. These segments were then linked to the marbled murrelet tables, after which a Hot Spot with Rendering analysis was run to determine significant "hot" and "cold" areas of marbled murrelet concentrations per interval. A distance threshold of 6000m was applied so that values from nearby segments would be included and the end result was not too washed out.

Input Data Files

Shapefiles

"Corepoints" (Source: PNW Olympia Forestry Sciences Laboratory). File was projected from WGS84 to NAD83.

"SJI_Islands" Polygon (Source: PNW Olympia Forestry Sciences Laboratory). File was projected from NAD27 to NAD83.

<u>Access File</u>

"AllSpecies" (Source: PNW Olympia Forestry Sciences Laboratory)

<u>The Process</u>:

<u>Construct Shapefiles</u>

Create File Geodatabase and name "Mamu_IntName" to save all the created point and island shapefiles and tables.

Create Individual Transect point shapefiles

1) Add Field to raw core points shapefile and name "Transect."
2) Perform calculation in new Transect field to equal left, 4 of Identity Field. This provides a list of Transect codes for each point.
3) Select by Attribute: Transect = individual transect code. Make point shapefile for each transect using Data>Export selected features.
4) Name shapefile "Transect_corepoints" for each Transect (ex. DECA_corepoints)

Create Individual Polygons for each island surveyed

1) Use select tool to select individual island
2) Create layer from selected feature and export to shapefile>"Island"
3) Create Buffer:
    a. Buffer island by 300m and select Dissolve All to reflect the survey lines that maintains a 300m distance from shore.
    b. Name shapefile "Island_300mBuff"

Create Individual Segment Lines

1) Create new shapefile and name it according to the transect.

2) Add file to the map. Turn on editor and select new shapefile. Use select tool to select the island's buffer. Copy and Paste. Save edits and turn off editor.
3) XTools Pro>Feature Conversions>Split Polylines
    a. Split polyline based on another file > Select corepoints file
    b. Name new file "Transect_Segments"
4) Add Short Integer field, "Segment."
5) Turn on editor and delete segments that are not part of transect and name each individual segment.
6) If there are more than one line per segment, dissolve on the segment field

Edit Corepoints and Segment File

1) Turn on editor and select modify feature with corepoints file selected
2) Turn on snap feature and snap to the end of polyline feature
3) Drag each corepoint until it snaps to the polyline where each segment starts and ends.
4) Select segment file and edit line by using modify feature and dragging vertices when transect deviates from 300m buffer.
5) Merge all Segment files together and name "Segment Merge"

Query Marbled Murrelet Files

1) Design Query from Access Database where Year >2001 (and does not equal 2003), Interval >2, and Species = Mamu
2) Export to Excel
3) Add Field: Name (Transect&Segment)

4) Add Field : IntName (Interval&Name)
5) Create Pivot Table
    a. IntName in Row Labels
    b. Sum of Numbers Field in Values
    c. Copy and Paste Table into separate worksheet (paste values only)
    d. Create Columns for each category (Interval, Name) using Text to Columns
    e. Create Column and Name Avg Mamu per Km
        i. Divide Sum by 8 to get an average over the 8 years of surveys
        ii. Divide the above number by 2 to get an avg per km for each 2 km segment
6) Filter by Interval and create new table for each Interval, named “Int#”, save in Mamu_IntName database and add to ArcMap

<u>Join Tables</u>

1) Join Segment_Merge to Int# table.
2) Export joined table to database, rename “Segment_Int#”
3) Remove join and repeat for each Interval (11 total).

<u>Create Graduated Symbols</u>

1) Buffer each Segment_Int# file by 300m, dissolve none to create Segment Polygon.
2) XTools Pro>Feature Conversions>Shapes to Centroids to create a center point for each Segment Polygon, name point shapefile “Int#” and save in separate folder named “Centroid”
3) Open Properties of point, Int#
    a. Under Symbology, Select Quantities, Graduated Symbols

b. Apply classification scheme used frequently in other marbled murrelet research papers

Hot Spot Analysis

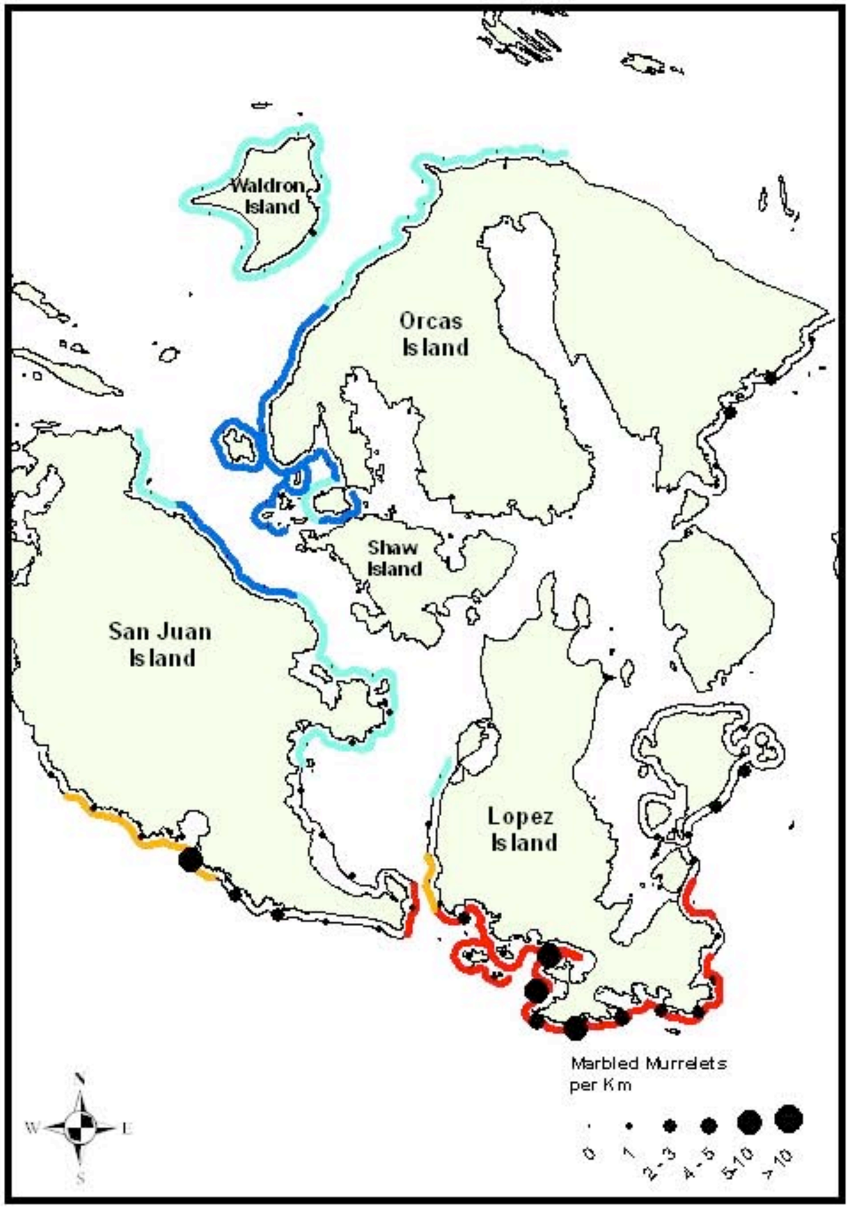
1) Run Hot Spot Analysis with Rendering on each Segment_Int#
    a. Distance Band = 6000m
    b. Name output polyline Int# and save files in separate “HotSpot” folder

Results

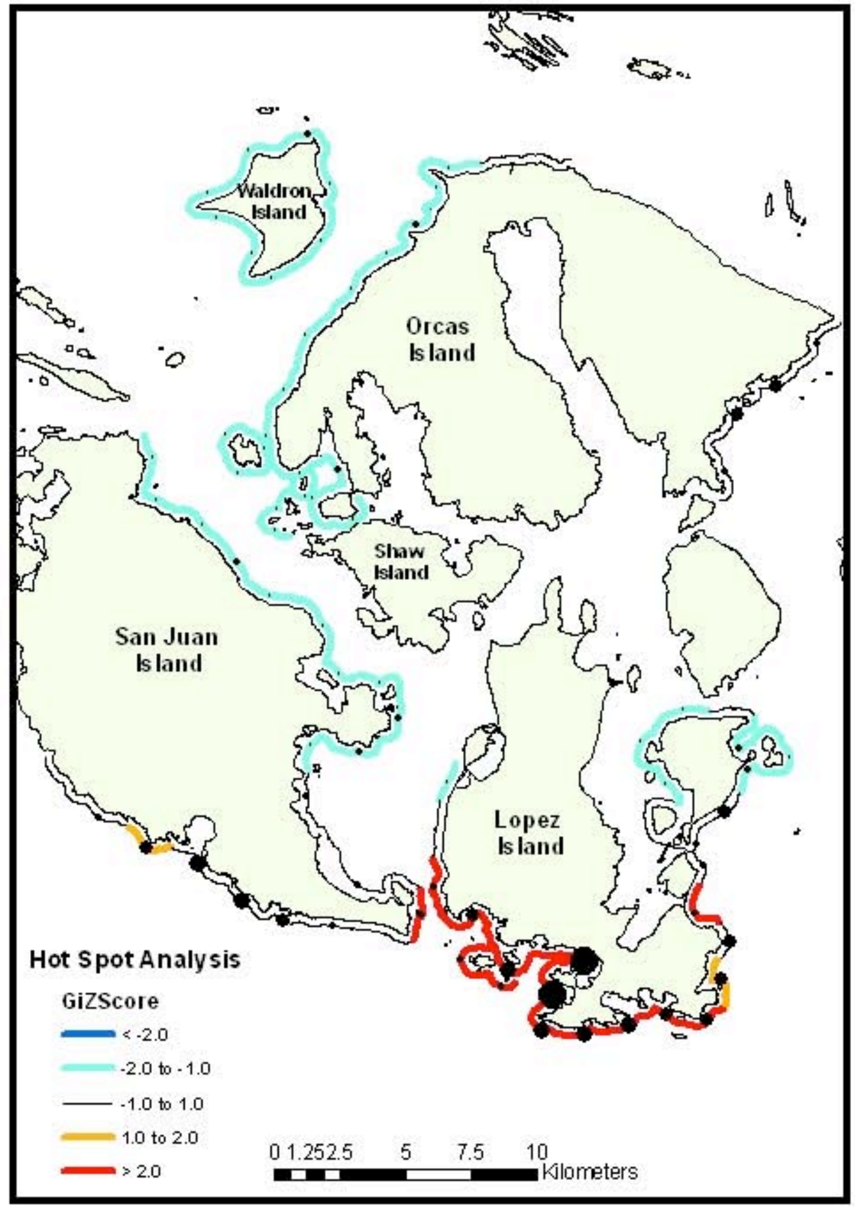
Segments with a GiZScore above 2 and below -2 were considered “hot” and “cold” respectively. Eleven maps were created highlighting hot and cold spot patterns. The maps demonstrated a shift in distribution patterns from the mid May until late August. During Interval 3, hot spots were focused around the south end of Lopez Island. In Interval 7, some hot spots started to appear around the southeast side of Orcas Island in addition to the hot spots at the south end of Lopez. Interval 11 saw a decrease in hot spots around the southeast side of Orcas but an increase in hot spots around San Juan North and the Wasp Islands area (Table 3).

During Intervals 3-7, there were a high number of cold spots (excluding Interval 4) mostly throughout the Wasp Islands area and parts of San Juan North. Intervals 8 and 9 show very few cold spots and Intervals 10-13 show an intermediate amount of cold spots and become more frequent within San Juan Southeast and San Juan Southwest (Table 4).

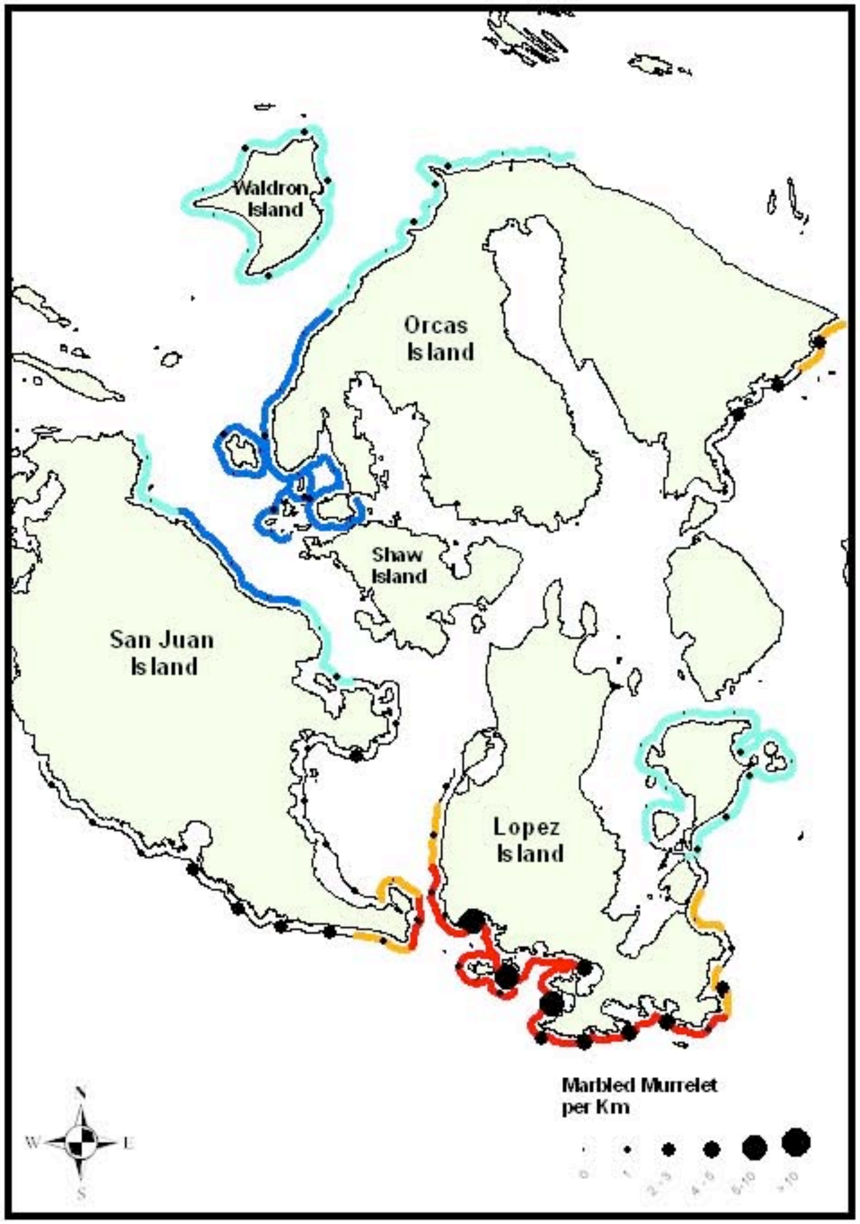
Interval 3 May 12 - May 21



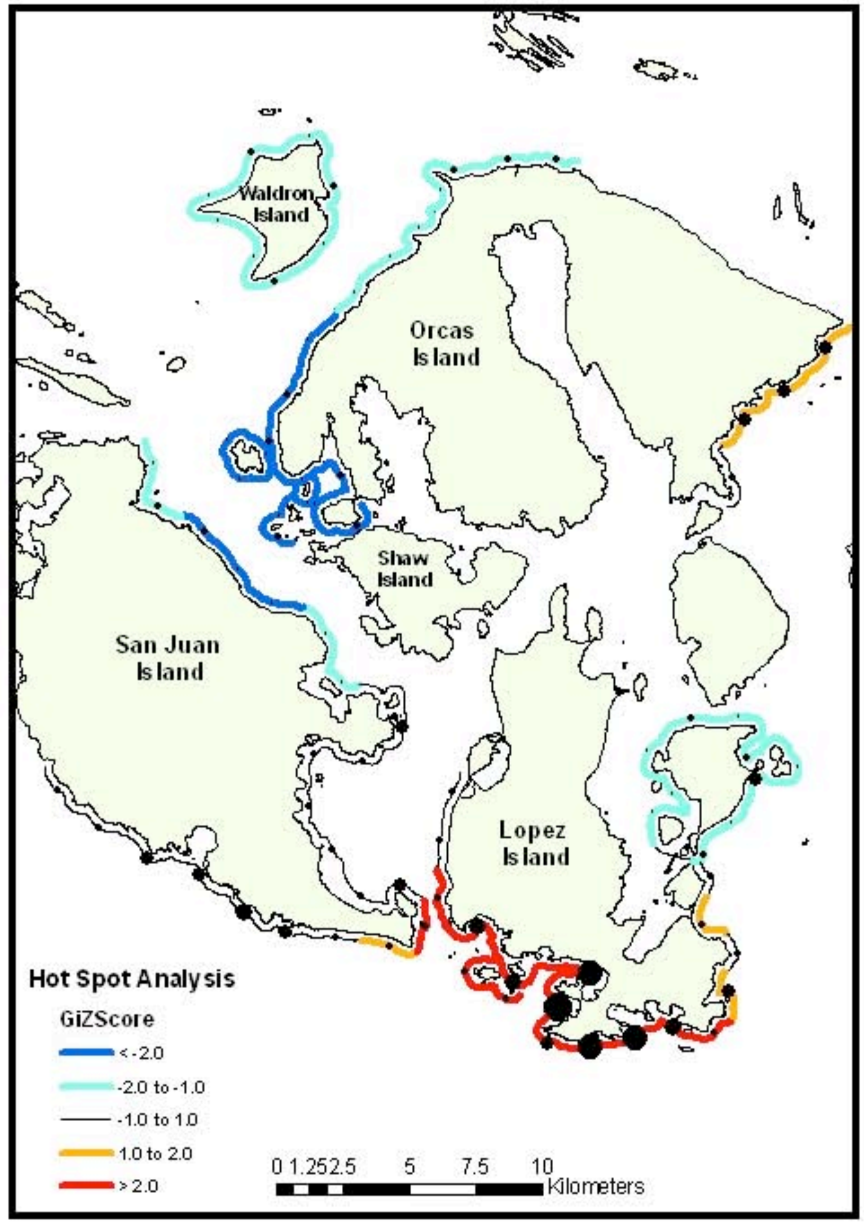
Interval 4 May 22 - May 31



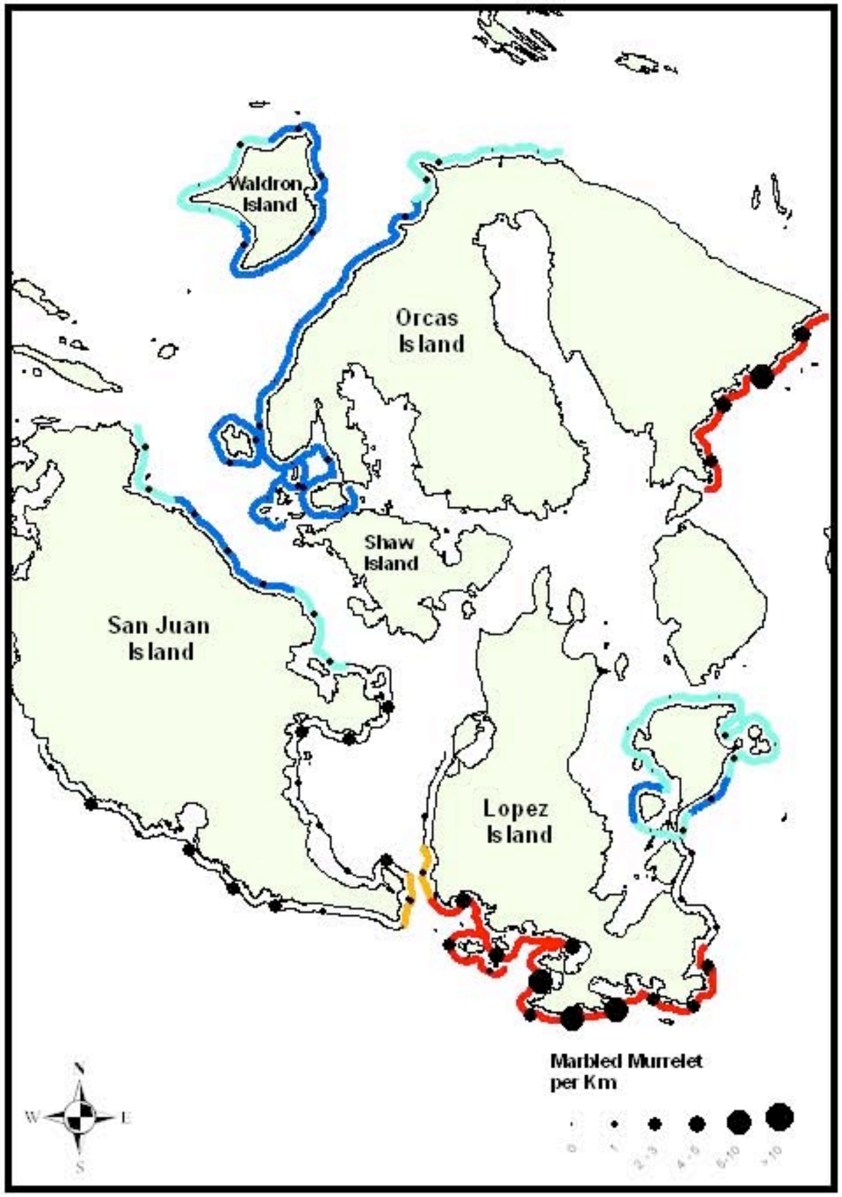
Interval 5 June 1 - June 10



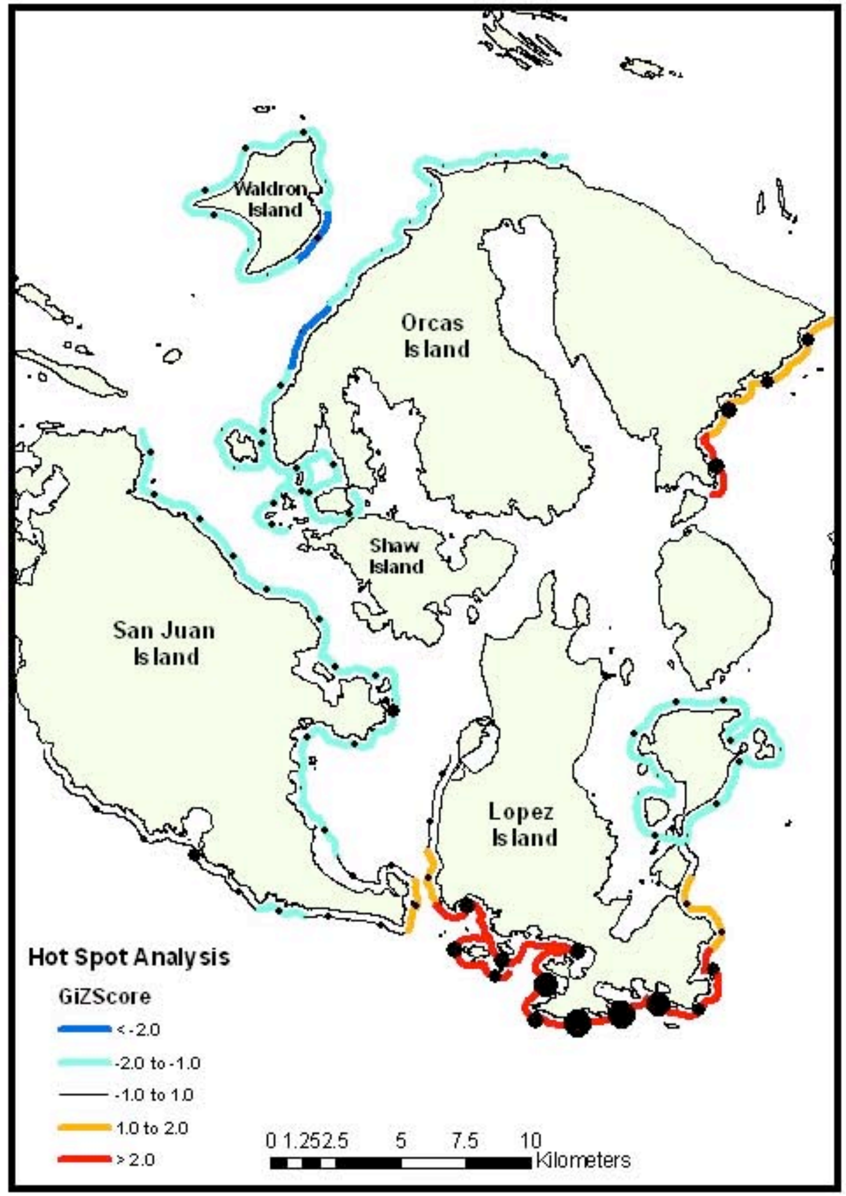
Interval 6 June 11 - June 20



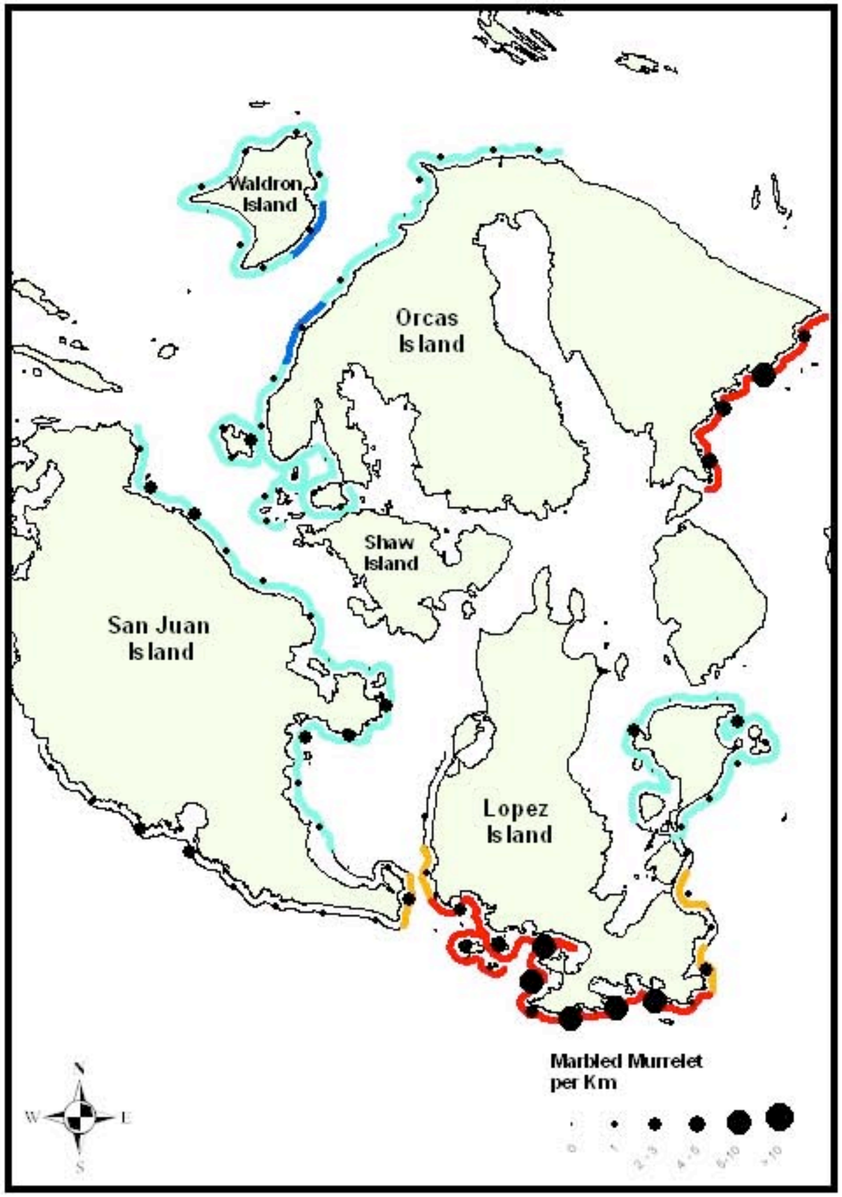
Interval 7 June 21 - June 30



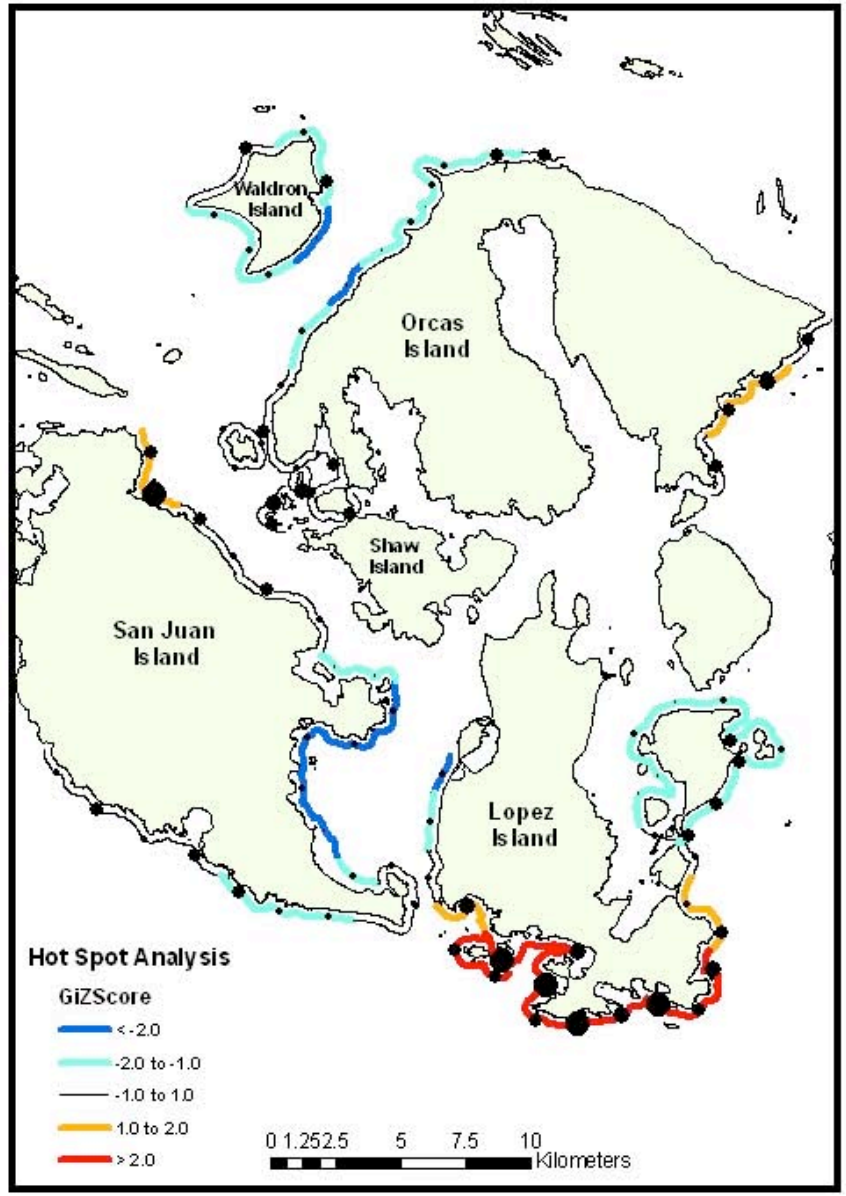
Interval 8 July 1 - July 10



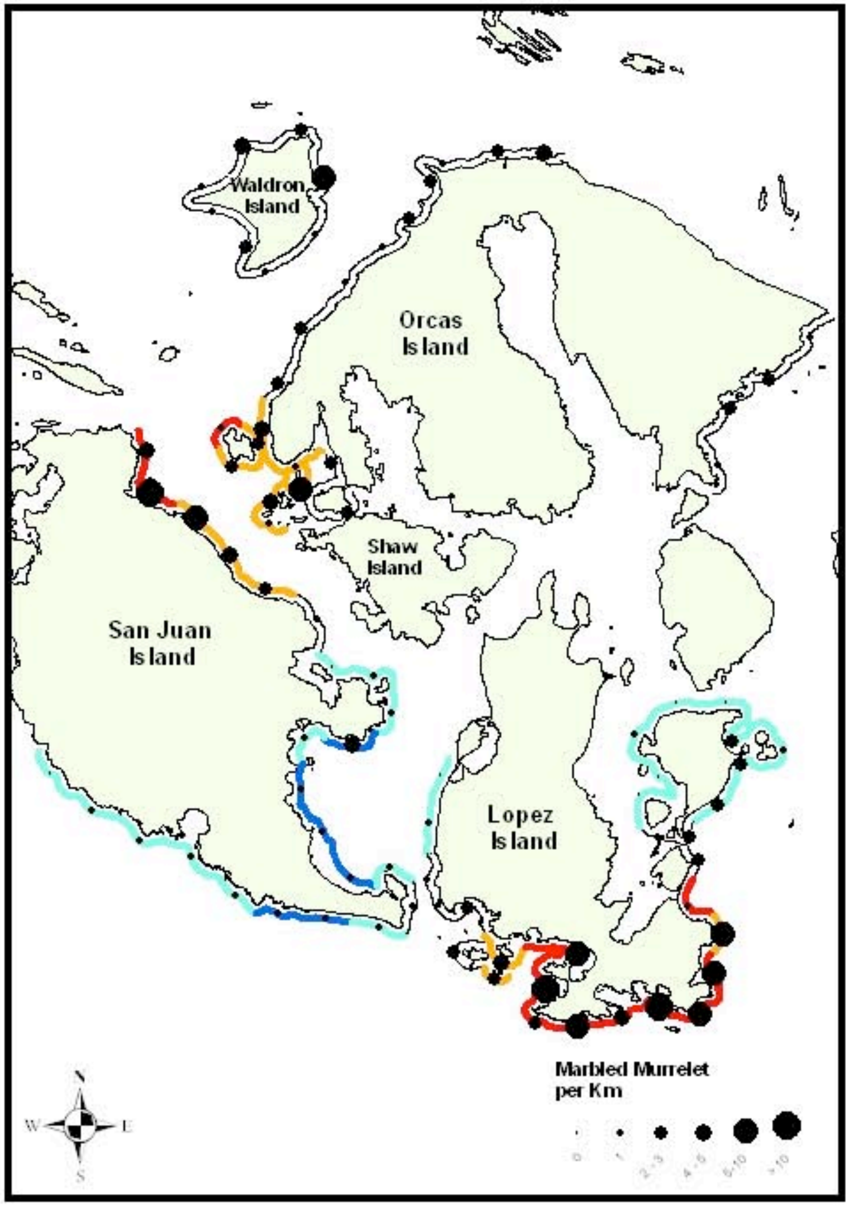
Interval 9 July 11 - July 20



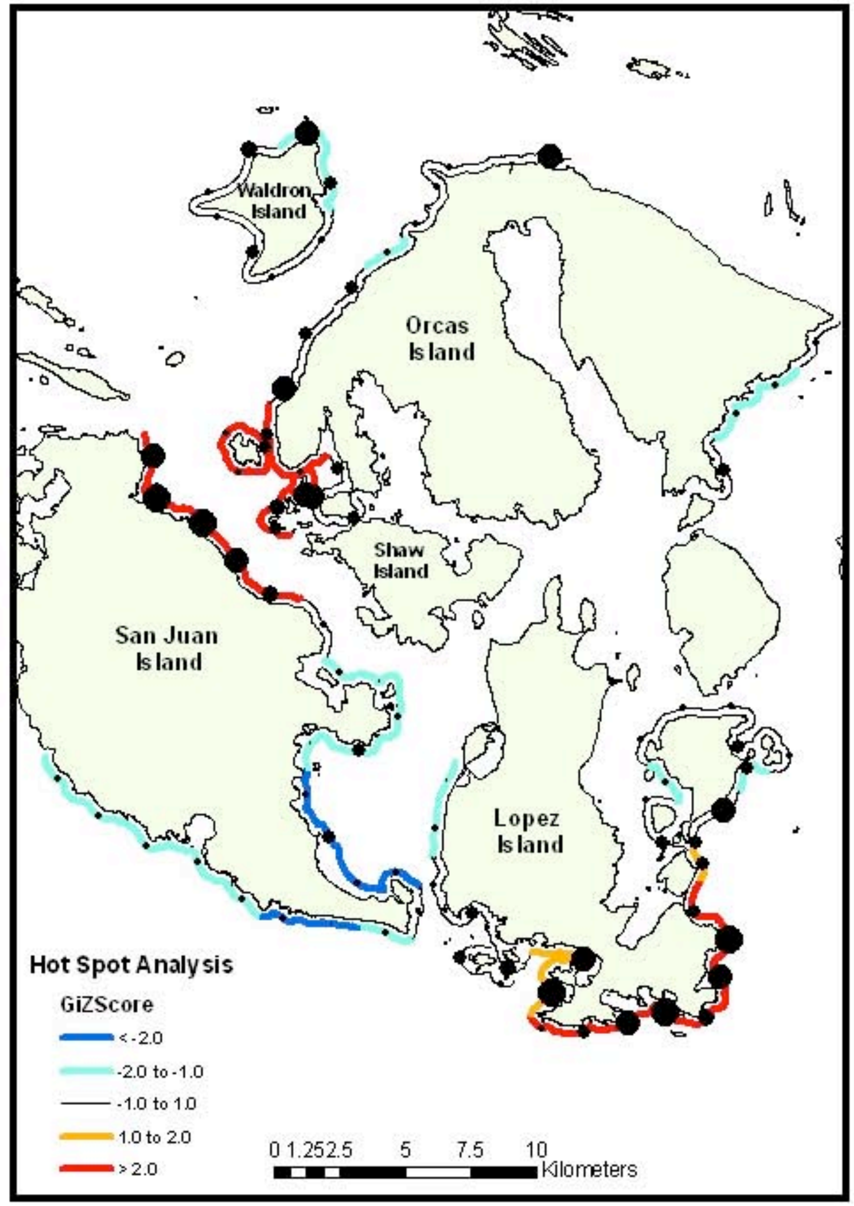
Interval 10 July 21 - July 30



Interval 11 July 31 - August 9



Interval 12 August 10 - August 19



Interval 13 August 20 - August 29

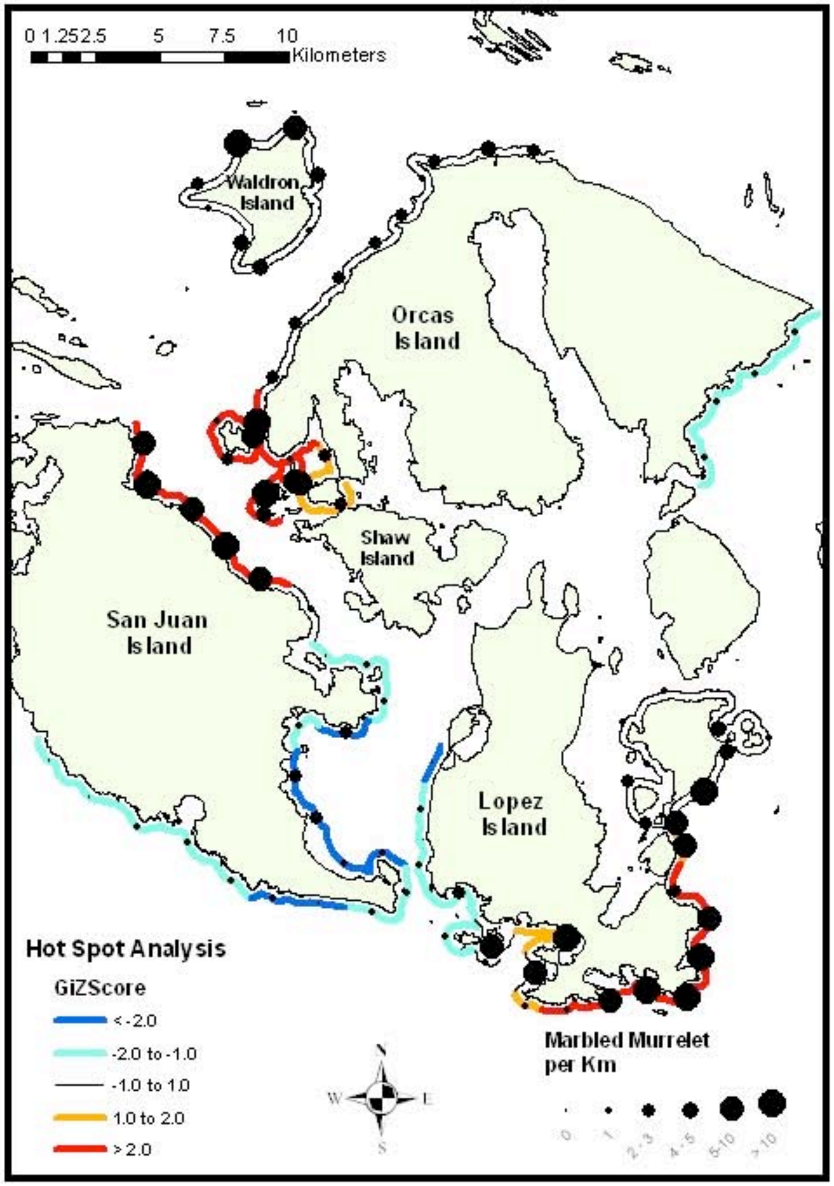


Table 3: Number of Hot Spots and Segments where Hot Spots (GiZScore>2) occurred for each Interval.

Interval	# of Hot Spots	Occurrences of Hot Spots
3	14	LOHA, LOSE304 and 308, LOSO, LOSW308-314, SJSW318
4	14	LOHA, LOSE304, LOSO, LOSW306-314, SJSW318
5	13	LOHA, LOSO, LOSW306-314, SJSW318
6	13	LOHA, LOSO, LOSW306-314, SJSW318
7	16	LOHA, LOSE308, LOSO, LOSW308-314, ORSE
8	13	LOHA, LOSE308, LOSO, LOSW308-314, ORSE308
9	15	LOHA, LOSO, LOSW308-314, ORSE
10	11	LOHA, LOSE308, LOSO, LOSW310-314
11	12	JONE304, LOSE 304 and 308, LOSO, LOSW312-314, SJNO310-312
12	21	JONE, LOSE304-308, LOSO, ORSW304, ORWE302, SJNO304-312, WASP
13	20	JONE, LOSE304-308, LOSO304-310, ORSW304, ORWE302, SJNO304-312, WASP

Table 4: Number of Cold Spots and Segments where Cold Spots (GiZScore< -2) occurred for each Interval.

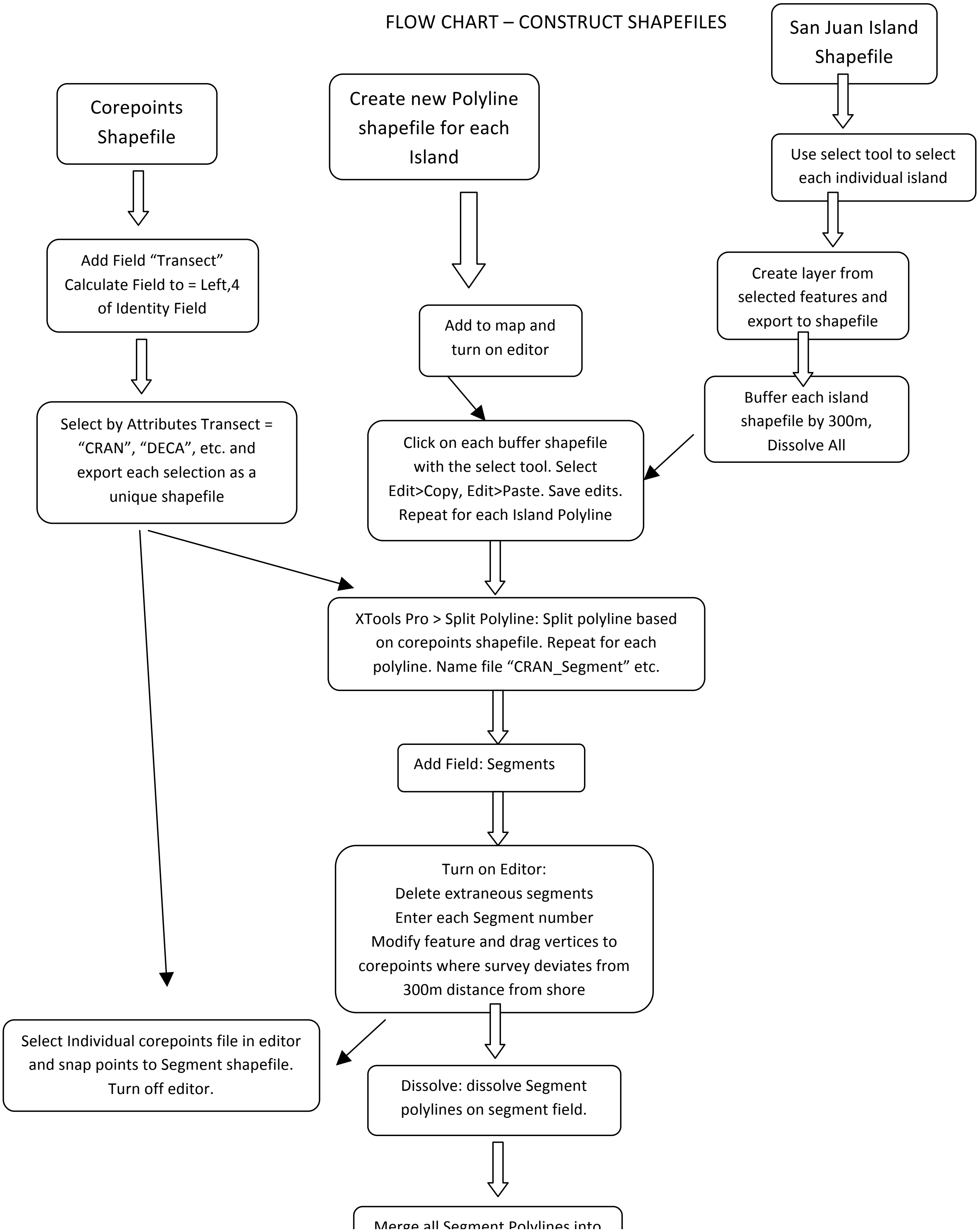
Interval	# Cold Spots	Occurrences of Cold Spots
3	15	CRAN304, JONE, ORSW, ORWE302-306, SJNO304-308, WASP
4	0	
5	16	CRAN, JONE, ORWE302-306, ORSW, SJNO304-308, WASP
6	16	CRAN302, JONE, ORSW304, ORWE306, SJNO304-306, WASP302-304
7	26	CRAN, DECA308 AND 314, JONE, ORSW, ORWE302-312, SJNO304-308, WALD302 AND 310-316, WASP
8	2	ORWE306 and WALD314
9	2	ORWE306 and WALD314
10	8	LOSW302, SJSE306-314, ORWE308, WALD314
11	6	SJSE308 AND 312-316, SJSW312-314
12	6	SJSE312-318, SJSW312-314
13	8	SJSE308 AND 312-318, SJSW312-314, LOSW302

Discussion

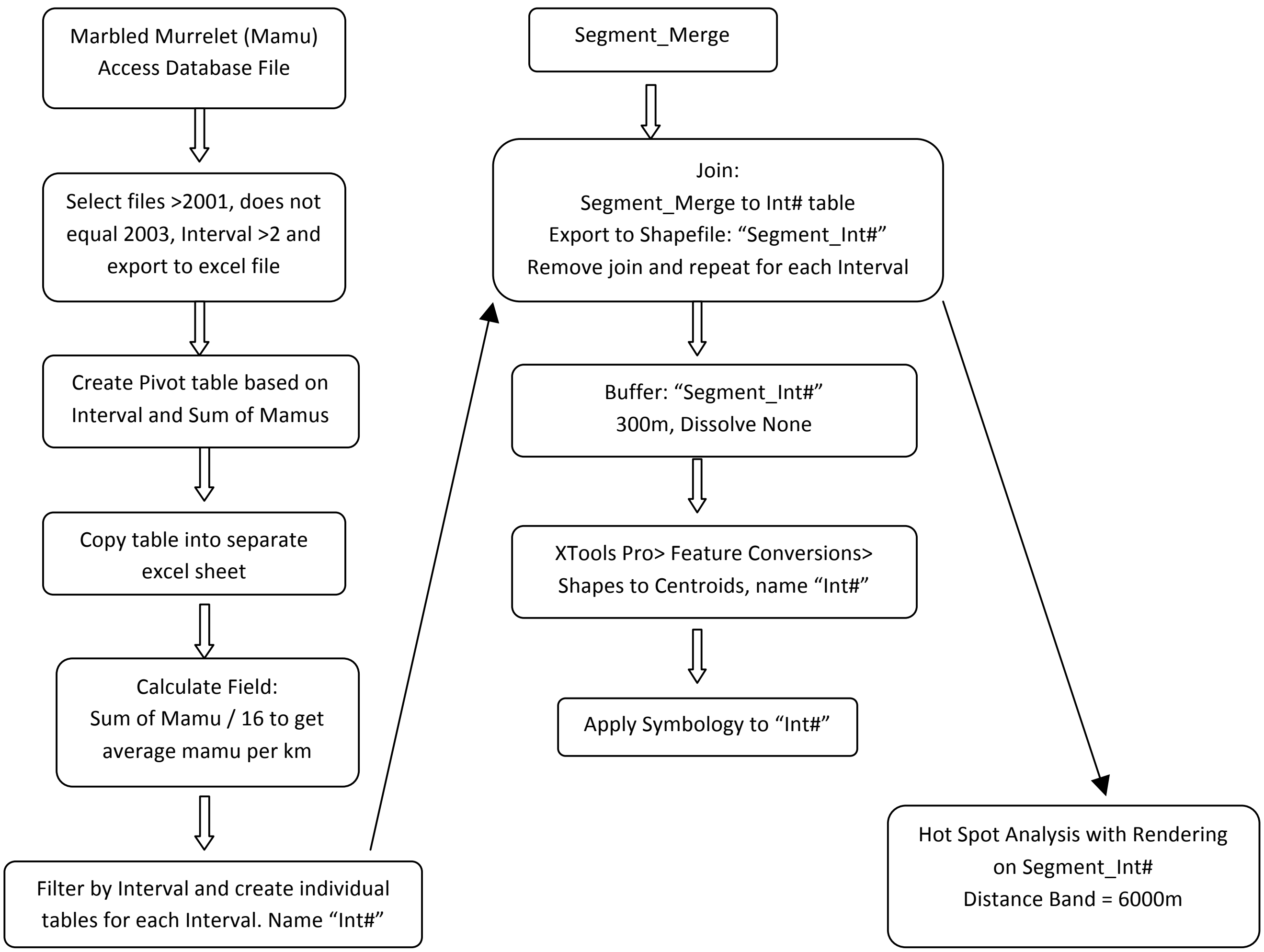
This analysis supports the hypothesis that the distribution of marbled murrelets within the San Juan Islands is spatially significant and the seabirds can be found clumped in certain hot spots. The south end of Lopez appeared to have the highest concentrations of birds, particularly Lopez South. The entire Lopez South transect was consistently identified as a hotspot throughout all intervals excluding LOSO302 in Interval 13. The south end of Lopez appears to be an important area for marbled murrelets and should be analyzed further for contributing environmental factors. Also, San Juan North changed from a cold spot in the beginning of the field season to a significant hot spot by the end of the field season. Analyzing environmental patterns in this particular area for each interval could help elucidate factors that impact marbled murrelet distribution.

This study did not take into account interannual variation, which could impact results. Distribution patterns between years could be especially interesting when investigating El Nino and La Nina years compared to normal years. Also, the hot spot analysis was impacted by the edge effect. Waldron Island appeared to have significant numbers of birds during Intervals 11, 12, and 13, yet never scored a GiZScore greater than 2 during the hot spot analysis. This could be due to the fact that the segments were at the north end of the island, which were along the northern edge of the survey area. Lastly, murrelet data is recorded to the scale of the segment line. If more detailed locations were collected on each bird, a more accurate hot spot analysis could be run.

FLOW CHART – CONSTRUCT SHAPEFILES



FLOW CHART – ANALYSIS



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