Exxon Valdez Oil Spill
Restoration Project Final Report

Common Murre Population Monitoring at the Chiswell Islands, Alaska, 2001

Restoration Project 01144
Final Report

This final report was prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program to assess project progress. Peer review comments have been addressed in this version of the report.

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Study History: *Exxon Valdez* Oil Spill Trustee Council-sponsored common murre damage assessment studies were initiated at the Chiswell Islands in 1989 as part of Department of Interior - Fish and Wildlife Service (DOI-FWS) Bird Study No. 3 (Population surveys of seabird nesting colonies in Prince William Sound, the outside coast of the Kenai Peninsula, Barren Islands, and other nearby colonies, with emphasis on changes in numbers and reproduction of murres). Three progress reports were produced during the damage assessment work (Nysewander and Dipple 1990, 1991; Dipple and Nysewander 1992), and a final report on the 1989-1991 work was completed in 1993 (see Nysewander *et al*. 1993, Effects of the *T/V Exxon Valdez* oil spill on murres: A perspective from observations at breeding colonies). In 1992, murre monitoring studies continued at the Chiswell Islands as part of Restoration Project No. 11 (see Dragoo *et al*. 1995, Effects of the *T/V Exxon Valdez* oil spill on murres: A perspective from observations at breeding colonies four years after the spill). In 1998 and 2001, Projects 98144 and 01144 recensused the Chiswell Islands murre colonies to obtain new information on this injured population (see Roseneau *et al.* 1999, Common murre population monitoring at the Chiswell Islands, 1998; and this report).

Abstract: We censused the Chiswell Islands murre colonies three years after the last population counts were made using the same methods used during the 1998 restoration monitoring project. Counts were pooled with the 1998 estimate and earlier 1989-1992 U.S. Fish and Wildlife Service and 1991 Dames & Moore scores, and analyzed for trends. Results were similar to 1998: the average score was almost the same as our earlier estimate, which strengthened the previously discovered negative trend. The 2001 data confirmed that a population decline had occurred sometime after 1992, and comparing numbers of birds by island and year indicated that the decline did not result from changes at just one of the colonies. Similarities between the 1998 and 2001 estimates also suggested that population size remained relatively stable after 1998.

Key Words: Chiswell Islands, common murres, *Exxon Valdez*, Gulf of Alaska, oil spill, population monitoring, Prince William Sound, restoration monitoring, thick-billed murres, *Uria aalge, Uria lomvia.*

Project Data: Data are archived in Microsoft Excel and Word spreadsheets and are stored at the Alaska Maritime National Wildlife Refuge headquarters in Homer, Alaska. Copies can be obtained from the authors.

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EXECUTIVE SUMMARY

Introduction

Several breeding concentrations of common murres *(Uria aalge)* were located in the northwestern Gulf of Alaska downstream of the T/V *Exxon Valdez* oil spill. When winds and currents swept oil through the region during April-May 1989, many of these seabirds were killed: they comprised 74% of 30,000 bird carcasses recovered by 1 August. Based on this information and a computer modeling study, estimates of total bird mortality suggested that 74,000-315,000 murres died after contacting floating oil. Because the impact of the spill on common murres appeared to be severe, the U.S. Fish and Wildlife Service (FWS) censused murres at the Chiswell Islands in 1989-1992. Dames & Moore (D&M) biologists also counted birds at this six-island nesting complex in 1991 during an Exxon-sponsored project.

We censused the Chiswell Islands murre colonies in 1998, six years after the last population counts were made, and found a negative trend over the 10-year postspill interval. We also discovered that our 1998 count was significantly lower than the average of the 1989-1992 scores. However, bird numbers were much lower at one of the colonies, compared to previous years, and when this island (Beehive B) was excluded from the analyses, the negative trend and difference between our 1998 count and the average of the 1989-1992 scores disappeared. These results, coupled with other information on murre attendance at the Chiswell and Barren islands, suggested that our 1998 population estimate was artificially low and may not have accurately reflected the number of birds breeding at the Chiswell Islands nesting complex.

In 2001, we censused murres at the Chiswell Islands to see if the population had changed since our last survey. Results were similar to 1998: the average score was almost the same as our earlier estimate, which strengthened the previously discovered negative trend (see Roseneau *et al.* 1999a). The 2001 data confirmed that a population decline had occurred sometime after 1992, and comparing numbers of birds by island and year indicated that the decline did not result from changes at just one of the colonies (i.e., Beehive B; see Roseneau *et al.* 1999a). Similarities between the 1998 and 2001 estimates also suggested that population size remained relatively stable after 1998.

Objectives

Our objective was to test the null hypothesis that murre populations have not increased at the Chiswell Islands nesting colonies since 1989, the year of the spill.

Methods

Data were collected and analyzed by the same methods used during the 1998 Chiswell Islands common murre population monitoring study and were comparable with those used during earlier 1989-1992 Chiswell Islands projects. Results were pooled with earlier 1989-1998 FWS and D&M estimates, and tested for trends and differences between year-groups with linear regressions and 2-tailed *t*-tests. Simulations were also run to predict numbers of surveys and years needed at different survey intervals to detect significant positive trends in northern Gulf of Alaska murre populations using a computer program written by T. Gerrodette.

Results

When we pooled our six-island estimate of 1,951 birds with the respective 1989-1998 scores of 2,613, 2,348, 2,628, 2,481 and 1,884 individuals and tested them for trends, the negative trend found in 1998 strengthened ($P = 0.01$ vs. $P = 0.04$ in 1998). After plotting the count data by island and year, it was evident that the population decline did not result from changes at just one

of the colonies. Although numbers of birds were considerably smaller at Beehive B in 1998 and 2001 than during the previous years, fewer birds were also present at Natoa and Matushka islands, while larger numbers were present at Chiswell Island. Results from computer simulations indicated that if the murre population was increasing at 8% per year, seven consecutive annual surveys at five replicate counts per nesting season would be needed detect a significant positive trend at the 0.1 level, and if the birds were increasing at 13% per year, five consecutive annual surveys at five replicate counts per season would be required to identify similar changes in population numbers. Significant trends could also be detected for both rates of increase in 12 years, if population censuses were made at three-year intervals.

Discussion

No evidence was found to indicate that the Chiswell Islands murre population had increased since 1989, the year of the spill. Instead, our six-island analyses confirmed that numbers of birds declined sometime after 1992 and remained relatively stable after 1998. In our previous study, we suggested that a change in attendance at one colony (Beehive B) was probably responsible for most of the post-1992 decline. However, an island-by-island comparison indicated that was not the case. Murre numbers were smaller at Natoa, Matushka, and Beehive B islands and larger at Chiswell island, compared to previous years, suggesting that the decline was probably population-wide. Based on our computer simulations, censusing murres at the Chiswell Islands at three-year intervals appeared to be the most cost-effective way to monitor future changes in numbers. If population counts followed this schedule and were initiated in 2004, significant trends could be detected by 2013.

Conclusions

No evidence was found to indicate that the Chiswell Islands murre population increased after 1989, the year of the spill. Instead, results indicated that the population declined sometime after 1992 and remained relatively stable after 1998.

Recommendations

Starting in 2004, the Chiswell Islands common murre colonies should be censused at three-year intervals until a significant positive trend is clearly evident in population numbers. Counting the six-island nesting complex on a three-year schedule will provide important information on the recovery of this injured population and the species in the spill area.

INTRODUCTION

Several breeding concentrations of common murres *(Uria aalge)* were located in the northwestern Gulf of Alaska downstream of the T/V *Exxon Valdez* oil spill (e.g., Sowls *et al.* 1978, Piatt *et al*. 1990, FWS 1994). When winds and currents swept oil through the region during April-May 1989, many of these seabirds were killed: they comprised 74% of 30,000 bird carcasses recovered by 1 August (see Piatt *et al.* 1990).[1] Based on this information and a computer modeling study, estimates of total bird mortality suggested that 74,000-315,000 murres died after contacting floating oil (see Piatt *et al.* 1990, ECI 1991). Because the impact of the spill on common murres appeared to be severe, the U.S. Fish and Wildlife Service (FWS) censused murres at the Chiswell Islands in 1989-1992 (e.g., Nysewander and Dipple 1990, 1991; Dipple and Nysewander 1992; Nysewander *et al.* 1993; Dragoo *et al.* 1995). Dames & Moore (D&M) biologists also counted birds at this six-island nesting complex in 1991 during an Exxon-sponsored project (see Erikson 1995).

We censused the Chiswell Islands murre colonies in 1998, six years after the last population counts were made, and found a negative trend over the 10-year postspill interval (see Roseneau *et al.* 1999a). We also discovered that our 1998 count was significantly lower than the average of the 1989-1992 scores. However, numbers of birds were much lower at one of the colonies, compared to previous years, and when this island (Beehive B) was excluded from the analyses, the negative trend and difference between our 1998 count and the average of the 1989-1992 scores disappeared. These results, coupled with other information on murre attendance at the Chiswell and Barren islands, suggested that our 1998 population estimate was artificially low and may not have accurately reflected the number of birds breeding at the Chiswell Islands nesting complex.

In 2001, we censused murres at the Chiswell Islands again to see if the population had changed since our last survey. Results were similar to 1998: the average score was almost the same as our earlier estimate, which strengthened the previously discovered negative trend (see Roseneau *et al.* 1999a). The 2001 data confirmed that a population decline had occurred sometime after 1992, and comparing numbers of birds by island and year indicated that the decline did not result from changes at just one of the colonies (i.e., Beehive B; see Roseneau *et al.* 1999a). Similarities between the 1998 and 2001 estimates also suggested that population size remained relatively stable after 1998.

OBJECTIVES

Our objective was to test the null hypothesis that murre populations have not increased at the Chiswell Islands nesting colonies since 1989, the year of the spill.

METHODS

The Chiswell Islands are located at about 59° 37' N, 149° 31' W, along the southeastern coast of the Kenai Peninsula near the entrances to Aialik and Resurrection bays (Fig. 1). Study sites included Natoa, Matushka, Chiswell, Chiswell B, Beehive, and Beehive B islands (Fig. 2). We used the M/V *Surfbird*, a 21-m-long FWS research vessel, as a base of operations to support our 19-27 July field work. Data were collected and analyzed by the same methods used during our 1993-1999 Barren Islands and 1998 Chiswell Islands common murre population monitoring projects (see Roseneau *et al.* 1995, 1996a, 1997a, 1998a, 1999a, 2000a), and were comparable to those used by the 1989-1992 FWS and 1991 D&M Chiswell Islands studies.

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[1] Seventy percent of the murre carcasses were common murres (Piatt *et al.* 1990; J.F. Piatt, pers. comm.).

We counted murres from an outboard-powered inflatable raft with the aid of 7 x 42 binoculars and hand-held tally meters (see Roseneau *et al.* 1999a). During the work, we allowed the raft to drift slowly past the nesting cliffs at distances of 30-50 m. Although distances between birds and observers varied depending on the height and configuration of cliffs and other factors (e.g., presence of offshore rocks), we kept this variable as consistent as possible among counts, including those made in 1998.

We based census dates and times of day for making counts (23-27 July and 1100-2000 hrs Alaska Daylight Time, respectively) on attendance and nesting chronology data from earlier Barren Islands studies (see Roseneau *et al.* 1995, 1996a,1996b, 1997b, 1999b, 2000b) and other work (see Byrd 1989, Hatch and Hatch 1989). During the counts, we arbitrarily divided the nesting cliffs into small, manageable sections and simultaneously counted birds on them by 1's.[1] One person recorded the scores without revealing his or her own count to the other observer and compared the scores to see if they were within 10% of each other (i.e., within 5% of their average). If they were not, the cliff sections were recounted until both scores fell within this range.[2]

We counted all of the murres on the six study islands on five different fair-weather days (23, 24, 25, 26, and 27 July) and calculated one-day totals for the six-island nesting complex. Our six-island estimate was derived by averaging the five scores. We pooled the six-island score with the respective 1998 and 1989-1992 FWS and 1991 D&M estimates (see Roseneau *et al.* 1999a; Nysewander and Dipple 1990, 1991; Dipple and Nysewander 1992; Nysewander *et al.* 1993, Dragoo *et al.* 1995; Erikson 1995), and checked them for trends with linear regression (the single 1991 D&M estimate was treated as an additional count and averaged with the 1991 FWS scores). We used the 0.1 significance level to increase the power of the test and reduce Type II error (the 0.9 confidence interval was adequate for our purposes; see Roseneau *et al.* 1996a 1997a, 1998a, 1999a, 2000a).

We also calculated numbers of birds island-by-island and plotted these values for each year in the count record to see if changes in population size could be tied to one particular colony (e.g., Beehive B, Fig. 2; see Roseneau *et al.* 1999a).

We also ran a series of simulations to predict numbers of surveys and years needed at different survey intervals to detect significant positive trends in northern Gulf of Alaska murre populations using an updated version of the TRENDIO computer program written by T. Gerrodette (i.e., see Gerrodette 1987). We based the simulations on the 1989-2001 Chiswell Islands and 1990-1999 Barren Islands East Amatuli Light Rock and Nord Island – Northwest Islet population counts (see Roseneau *et al*. 1999a and 2000a, respectively), and used the following variables and assumptions: a) rates of change were set at 8% and 13% per year; b) the coefficient of variation was set at 10%; c) Alpha (α) and Beta (β) levels were set at 0.1 and 0.9, respectively; and d) murre populations were assumed to grow exponentially.

RESULTS

We counted the Chiswell Islands murre colonies on five different days and estimated that 1,951 birds were present at the Natoa, Matushka, Chiswell, Chiswell B, Beehive, and Beehive B island nesting cliffs (Table 1, Appendices 1-6). After pooling our average six-island score with the respective 1989-1992 and 1998 estimates of 2,613, 2,348, 2,628, 2,481, and 1,884 individuals, we ran a linear regression to check for trends, just as we did during our previous study (see Roseneau *et al.* 1999a). As expected, the results were significant: the negative trend found in

[1] We also counted murres on the water within 150 m of the colonies by 1's and 10's because of historical precedent (e.g., similar counts were made during the 1989-1992 FWS studies for comparison with corresponding prespill estimates).

[2] Recounting birds on sections of cliffs because of discrepancies between observers was rarely necessary.

1998 strengthened with the addition of the relatively low 2001 count (see Table 1 and Fig. 3a; slope of linear regression, $r^2 = 0.82$, $P = 0.01$ vs. $r^2 = 0.80$, $P = 0.04$ in 1998).

When we plotted the murre count data by island and year, it was evident that the population decline did not result from changes at just the Beehive B colony (Fig. 3b; also see Roseneau *et al.* 1999a). Although numbers of birds were considerably smaller at Beehive B in 1998 and 2001 than during the previous years, fewer birds were also present at Natoa and Matushka islands, and larger numbers were present at Chiswell Island.

Results from our computer simulations indicated that if the Chiswell Islands murre population was increasing at 8% per year, seven consecutive annual surveys at five replicate counts per nesting season would be needed to detect a significant positive trend at the 0.1 level (i.e., 90% power; see Appendix 7), and if the birds were increasing at 13% per year, five consecutive annual surveys at five replicate counts per season would be required to identify similar changes in population numbers. Significant trends could also be detected for both rates of increase in 12 years, if population censuses were made at three-year intervals (i.e., at both the 8% and 13% levels; results were the same for these values because of rounding). Counts made at five-year intervals would need 15 and 20 years to identify similar changes, respectively.

DISCUSSION

No evidence was found to indicate that the Chiswell Islands murre population increased after 1989, the year of the spill. Instead, our six-island analysis helped confirm that numbers of birds declined sometime after 1992 (see Fig. 3a and Table 1). Also, the similarity between our 1998 and 2001 estimates suggested that murre numbers remained relatively stable at this northern Gulf of Alaska nesting location after 1998.

In our 1998 study, we suggested that a change in attendance at Beehive B was probably responsible for most of the post-1992 decline (see Roseneau *et al.* 1999a). However, based on the 2001 counts and our island-by-island comparisons, that did not appear to be the case. Indeed, the fact that murre numbers were smaller at Natoa, Matushka, and Beehive B islands and larger at Chiswell island, compared to previous years (see Fig. 3b and Table 1) suggested that the decline was probably population-wide.

Based on our computer simulations, censusing murres at the Chiswell Islands at three-year intervals appeared to be the most cost-effective way to monitor changes in bird numbers (see Appendix 7). If population counts followed this schedule and were initiated in 2004, significant trends could be detected by 2013 (i.e., the 12th year after our 2001 census).

CONCLUSIONS

No evidence was found to indicate that the Chiswell Islands murre population increased after 1989, the year of the spill. Instead, results indicated that the population declined sometime after 1992 and remained relatively stable after 1998.

RECOMMENDATIONS

Starting in 2004, the Chiswell Islands common murre colonies should be censused at three-year intervals until a significant positive trend is clearly evident in population numbers. Counting the six-island nesting complex on a three-year schedule will provide important information on the recovery of this injured population and the species in the spill area.

ACKNOWLEDGMENTS

We would like to thank Barbara L. Slater for helping us count the Chiswell Islands murre colonies. Our thanks also go to Philip Schempf and Captain Joe McClung of the FWS Raptor Management Office in Juneau. Phil arranged for our use of the M/V *Surfbird*, and Joe gave us valuable assistance while sailing under his command. Joe's maritime expertise and willingness to help contributed significantly to the overall safety and success of the field work. Kris Thorsrud and Belinda Dragoo, AMNWR headquarters, monitored our daily radio and satellite calls, and helped us with logistical needs. The study was funded by the *Exxon Valdez* Oil Spill Trustee Council, as part of their ongoing restoration monitoring effort. Additional support was provided by AMNWR.

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Table 1. Average counts of murres at the Chiswell Islands, Alaska, 1989-2001.

Year	Natoa Island	Matushka Island	Chiswell Island	Chiswell B Island	Beehive Island	Beehive B Island	Total (6 Islands)	SD (n)[a]
1989[b]	267	1,076	375	274	93	528	2,613	---- (1)
1990[b]	424	507	251	329	212	624	2,348	168 (3)
1991[c]	480	951	350	326	83	440	2,628	534 (5)
1992[d]	378	954	330	227	81	512	2,481	149 (2)
1998[e]	198	685	612	225	89	74	1,884	232 (5)
2001[f]	169	642	664	275	62	139	1,951	122 (5)

Regression Analysis: Count vs. Year (Significance Level = 0.1)

Chiswell Murre Colonies: 6 Islands
(Natoa, Matushka, Chiswell, Chiswell B, Beehive, & Beehive B)

$r^2 = 0.82$, H_o: Slope = 0, $P = 0.01$ (n = 5)

[a] SD = standard deviation; (n) = number of counts.

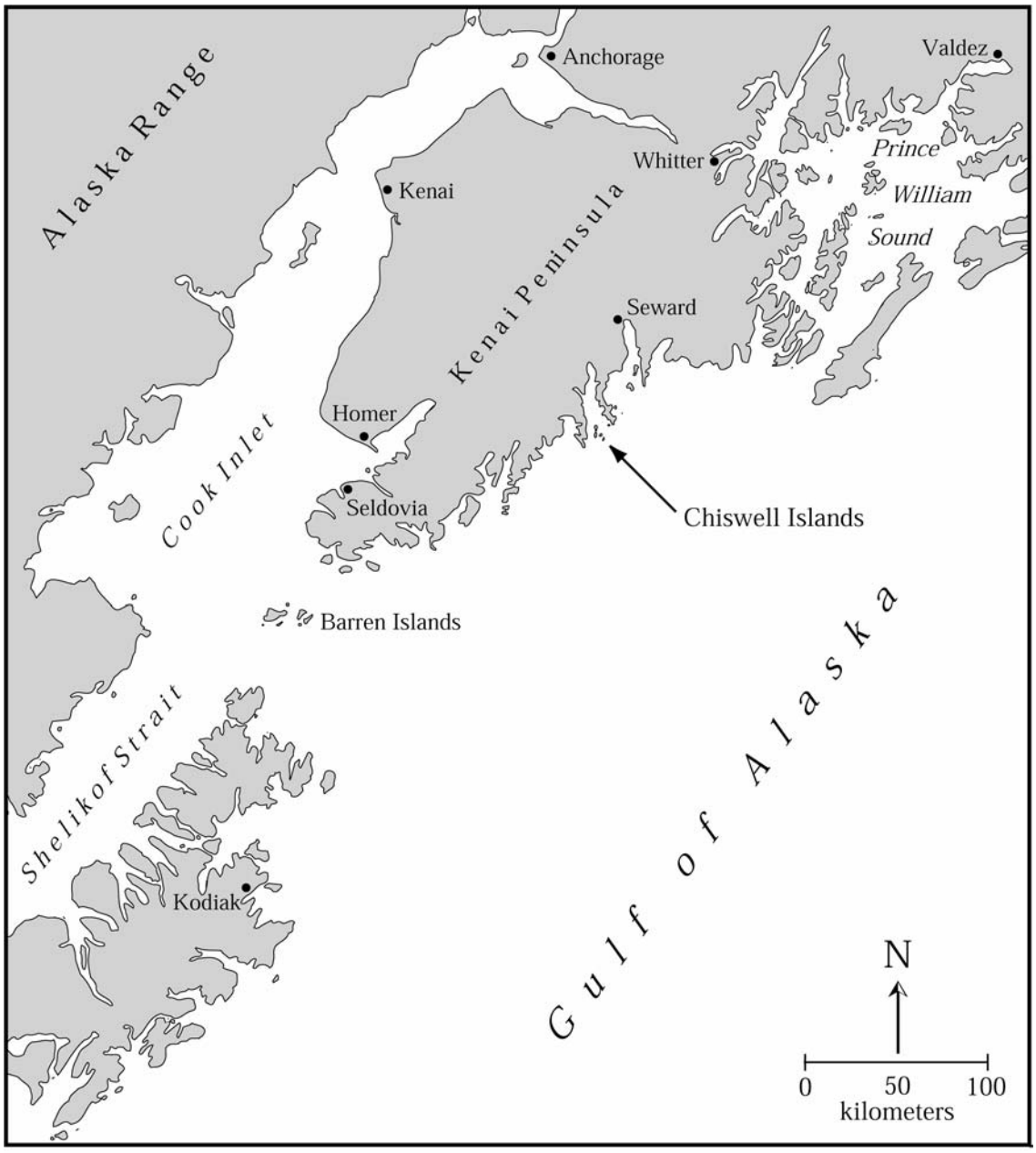

Figure 1. Location of the Chiswell Islands, Alaska.

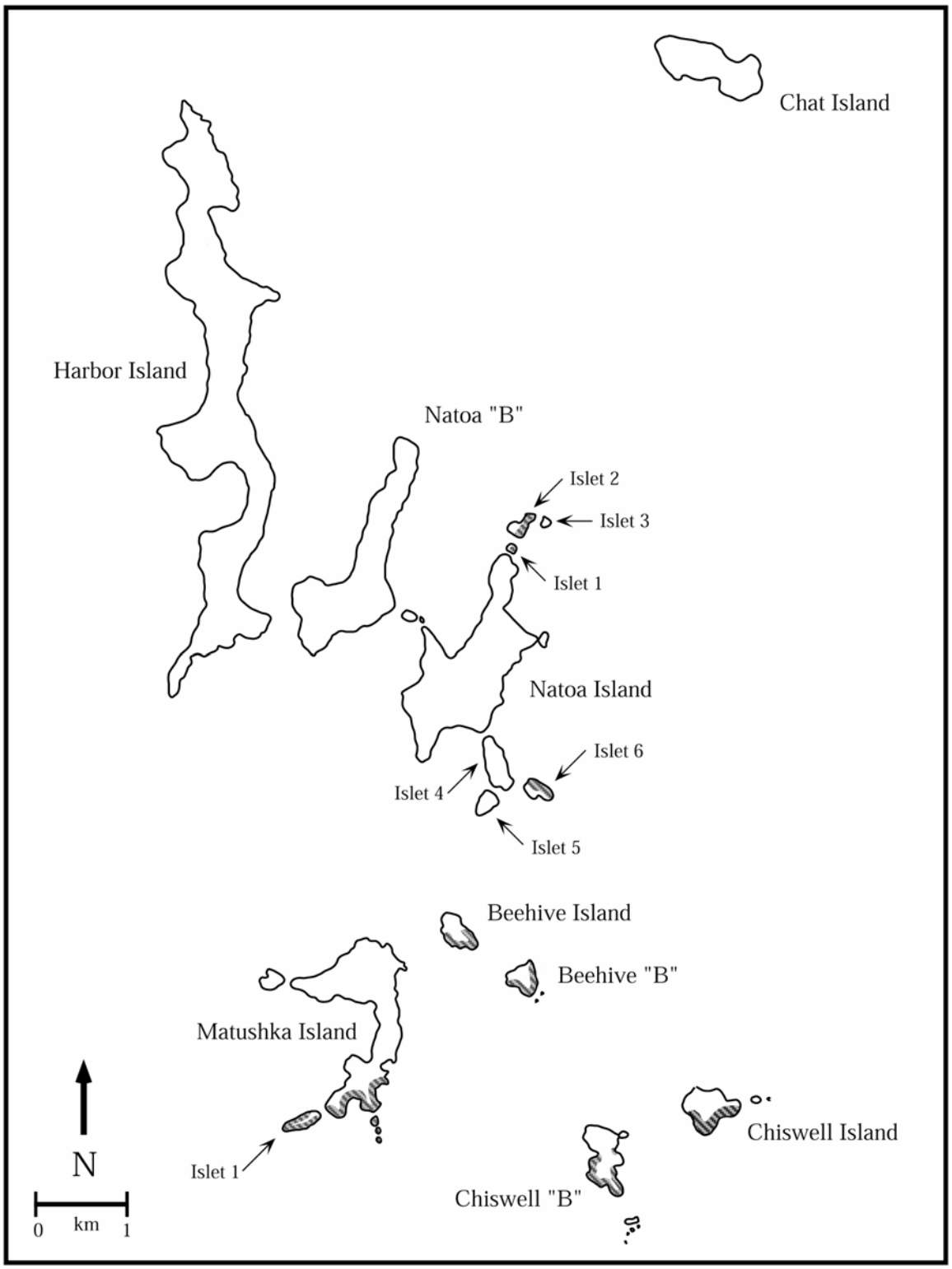

Figure 2. The Chiswell Islands study area (shaded areas show locations of murre nesting habitat).

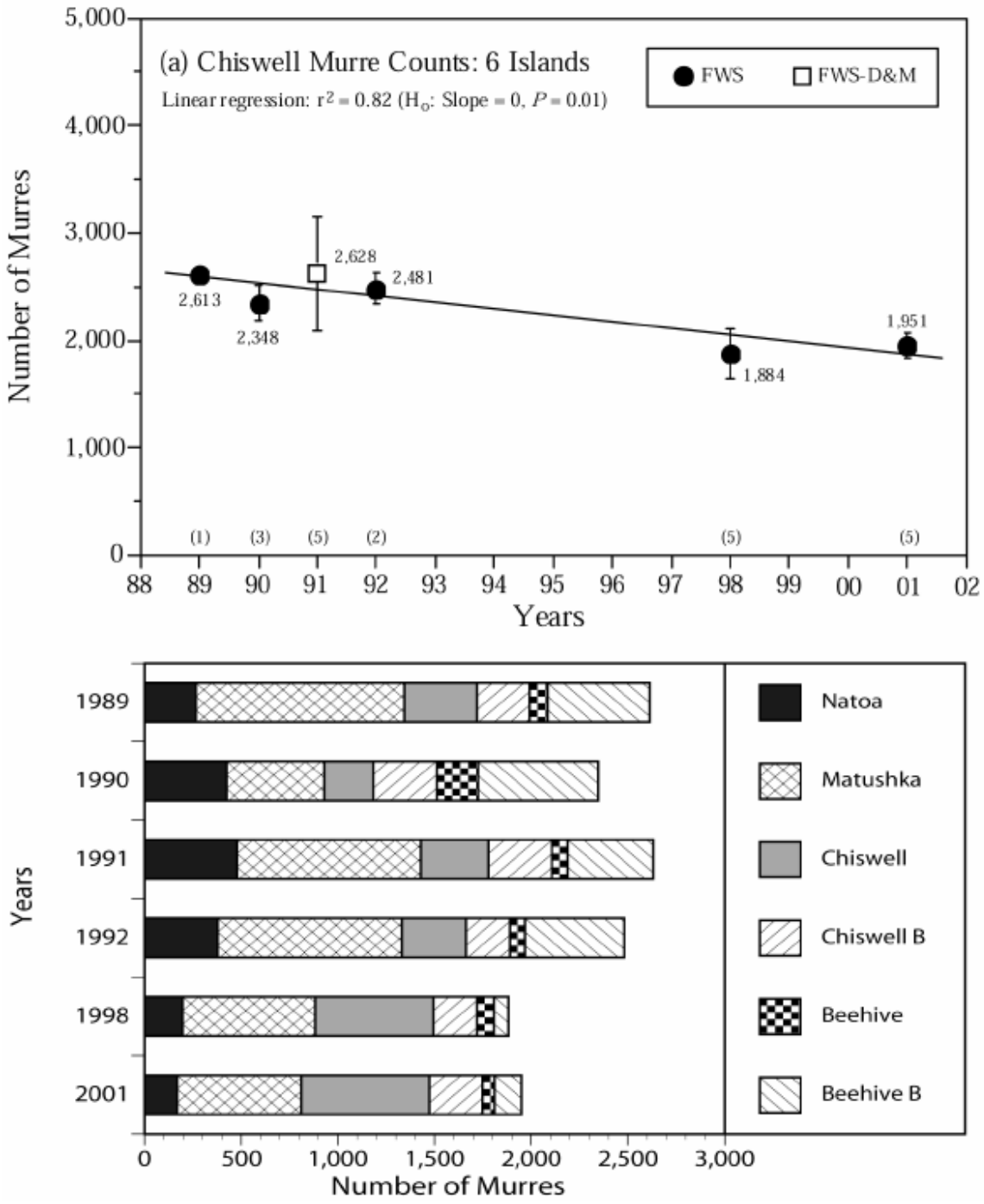

Figure 3. (a) Average counts of murres at the Chiswell Islands, Alaska, 1989-2001, and (b) number of birds by island. Counts were made by the U.S. Fish and Wildlife Service (FWS) and Dames & Moore (D&M; see Erikson 1995). Number of counts shown in parentheses; error bars and SD = standard deviation.

Appendix 1. Counts of murres at the Chiswell Islands, Alaska, 23 July 2001.

Note: All counts were made by 1's from small boats during 1343-1859 hrs Alaska Daylight Time; Observer 1 = David G. Roseneau (DGR), Observer 2 = Barbara L. Slater (BLS).

Island	Time	(DGR) Count 1	(DGR) Count 2	(DGR) Average	(BLS) Count 1	(BLS) Count 2	(BLS) Average	Observer 1-2 Average
Natoa								
Main island	1805							0[a]
Islet 1	1850							0[a]
Islet 2	1855							44[a]
Islet 3	1900							0[a]
Islet 4	1636							0[a]
Islet 5	1621							0[a]
Islet 6	1631							139[a]
Subtotal:								183[a]
Matuska								
Main island	1529							416[a]
Islet 1	1553							217[a]
Subtotal:								633[a]
Chiswell								
Main island	1418							588[a]
Subtotal:								588[a]
Chiswell B								
Main island	1459							227[a]
Subtotal:								227[a]
Beehive								
Main island	1343							53[a]
Subtotal:								53[a]
Beehive B								
Main island	1355							115[a]
Subtotal:								115[a]
TOTAL (All Islands)								1,799

[a] The counts were made by two observers and they only varied by a few birds at each island. However, individual observer scores are not reported here because one of the observers only recorded the averages in the field notebook.

Appendix 2. Counts of murres at the Chiswell Islands, Alaska, 24 July 2001.

Note: All counts were made by 1's from small boats during 1230-1708 hrs Alaska Daylight Time; Observer 1 = David G. Roseneau (DGR), Observer 2 = Barbara L. Slater (BLS).

Island	Time	(DGR) Count 1	(DGR) Count 2	(DGR) Average	(BLS) Count 1	(BLS) Count 2	(BLS) Average	Observer 1-2 Average
Natoa								
Main island	1603							0[a]
Islet 1	1653							0[a]
Islet 2	1700							45[a]
Islet 3	1708							0[a]
Islet 4	1243							0[a]
Islet 5	1233							0[a]
Islet 6	1238							122[a]
Subtotal:								167[a]
Matuska								
Main island	1354							448[a]
Islet 1	1422							164[a]
Subtotal:								612[a]
Chiswell								
Main island	1258							601[a]
Subtotal:								601[a]
Chiswell B								
Main island	1329							265[a]
Subtotal:								265[a]
Beehive								
Main island	1501							59[a]
Subtotal:								59[a]
Beehive B								
Main island	1449							164[a]
Subtotal:								164[a]
TOTAL (All Islands)								1,868

[a] The counts were made by two observers and they only varied by a few birds at each island. However, individual observer scores are not reported here because one of the observers only recorded the averages in the field notebook.

Appendix 3. Counts of murres at the Chiswell Islands, Alaska, 25 July 2001.

Note: All counts were made by 1's from small boats during 1240-1659 hrs Alaska Daylight Time; Observer 1 = David G. Roseneau (DGR), Observer 2 = Barbara L. Slater (BLS).

Island	Time	(DGR) Count 1	(DGR) Count 2	(DGR) Average	(BLS) Count 1	(BLS) Count 2	(BLS) Average	Observer 1-2 Average
Natoa								
Main island	1553	0		0	0		0	0
Islet 1	1629	0		0	0		0	0
Islet 2	1634	60		60	56		56	58
Islet 3	1658	0		0	0		0	0
Islet 4	1532	0		0	0		0	0
Islet 5	1527	0		0	0		0	0
Islet 6	1517	118		118	113		113	116
Subtotal:		178		178	169		169	174
Matuska								
Main island	1419	460		460	418		418	439[a]
Islet 1	1419	174	174	174	165	180	173	174
Subtotal:		634		634	583		591	613
Chiswell								
Main island	1258	839		839	806		806	823
Subtotal:		839		839	806		806	823
Chiswell B								
Main island	1318	254		254	257		257	256
Subtotal:		254		254	257		257	256
Beehive								
Main island	1504	74		74	75		75	75
Subtotal:		74		74	75		75	75
Beehive B								
Main island	1449	163		163	164		164	164
Subtotal:		163		163	164		164	164
TOTAL (All Islands)		2,142		2,142	2,054		2,062	2,105

[a] The main island count included 6 thick-billed murres.

Note: Birds were also counted on the water within about 200 meters of the nesting cliffs. The totals were Natoa = 51; Matushka = 32; Chiswell = 8; Chiswell B = 28; Beehive = 0; and Beehive B = 2 (six island total = 121).

Appendix 4. Counts of murres at the Chiswell Islands, Alaska, 26 July 2001.

Note: All counts were made by 1's from small boats during 1223-1750 hrs Alaska Daylight Time; Observer 1 = David G. Roseneau (DGR), Observer 2 = Barbara L. Slater (BLS).

Island	Time	(DGR) Count 1	(DGR) Count 2	(DGR) Average	(BLS) Count 1	(BLS) Count 2	(BLS) Average	Observer 1-2 Average
Natoa								
Main island	1700	0	0	0	0		0	0
Islet 1	1739	0	0	0	0		0	0
Islet 2	1744	75	80	78	78		78	78
Islet 3	1750	0	0	0	0		0	0
Islet 4	1223	0	0	0	0		0	0
Islet 5	1238	0	0	0	0		0	0
Islet 6	1223	96	95	96	97		97	96
Subtotal:		171	175	173	175		175	174
Matuska								
Main island	1410	468		468	478		478	473[a]
Islet 1	1446	180		180	186		186	183
Subtotal:		648		648	664		664	656
Chiswell								
Main island	1251	602		602	606		606	604
Subtotal:		602		602	606		606	604
Chiswell B								
Main island	1335	335		335	345		345	340
Subtotal:		335		335	345		345	340
Beehive								
Main island	1536	57		57	61		61	59
Subtotal:		57		57	61		61	59
Beehive B								
Main island	1516	127		127	122		122	125[b]
Subtotal:		127		127	122		122	125
TOTAL (All Islands)		1,940		1,942	1,973		1,973	1,958

[a] The main island count included 6 thick-billed murres.
[b] The main island count included 4 thick-billed murres.

Note: Birds were also counted on the water within about 200 meters of the nesting cliffs. The totals were Natoa = 16; Matushka = 20; Chiswell = 16; Chiswell B = 42; Beehive = 8; and Beehive B = 0 (six island total = 102).

Appendix 5. Counts of murres at the Chiswell Islands, Alaska, 27 July 2001.

Note: All counts were made by 1's from small boats during 1232-1558 hrs Alaska Daylight Time; Observer 1 = David G. Roseneau (DGR), Observer 2 = Barbara L. Slater (BLS).

Island	Time	(DGR) Count 1	(DGR) Count 2	(DGR) Average	(BLS) Count 1	(BLS) Count 2	(BLS) Average	Observer 1-2 Average
Natoa								
Main island	1507	0		0	0		0	0
Islet 1	1552	0		0	0		0	0
Islet 2	1557	45		45	41		41	43
Islet 3	1558	0		0	0		0	0
Islet 4	1242	0		0	0		0	0
Islet 5	1247	0		0	0		0	0
Islet 6	1232	102		102	103		103	103
Subtotal:		147		147	144		144	146
Matuska								
Main island	1352	527		527	523		523	525[a]
Islet 1	1425	170		170	167		167	169
Subtotal:		697		697	690		690	694
Chiswell								
Main island	1252	707		707	703		703	705
Subtotal:		707		707	703		703	705
Chiswell B								
Main island	1325	290		290	284		284	287
Subtotal:		290		290	284		284	287
Beehive								
Main island	1500	66		66	66		66	66
Subtotal:		66		66	66		66	66
Beehive B								
Main island	1445	129		129	125		125	127[b]
Subtotal:		129		129	125		125	127
TOTAL (All Islands)		2,036		2,036	2,012		2,012	2,025

[a] The main island count included 7 thick-billed murres.
[b] The main island count included 1 thick-billed murres.

Note: Birds were also counted on the water within about 200 meters of the nesting cliffs. The totals were Natoa = 5; Matushka = 97; Chiswell = 0; Chiswell B = 28; Beehive = 6; and Beehive B = 0 (six island total = 136).

Appendix 6. Counts of murres at the Chiswell Islands, Alaska, 1989-2001[a].

Date	Natoa Island	Matuska Island	Chiswell Island	Chiswell B Island	Beehive Island	Beehive B Island	Total	(SD)[b]	On Water[c]	Grand Total
1989[d]										
3 Jul	267	1,076	375	274	93	528	2,613		ND[e]	2,613
Mean	267	1,076	375	274	93	528	2,613		ND	2,613
1990[d]										
27 Jun	372	706	260	158	135	552	2,183		ND	2,183
28 Jun	444	380	380	305	210	623	2,342		ND	2,342
29 Jun	456	435	114	525	290	698	2,518		1,935	4,453
Mean	424	507	251	329	212	624	2,348	(168)	1,935	4,283
1991[f]										
26 Jun	515	918	191	454	71	592	2,741		ND	2,741
28 Jun	328	985	196	349	73	435	2,366		ND	2,366
30 Jun	657	1,008	602	271	144	582	3,264		ND	3,264
2 Jul	583	1,145	358	284	93	439	2,902		224	3,126
20-26 Jul	315	700	401	270	32	150	1,868		ND	1,868
Mean	480	951	350	326	83	440	2,628	(534)	224	2,852
1992[g]										
26 Jun	416	862	295	197	99	507	2,376		522	2,898
28 Jun	340	1,046	365	257	62	516	2,586		474	3,060
Mean	378	954	330	227	81	512	2,481	(149)	498	2,979
1998[h]										
13 Jul	133	631	454	239	93	5	1,555		865	2,420
14 Jul	269	777	723	188	129	38	2,124		110	2,234
15 Jul	192	820	657	236	96	42	2,043		581	2,624
16 Jul	206	638	690	326	71	19	1,950		759	2,709
17 Jul	192	559	538	136	55	266	1,746		672	2,418
Mean	198	685	612	225	89	74	1,884	(232)	597	2,481
2001[i]										
23 Jul	183	633	588	227	53	155	1,799		0	1,799
24 Jul	167	612	601	265	59	164	1,868		0	1,868

Appendix 6 (Cont.)

Date	Natoa Island	Matuska Island	Chiswell Island	Chiswell B Island	Beehive Island	Beehive B Island	Total	(SD)[b]	On Water[c]	Grand Total
2001[i]										
25 Jul	174	613	823	256	75	164	2,105		121	2,226
26 Jul	174	656	604	340	59	125	1,958		102	2,060
27 Jul	146	694	705	287	66	127	2,025		136	2,161
Mean	169	642	664	275	62	139	1,951	(232)	72	2,023

[a] In 1998, birds were counted on the nesting cliffs by 1's. Most 1989-1992 counts were also probably made by 1's; however, birds on some cliff sections may have been estimated by 10's.
[b] SD = standard deviation.
[c] In 1998 and 2001, birds were counted on the water by 1's and 10's within 150 meters of the nesting cliffs (about 90% were within 100 meters). The 1990-1992 counts were also probably made by 1's and 10's within 150 meters or less of the nesting cliffs; however, the 1990-1992 count dates were unclear—we assigned these estimates to the last Fish and Wildlife Service counts made during those years.
[d] Data are from Nysewander and Dipple (1990, 1991), Dipple and Nyswander (1992), Nyswander *et al.*(1993), and upubl. field notes and summary sheets.
[e] ND = no data.
[f] The 26 June - 2 July data are from Nysewander and Dipple (1990, 1991), Dipple and Nyswander (1992), Nyswander *et al.(*1993), and upubl. field notes and summary sheets. The 20-26 July data are from Erikson (1995)—the count was made on one day during this seven day period.
[g] Data are from Dragoo *et al.*(1995) and unpubl field notes and summary sheets. One additional count made on 14 July 1992 was dropped from the data base because it was incomplete and partially based on results from the 11-12 July counts.
[h] Data are from Roseneau *et al.(*1999a).
[i] Data are from this study.

Appendix 7. Power analysis of common murre counts at the Chiswell Islands, Alaska.[1]

We know from prior work that a total of about 5-7 counts made on separate days are needed each year to detect among-year differences of 20% at the $P = 0.1$ significance level (90% power; see Byrd 1989, Hatch and Hatch 1989). Using an updated version of the TRENDIO computer program written by T. Gerrodette (i.e., see Gerrodette 1987), we ran a series of simulations to predict numbers of surveys and years needed at different survey intervals to detect significant positive trends in northern Gulf of Alaska murre populations using the following assumptions:

1. *Rate of Change*: We chose two rates of change, 8% yr^{-1} and 13% yr^{-1}; these rates were chosen because they represented the normal range of values reported in the literature for common murres.

2. *Coefficient of Variation CV)*: We used 10% because this is the average value reported for counts made at the Chiswell Islands in 1989-2001 and at East Amatuli Light Rock and Nord Island – Northwest Islet in 1990-1999 (see Roseneau *et al*. 1999a and 2000a, respectively).

3. *Alpha (α) and Beta (β) Levels*: We were more concerned about Type II errors than Type I errors, and as a result, we relaxed Alpha to 0.1 and set power at 0.9.

4. *Model Selection*: We expected murre populations to grow exponentially rather than linearly.

Table 1. Summary of power analysis simulations for detecting significant positive trends (1-tailed) in murre populations at the Chiswell and Barren island colonies.

Rate of Change ($year^{-1}$)	Years Between Surveys	CV	α	β	Number of Surveys Required[a]	Number of Years Required to Detect Trends
0.8	1	0.10	0.1	0.9	7	7
	2	0.10	0.1	0.9	5	10
	3	0.10	0.1	0.9	4	12
	4	0.10	0.1	0.9	4	16
	5	0.10	0.1	0.9	4	20
0.13	1	0.10	0.1	0.9	5	5
	2	0.10	0.1	0.9	4	8
	3	0.10	0.1	0.9	4	12
	4	0.10	0.1	0.9	3	12
	5	0.10	0.1	0.9	3	15

[a] Each survey consists of 5 replicate counts—i.e., a total of 5 counts made during the correct time of day (1100-2000 hrs) on different days during the census period (the interval between the peak of laying and first sea-going of chicks).

Conclusions: If murre populations in the T/V *Exxon Valdez* oil spill area were increasing at 8% yr^{-1}, it would take 7 consecutive annual surveys at 5 replicate counts yr^{-1} to detect significant positive trends at the 0.1 level (i.e., 90% power), and if birds were increasing at 13% yr^{-1}, it would require 5 consecutive annual surveys at 5 replicate counts yr^{-1} to detect similar changes in population numbers. At survey intervals of 3 years (5 replicate counts yr^{-1}), positive trends could be detected for both rates of increase in 12 years (i.e., at 8% yr^{-1} and 13% yr^{-1}; results were the same for these values because of rounding), and surveys made at 5-year intervals would require 15 and 20 years to identify similar changes, respectively.

[1] Information provided in this power analysis is applicable to the Chiswell and Barren islands murre colonies. Copies of the analysis can be obtained from the Alaska Maritime NWR. Contact David G. Roseneau or Vernon Byrd at (907) 235-6546, or e-mail <dave_roseneau@fws.gov>.