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Factors affecting intra-colony variation in reproduction of common murres, *Uria aalge*

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HMSC REU 2009

Abstract
The Common Murre (*Uria aalge*), a piscivorous seabird, has been studied as an indicator species for climate change and annual ocean conditions. Murre reproductive success, however, is influenced by many factors, such as individual variation in parental quality and predation. The Yaquina Head murre colony is one of the largest (over 60,000 pairs), and most rapidly growing colonies on the Oregon Coast. Rapid colony growth suggests a potential influx of less experienced breeders and, along with frequent predation, likely cause marked intra-colony reproductive variation. We hypothesized that the chicks within the inner colony (i.e., more experienced breeders) and on the small islet with less predation pressure, will hatch earliest, have the greatest reproductive success, and that breeding pairs will have positive correlations with neighboring pairs within plots. We compared reproductive metrics on three scales: 1) adjacent pairs within plots, 2) pairs among plots, and 3) between islets. Reproductive success between the two islets was not significantly different (0.77 vs. 0.79 fledglings pair^{-1}). Median hatching date, however, was five days earlier on the smaller islet, likely from less predation disturbance prior to and during egg laying. During incubation and chick-rearing 92% of the predator-related disturbances (n = 26) occurred on the large islet. These results demonstrate that the colony is reproductively successful despite sometimes frequent predation events, however, predation events do appear to influence some reproductive measures, but not throughout the entire colony.

Introduction
The Common Murre, *Uria aalge*, has been studied as an indicator species for climactic changes and the condition of the ocean (Parrish and Zador 2003). As an upper-trophic level species, this piscivorous seabird's reproductive success is strongly linked to productivity and nutrient conditions of local waters within the California Current. This can be in relation to upwelling, primary production, and forage fish productivity (Parrish 2005). This is the only time of year that murres can be found on land because they are primarily piscivorous, marine predators and spend most of the year at sea. The birds are a relatively easy taxa to monitor during the breeding season because they are found in large dense colonies on cliffs and rocks close to shore. Chick survival is dependent upon the ability of parent murres to deliver food and to protect their offspring from predators (Harding et al. 2007). The choice of location within the colony for adult murres to nest suggests either they are seasoned and successful parents or inexperienced and unproductive parents. There is evidence that suggests location within the colony can reflect parental "quality" or "experience", with higher quality individuals located in the middle (Murphy and Schauer 1996). The location of the chicks within the colony may also suggest that certain chicks will fledge, or leave the nest, before others. For example, Reed demonstrates that heavier chicks that fledged sooner were from the earliest laid

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Comment: Citations in text should not have initial, correct throughout

eggs by the most experienced and productive adults and the lightest fledglings were from later laid eggs from the less experienced parents (Reed et al. 2009). Furthermore, inner colony plots may have earlier hatchlings and later fledge times because they are less affected by predation and disturbances. Also, placement of eggs within a colony will effect predation and subsequent reproductive success of the parent (Coulson and Porter 1985). Nesting sites not only depend on location within the colony, but also on closeness to other more experienced and reproductively successful pairs within plots and positively correlate the synchrony of median hatch dates between neighboring pairs (Murphy and Schauer J.H. 1996). The synchrony among pairs has been found to occur among neighbors, but not always (Murphy and Schauer 1996). The common murre's reproductive success is dependent upon ocean conditions, parents' foraging capabilities, predation factors, and location of egg sites in the colony, either on the edge of the colony or within the colony.

In this study I compared and defined relationships between the reproductive successes for the adult common murres between colony islets, among plots, and among neighboring pairs within the same plots of the breeding colony at Yaquina Head, in Newport, Oregon. I also defined relationships between successful hatchlings from center and outer edge plots. Moreover, the reproductive successes were compared to number of nearby predation events. This is the only murre colony to be studied within Oregon, despite being the most abundant seabird breeding on the Oregon Coast (ca., 685,000 individuals; Naughton et al.). It provides another set of data to compare to similar studies in California, Washington, and Alaska. It will focus primarily on location of eggs and chicks within the colony and the number of mortalities associated with these areas, especially related to predation, median hatch dates, and time of fledging.

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Comment: The way you stated earlier, you give the impression murre studies are more common along the coast, which they are rather rare.

Methods

Study area

We monitored the reproductive success of common murres at Yaquina Head in Newport, Oregon (44° 40'36"N, 124°04'43W) from the viewing deck of the Yaquina Head Lighthouse and from a balcony at the top of the lighthouse, which are approximately 150 meters from the colony. Surveys were conducted through the breeding season of the common murres, beginning when the first egg was observed and ending when the last monitored pair's chick had left the nesting site, or fledged. A spotting telescope (20-60X) was used to monitor the birds and this was done every 1-3 days within a week, weather permitting. We recorded the presence of the birds' and their egg or chick.

Productivity

Limiting factors affecting chick and egg success will be measured by monitoring the twelve sample plots throughout the colony using plot photographs taken from the observation points with marked plots and numbered birds within the plots. We will follow 141 pairs of birds within these plots and monitor their eggs and, when hatched, their chicks. To determine chronology of egg laid, hatchling, and fledgling we monitored the murres and checked for egg or chick presence. These techniques were used to monitor development of the chicks and where on the colony they were most successful. To track inner versus outer colony areas I selected pairs within plots to compare with edge pairs

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Comment: Make sure you change all future and present tense to past.

and used a Chi-square analysis to compare reproduction success rates. I also compared the number of successful nest sites (chicks are present for at least fifteen days after hatch date) for reproductive success between the large islet of Colony Rock and the smaller islet of Flattop Rock using a *t*-test. Median hatch date was compared using a Chi-square contingency table to compare Flattop Rock and Colony Rock. Synchrony between pairs was measured using mean hatch dates for chicks among neighboring pairs, among plots, and between colony islets for related nest site success or failure. Log transformed values of hatch date were used in the ANOVA test.

Predation

The predation on the Yaquina Head murre colony is predominately Bald Eagles, Peregrine Falcons, Common Ravens, and Western Gulls. Ravens and the Western Gulls often are secondary predators and gain access to murre eggs after a preliminary attack by a Bald Eagle. To monitor predation we measured when predation events occurred, what was lost during the predation, and where on the colony islets these events occurred. Often when a large predator or disturbance approaches to close to the colony murres will abandon their nest-sites and retreat to the sea, this can cause catastrophic reproductive failures and result in loss of eggs and chicks to primary and secondary predators. Predation effects on chick success were compared between the two colony islets in relation to median hatch date and predation event frequency of occurrence. For this analysis, I included two previous year's data (2007, 2008) for comparison to this year's results.

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Comment: Add latin names first time any species is mentioned

Chick survival

Murre chicks leave the breeding colony prematurely, before they are capable of flight, and continue development at sea. The success of chicks was assumed if they survived on colony for fifteen days prior to fledging. Chicks are deemed successful if they live for fifteen days because this is the average amount of time chicks are found within the colony and a standardized value used in murre studies throughout the Northeast Pacific Ocean.

Results

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Reproductive Success

The reproductive success for the entire colony was 78% in 2009, 77% in 2008 and 54% in 2007. Reproductive success was not significantly different (ADD –test results here or refer to table) between Flattop Rock (66%) andColony Rock (69%,) for all years combined. Reproductive success between inner colony pairs and edge-of-colony pairs was not significantly different ($P>.05$, $X^2= .007$) (Figure 6).

Mean and Median Hatch Dates

Median hatch date was five days earlier on Flattop (6/22/09) vs. Colony Rock (6/27/09) and was significant ($P = 0.004, X^2=8.??$) (Table 1) (Figure 2). The median hatch date between plots was not significantly different ($df=11$, $P>.05$) (Table 3). This pattern was the same in 2008, with median hatch date for Colony Rock being June 26th and June 19th on Flattop Rock (Figure 4). However, in 2007 Median hatch dates were the same, June 27th, between both islets (Figure 4). This shows inconclusive results for the past three

Rob Suryan 8/18/09 10:47 AM
Comment: Present tables and figs consecutively. Need to be reordered and renumbered

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Comment: You can state the actual p value

years, which may mean that because Flattop Rock is smaller and farther away from predator vision; it does not necessarily have a more positive effect on overall reproductive success.

Predation and Disturbance

Predation and disturbance events were found to be highly concentrated on Colony Rock, specifically in subsection A and Colony Rock Annex, thereby causing little disturbance at our study plots. Flattop Rock was only disturbed by predation on one observed occasion and seems to be targeted less by predators. Because smaller area or because less easily seen from perch of predator. The totally number of predation events was not higher for 2009(25) from 2008 (20) and 2007 (23). The percent occurrence of predation within the colony islets was higher on Colony (92%) then on Flattop (7%), (1% on other). The data for 2008 indicate less pressure on Colony with 75% occurrence and 12.5% occurrence on Flattop Rock, (12.5% on other). In 2007 65% of predation was on Colony while 23% was on Flattop Rock, (12% on other). The predation events seemed to occur most heavily during pre-egg laying and incubation, from mid May to mid June, and far less during chick-rearing.

Rob Suryan 8/18/09 10:40 AM
Comment: This is really more Discussion material, not really appropriate for Results section

Rob Suryan 8/18/09 10:42 AM
Comment: Without a map or diagram, the reader does not know where secton A is. Use more descriptive words such as "...at the northern tip of colony rock and a nearby outcrop, and away from most of our study plots."

Rob Suryan 8/18/09 10:43 AM
Comment: Save this type of speculation for Discussion, as I noted above

Rob Suryan 8/18/09 10:44 AM
Comment: Among years you need to compare predation rate, event per hour observed because we were out observing for different numbers of hours each year. Within a year, you observe colony and flattop equally, so OK to compare #s alone

Discussion

Median Hatch Date and Synchrony

Median hatch dates between the colony islets, Flattop and Colony Rock, were the most significant finding in this study and most likely a resulted from influences from predation events. Median hatch dates have been found to be positively correlated and related to each other in other synchrony studies, as well (Gaston and Nettelship 1981; Murphy and Schauer 1996). The median hatch date for Flattop Rock was five days earlier than for Colony Rock and this seems to be an indication of predation influences on Colony Rock. Possibly there are less predation events early in the breeding season when murres are returning to shore, establishing territories, and laying eggs and this allowed Flattop to colonize more quickly and begin egg laying and incubation sooner than Colony Rock. I believe that this resulted from having a smaller sampling size than other studies. For example, I used 90 birds in my study of reproductive success, so about 45 in each islet; this was compared to over 300 birds used in Murphy and Schauer's (1996) study of synchrony among common murres in Nome, Alaska.

Rob Suryan 8/18/09 10:49 AM
Comment: Really, so you are saying that your most significant finding is not significant, but just an artifact of having a small sample size?

Reproductive Success, Mean Hatch Date, and Predation

The reproductive success of both Flattop Rock and Colony Rock have increased since the beginning of this study, while within the Washington area, due to increasing bald eagle populations, the Tatoosh population is declining (Parrish et. al 2001; Wilson 1991). Increasing eagle populations is a similar story in Oregon and Washington. The increase began from the banning of the use of DDT and the ban on shooting the eagles. The Yaquina Head Colony is a much larger colony, so predator swamping is occurring, but may not have as big as an effect on reproductive success. Instead, at the Tatoosh colony in Washington, reintroduction has been so rapid that the colony has not had the time to adapt to the growing numbers of this predator quickly enough for its size and is in turn repeated failing reproductively. Another reason that predation may have less of an impact

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Comment: Wilson is not in Lit Cite, check others

Rob Suryan 8/18/09 10:53 AM
Comment: Will need to explain what this is or cite (e.g., Suryan et al 2006 Progress in Oceanography)

Rob Suryan 8/18/09 10:56 AM
Comment: Best to avoid using this word, it has too many alternative implications. Also, Tatoosh may not have space or other colonies nearby to provide immigrants, like along the OR coast (as I showed you in that figure of YHONA increasing while others declined).

is that the perch of the predators sits away from the colony and does not allow for easy watching of prey, along with constant attacks from protective and aggressive Western Gulls. The presence of humans so often at Yaquina Head because of visitors to the lighthouse may also affect the activity and success of predation on the colony.

Although predation has an effect on the reproductive success of the murre at Yaquina Head it does not seem to be the single most important influence. On Tatoosh in Washington it is found that primary production is stronger than off the Oregon coast (Hickey and Banas 2003; Parrish and Zador 2003). Although, Oregon has a much, much higher biomass of common murres in the coastal near shore environment than Tatoosh in Washington, and the explanation seems to reside within the predation of murres by Bald Eagles on the Tatoosh colony (Parrish et al. 2001). The Oregon and California colonies are thriving and seem to be primarily driven by bottom-up influences (prey density dependent), instead of top-down influences like that in Washington by the Bald Eagles (Parrish et al. 2001; Parrish and Zador 2003).

Rob Suryan 8/18/09 10:07 AM
Comment: This is pretty strong, many OR colonies are also struggling under predation pressure, Yaquina Head is an exception for the central and North OR coast

Conclusion

These results indicate that while predation can have a major effect on reproductive success, it may also causebreeding asynchrony within the colony. It is not the only factor effecting success and may not be as important as parental experience, foraging capabilities, and time management (Coulson and Porter 1985). Sample size must also be considered when comparing data to other studies because this study had a much smaller sample size than needed to correctly fulfill the analysis the data underwent. There could also be a difference in colony success and between Colony Rock and Flattop Rock, but it was not accounted for because many more years of data are needed before a significant comparison could occur.

Rob Suryan 8/18/09 11:00 AM
Comment: Possibly, but predation may be overshadowing these other factors at Yaquina Head, even if not the case for Coulson's colony (which may not have been affected by predators at all)

Rob Suryan 8/18/09 11:02 AM
Comment: Again, I wouldn't default to sample size alone. It seems the main reason you didn't find a sig diff in repro success between colony and flattop in relation to predation is that the major loss to predation was outside of your repro plots.

Acknowledgements

I would like to thank Rob Suryan (OSU) for all of his guidance and his awesome attitude, because without them I would not have been able to get through or finish this project. I would like to thank Amanda Gladics (USFWS) for helping me collect data and always being just an email away from helping me. Itchung Cheung (OSU) was a constant source for me throughout this program and I would like to thank him for always being available. Thank you to The Bureau of Land Management staff for allowing lighthouse access and data collection this summer and for partial funding. Thank you to U.S. Fish and Wildlife Service for providing photographs and partial funding to the project. Thank you to Oregon State University's Hatfield Marine Science Center for hosting me this summer and the National Science Foundation for funding my summer through the Research Experience for Undergraduates Program.

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FIGURES

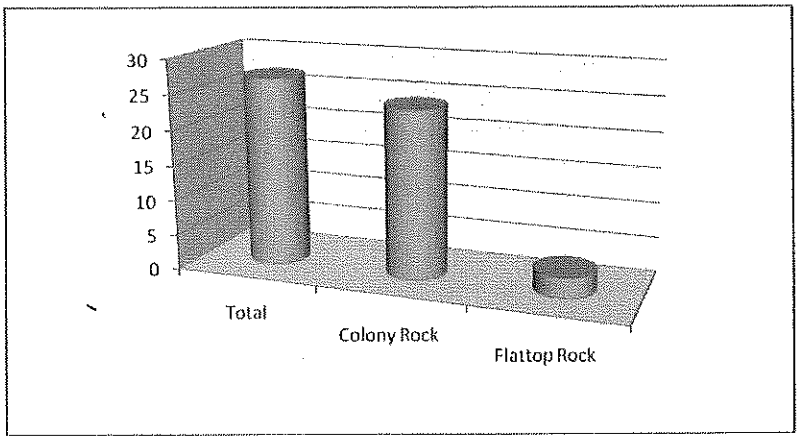
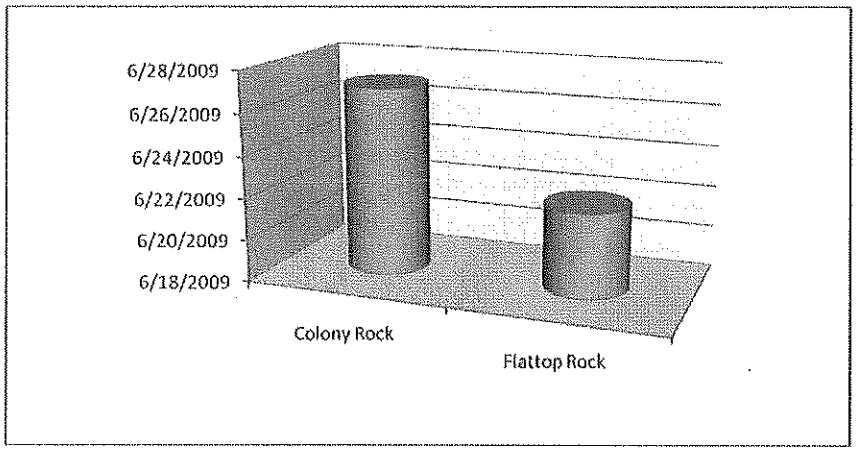


Figure 1. Predation events (n = 25) took place most commonly on Colony Rock and seemed to put a visible strain on the reproductive success of Colony Rock.

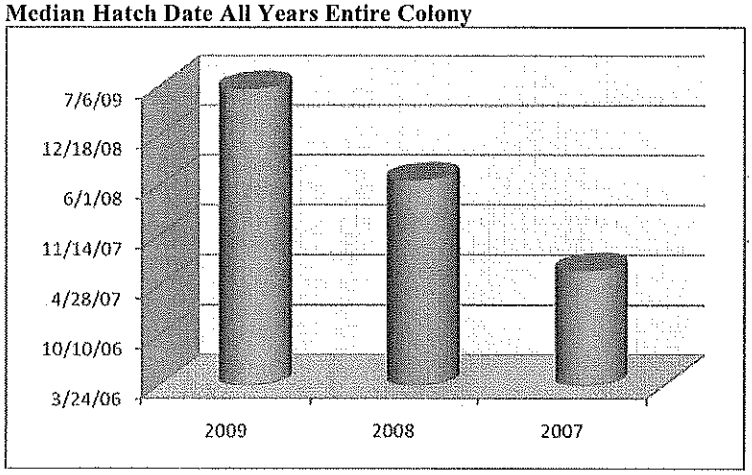
Rob Sturyan 8/18/09 10:11 AM
Comment: The Total column is not needed here. Within the text, you simply add (n = 25). Also, Figure captions are positions below the figures, as opposed to Tables where captions are above. Also in a paper, Tables come before Figures.

Figure 2
Median Hatch Date



Median hatch date for Flattop Rock was significantly earlier than Colony Rock, five days difference.

Figure 3
Median Hatch Date All Years Entire Colony



Median hatch date between all three years was not significantly different.

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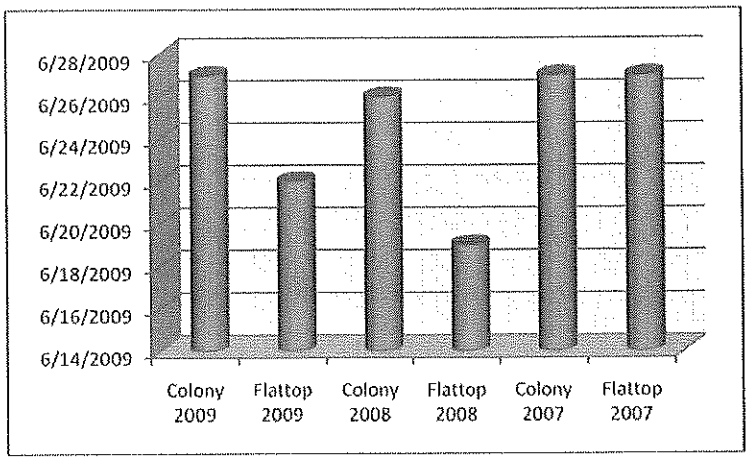
Comment: The dates are not correct on the Y axis

Figure 4
Median Hatch Date All Years Colony vs Flattop



Median hatch date between Colony Rock and Flattop Rock for all three years was not found to be significantly different.

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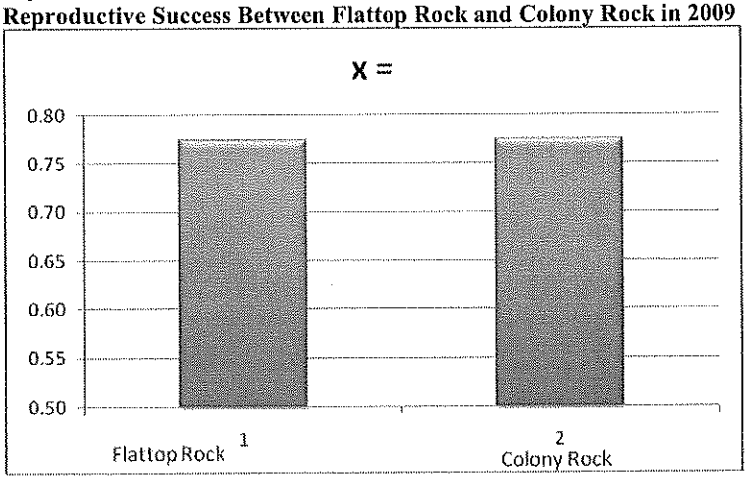
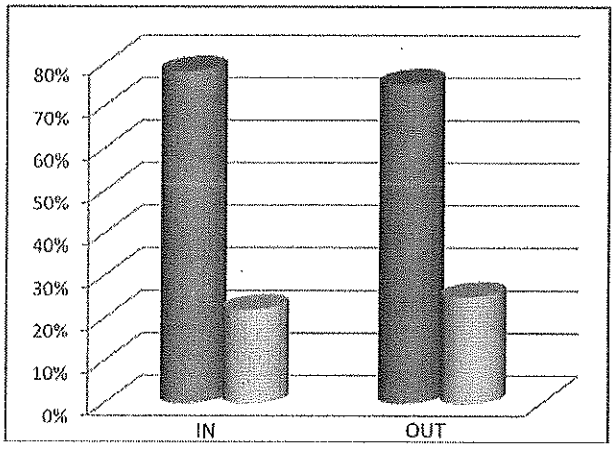
Comment: How did you compare this? Each year individually?

Figure 5
Reproductive Success Between Flattop Rock and Colony Rock in 2009



Reproductive Success between Flattop Rock and Colony Rock were not significantly different.

Figure 6
Reproductive success for Inner Colony Plots and Edge-of –Colony Plots



Reproductive success between inner colony chicks and edge-of-colony chicks was not significantly different.

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Comment: Only need 1 bar here, % successful only

Tables

Table 1

Chi-square: Median Hatch Date between Colony Rock and Flattop Rock

#	Colony	Flattop	Total
Above median	22	15	37
Not above median	10	30	40
Total	32	45	77
Chi sqr	8.03211489		
P-value	0.00459552		

Rob Suryan 3/19/09 10:36 AM
Comment: You do not need this much detail presented for stats, just n, df, chi-square value, and P-value (which can be stated in text, rather than a table). You do not need a table or figure for every result

Rob Suryan 3/19/09 11:06 AM
Comment: Format of tables should be horizontal lines shown here, not grids or borders. Change by highlighting table, rt click, borders and lines, none. Then highlight individual rows and add borderlines.

Table 2

Chi-square: Inner Colony chicks versus Edge-of-Colony chicks for Reproductive Success

#	In	Out	Total
Successful	31	38	69
Not Successful	9	13	22
Total	40	51	91
Chi sqr	0.00705997		
P-value	0.93303765		

No significant difference between Inner Colony chicks and Edge-of-Colony chicks reproductive success.

Table 3
ANOVA: Comparison of Mean Hatch Dates among plots and between islets
ISLET

Source	DF	Sum of Sq.	Mean Sq	F Value	Pr (F)
Islet	1	46.105	46.10499	1.593	.2107
Residuals	75	2169.713	28.92951		

PLOT

Source	DF	Sum of Sq.	Mean Sq.	F Value	Pr (F)
Plot	10	376.929	37.6929	1.3528	.2222
Residuals	66	1838.889	27.86195		

Table 4
ANOVA log: Comparsion of Mean Hatch Dates among plots and between islets
ISLET&PLOT

Source	DF	Sum of Sq.	Mean Sq.	F Value	Pr (F)
Islet	1	.00023	.00023	1.553	.217
Plot	10	.0017	.0001889	1.27	.2694
Residuals	66	.0098	.0001486		

PLOT

Source	DF	Sum of Sq.	Mean Sq	F Value	Pr (F)
Plot	10	.00193	.000193	1.299	.24956
Residuals	66	.0098	.000148		

No significant difference between mean hatch dates among plots or between colony islets in either ANOVA or ANOVA log.

Table 5
T-Test: Reproductive Success between Colony Rock and Flattop Rock for all years combined 2007-2009.

		Flattop Rock	Colony Rock

T	-.3828		
DF	29		
P	.7046		
Mean of X		.657333	
Mean of Y			.6877778

Wilcox rank-sum test

Z= -.3801	p-value= .7039

No significant difference between the reproductive success of Colony Rock and Flattop Rock.