Anne Vallee (Triangle Island)

Common Murre Demography on Triangle Island, 1995

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Introduction

Common Murres (*Uria aalge*) are the nearshore marine "canary-in-the-coalmine" for a variety of perturbations, both natural and human-induced. Murres are among the most seriously affected species in the wake of oil spills (70-80% of recovered carcasses; Burger & Fry 1993) and gillnet fishing (70-80% of recovered carcasses; Takekawa et. al. 1990, DeGange et. al. 1993). In addition, murres suffer temporary breeding failures and attendance drops as a function of declining oceanic productivity associated with El Nino-Southern Oscillation events (Boekelheide et. al. 1990, Hodder & Graybill, 1985). Wilson (1991) suggested that the persistent declines in attendance experienced by Washington colonies during the 1980's was associated with warm water-low productivity events. Finally, Parrish (1995a) has shown that Bald Eagles (*Haliaeetus leucocephalus*) can have a significant effect on murre reproductive success through indirect facilitation of egg predation by Glaucous-winged Gulls (*Larus glaucescens*).

Because murres are diurnal, gregarious, surface nesters, they can be easily monitored without direct intervention. Because murres are long-lived birds, they are ideal for studies on the acute and chronic effects of environmental stressors on demographics. Several longterm studies on continuously banded colonies of both Common and Thick-billed Murres (*Uria lomvia*) have provided a wealth of information about patterns of philopatry, attendance, reproduction, and foraging (e.g. Gaston & Nettleship 1981, Tuck 1960, Boekelheide et. al. 1990).

Although Triangle Island houses the largest stable breeding colony of Common Murres in British Columbia (Rodway 1990), relatively little attention has been paid to these birds. Visits have been made to survey flora and fauna in the 1940's (Carl et. al. 1951), the 1970's (Vermeer et. al. 1976), and again in the late 1980's (Rodway et. al. 1990), during which counts of murres and occasionally reproductive data were gathered. There has never been a systematic attempt to collect quantitative information on trends in demographic parameters (i.e. population size and reproductive success over time). While this colony is of obvious interest to British Columbia, it is also of regional interest: Hundreds of thousands of murres nest in colonies to the north in the Gulf of Alaska (1.5 million - Sowls et. al. 1978), and to the distant south in California (350,000 - J. Takekawa pers. comm.) and Oregon (750,000 - R. Lowe pers. comm.); however to the immediate south in Washington, murres are depauperate (15,000 - Parrish 1995b, Wilson unpub. data). Furthermore, Washington has only one stable murre breeding colony, Tatoosh Island. Thus, British Columbia and Washington represent a gap in the middle of the Common Murre range.

A systematic monitoring protocol for Common Murres was set up on Tatoosh Island in 1992. Data are collected on: 1. attendance as a function of time of day, phenology, and subcolony (defined as an isolated group of breeding murres); 2. reproductive success as a function of subcolony habitat type (rock ledge versus flat cliff-top/vegetated); and 3. community interaction pathways influencing both population size and reproductive success. In 1995, I was able to collect preliminary demographic data on a small subset of the Triangle Island murres, which can be compared directly to the Tatoosh data for 1995, to Triangle data collected in other years (e.g. Rodway 1990), and more generally to other more distant murre colonies.

Methods

Observations commenced on 3 July 1995 and continued almost daily through 31 August 1995. All observations on Common Murres were made from a blind set-up by Colleen Cassidy-St Clair on the west-facing edge of the Puffin Rock saddle. From this location, approximately 10-12% of the Island's murre population could be monitored. Data were collected on the hour on attendance at seven breeding areas defined by topographic boundaries: three were principally in exposed rock and four were principally in grassy vegetation, between the hours of 0600 and 2200. Half-hourly counts were made of the species, abundance, and location (specific to breeding murres: on the edge versus interior) of all egg predators within "striking" distance of any of the seven murre attendance areas. Both murre attendance and egg predator counts were also made following Glaucous-winged Gull flight alarm calls and/or the appearance of Bald Eagles.

Within two of the rock habitat attendance areas (Rock 2 and Rock Top), subplots were delineated to follow the reproductive success of all mapped pairs: Lower Cluster (LC; 31 pairs) and Middle Sparse (MS; 26 pairs) in Rock 2, and all of Rock Top (RT; 20 pairs). In-between set hourly and half-hourly counts, pairs in these subplots were monitored to determine reproductive status (egg, chick, nothing), if possible on a daily basis, in order to estimate breeding phenology and reproductive success. Because observations started in early July, after eggs had been laid and an unknown number lost, the initial timing of egg laying could not be determined. Likewise, estimates of reproductive success as probably higher than the actual values, as some pairs may have deserted before 3 July.

During the period when chicks were present and fledging, counts were made of the number of murres leaving and returning to the Rock 2 attendance plot, at four times of day (0700, 1100, 1500, 1900H), during a 15 minute observation period. Returning birds were classified as with or without fish. These "fish watches" were used to calculate how long the "average" chick had to wait in-between feedings (fish turnover), by using the number of chicks on the reproductive success subplots (LC, MS) as a function of adult attendance on those subplots to calculate the theoretical number of chicks present on Rock 2. This number was divided by the number of adults returning with fish multiplied by four (i.e. per hour) to get the number of hours until all chicks would be fed once, or average foraging trip time:

$$FishTurnover = \frac{R2Adults \times \dfrac{MS + LCChicks}{MS + LCAdults}}{Adultswithfish \times 4}$$

Adult turnover was calculated as the number leaving divided by the number returning, and used to flag anomalous observations in which the murres might have been disturbed (defined as leaving much higher or lower than returning). Anomalous data were deleted from the analysis. Fish watch data were compared with similar data collected on Tatoosh Island, to determine whether the foraging patterns of these two colonies were similar.

Results and Discussion

Attendance - Whole island attendance was not estimated in 1995; however, this would be possible in future years with the use of a small boat. The majority of the murres are located on the west side of Puffin Rock and on Murre Rock (Rodway 1990; Figure 1). Most of these birds are not visible from land. By 3 July, a blind had already been constructed in the saddle on Puffin Rock. From this blind it was possible to observe approximately 750 murres (Figure 2) or about 7.5% of the 1989 population estimated by Rodway (1990). Rodway's counts were principally made from photographs taken between the hours of 1800 and 2000, from 27 July and 17 August, 1989 (Rodway 1990). Table 1 indicates attendance in the sampled plots at the same time (B). However, evening attendance was volatile, particularly during the chick period (Figure 3). Furthermore, chicks had begun to fledge by 12 August 1995, making counts after this date dubious. In general, attendance counts of Common Murres are usually performed during the period after eggs have been laid but before chicks have fledged (unless visit timing and brevity precludes this possibility), during a time of day when attendance fluctuates minimally (Hatch & Hatch 198?). Compare Table 1-A to Table 1-B: total attendance in the former is 525, and in the latter 750, an almost 50% gain. These discrepancies reinforce the fact that comparisons between individual studies must take time of season, time of day, and breeding phenology into careful account.

While numbers of birds are not directly comparable between the 1995 data and those collected by Rodway (1990), patterns of attendance are. Attendance peaked in evening (2000-2100; Figure 3, Table 2) with a lesser early morning peak (0600-0700) and a nadir between 0900 and 1400 hours. This pattern is almost identical to that described by Rodway (1990, Figure 3). Both the "tightness" of the pattern and the range appear to differ between habitat types. In the grass plots, minimum attendance values were 36% (egg period) to 46% (chick period) of the maximum daily value, a substantial range. The variance in hourly attendance was also low (i.e. a tight pattern). By contrast, in the rock subplots minimum attendance values were only 70-73% of maximum values. Furthermore, during the chick period, variance in hourly attendance was quite high. Although this might have been an artifact of switching observers (JKP left and JS arrived on 19 July 1995), this explanation is unlikely as the increase in variance should have been observed across habitat type. An alternate explanation is that these two habitats differed in percentage of breeding pairs. As maximum daily attendance in the grass was roughly twice the minimum, it is likely that this habitat housed non-breeding murres. Diurnal patterns of attendance adopted by non-breeders are not likely to change over the season, whereas the attendance patterns of breeding birds will be dependent on their success. In other words, as pairs either fail or fledge their chicks, they will leave. Therefore, increasing variance and decreasing attendance as a function of phenology in the rocks (Table 2), combined with the knowledge that breeding success was low (see below), may explain why attendance patterns were variable during the chick period, but no the egg period. Unfortunately, although breeding in the rock habitat was relatively easy to determine, grass obscured accurate observation.

Phenology and Reproductive Success - By the start of observations, all eggs had been laid. It is likely that all three subplots originally contained more eggs: during the course of our observations we witnessed 10 murre eggs stolen off attendance plots by Glaucous-winged Gulls. Several more disappeared in-between observation periods. As egg predation pressure was high, it is likely that many early eggs were removed by gulls.

The first chick was seen on 13 July 1995 (Table 3). In 1995, the presence of an egg or chick was not recorded for every pair on every day. Thus, a conservative estimate of mean hatch date is the mean day chicks were first seen. In the three reproductive success subplots, these dates fell between 30 July and 1 August (Table 3). Rodway (1990) documented peak hatching between 5 and 11 August in 1989, a week later than in 1995. By 7 August 1995, 84% of all chicks had been seen at least once. Fledging began less than one week later: the first fledger was seen on 12 August and mean fledge date ranged between 20 and 25 August across the three subplots (Table 3). By the time observations ended on 30 August, only one chick was left in each subplot. Along the Pacific Northwest coast, Common Murre fledging follows a clinal pattern - earlier in the south and later in the north. Mean fledge dates on the Farallon Islands, California range from 10-20 July (1972-1982; Boekelheide et. al. 1990), on Tatoosh Island, Washington from 10-20 August (1993-1995; Parrish unpub. data), and in the Barren Islands, Gulf of Alaska from 1-10 September (1991-1994; Boersma unpub. data). Thus, the Triangle Island 1995 fledging dates appear to corroborate this pattern.

However, time to fledging (i.e. number of days chicks are on the colony) is longer than average. In the north Atlantic, Common Murre chicks spend 18-22 days on colony (Birkhead 1977, Hedgren & Linnman 1979), whereas in the Pacific chicks take longer to fledge (Semidis, AK - 23 days, Hatch & Hatch 1990; Farallons, CA - 23.5 days, Boekelheide et. al. 1990). The chicks on Triangle Island spent at least 25 days on the colony, on average, and some chicks were present more than 30 days (range: 15-34 days). The mean value is the average number of days chicks which were known to have fledged (i.e. were seen fledging) were seen, and is thus a conservative measure (i.e. chicks could have been present for several days without being seen). During the chick period, Glaucous-winged Gulls were observed taking chicks (5 occasions) and many of these were several weeks old, suggesting that continued chick presence was not a matter of relative safety but probable necessity.

Because predation pressure from gulls continued throughout the chick and fledging periods, and chicks were present on the breeding grounds for extended periods of time, it was often difficult to determine whether a chick had fledged or was eaten. Therefore, a conservative operational hierarchy was used to estimate fledging: Definitely fledged was defined as chick was seen fledging. Probably fledged was defined as chick "age" (i.e. days seen) was greater than or equal to the mean of known fledgers (i.e. 25 days). Possibly fledged was defined as chick age greater than or equal to the mean minus the standard deviation of known fledgers (SD = 5.5 days). Using these definitions, reproductive success of pairs on the three subplots ranged from a minimum of 0.21 fledgers/pair to a maximum of 0.42 (Table 4). While most pairs observed were able to hatch their eggs (hatching success 82% as compared to Farallon Islands, CA murres - 85% Boekelheide et. al. 1990), chick loss was high. Gulls took both chicks and fish intended for chicks. Out of 63 known chicks, roughly one-third (18) were known to have died (Table 4). By comparison, on the Farallons, 93-100% of hatched chicks survive to fledging (Boekelheide et. al. 1990). The same is true of murre chicks on Tatoosh Island, WA (Parrish, unpub. data).

Given the risk of predation, why did chicks remain so long? Fish watch data suggest an answer. On average, parents were able to feed their chick once every three hours (Table 5), and this value does not take into account gull kleptoparasitism. On Tatoosh Island, the nearest murre colony to the south, parents took half as long (1.5 hours) in between feedings (Parrish 1996). However, in 1993, an "El Niño" year in which many of the Tatoosh murres failed to breed successfully (reproductive success of monitored pairs was 0.43 chicks/pair), fish turnover rates were 2.95 hours (Parrish unpub. data; Table 5). It is possible that food sources surrounding Triangle Island were either scarce, distant, or both. This would explain the relatively long fish turnover rate and the extended chick period. Whether fish turnover is causally related to reproductive success is open to speculation. Obviously, food supply is a critical parameter; however, predation also played a key role in determining chick survival. On the other hand, starving or debilitated chicks might be easier prey for gulls, especially if parents are occasionally forced to leave to secure their own food.

Although pairs in the monitored subplots fledged chicks, many of the breeding areas around and adjacent to Puffin Rock did not. Murres nesting on Murre Rock (Figure 1) had abandoned breeding ledges by mid-late July. According to Rodway (1990), Murre Rock accounts for at least 1,000 birds (numbers from photographic counts). In addition, murres nesting on the northwest side of Puffin Rock were frequently seen temporarily abandoning their nesting areas at the approach of Bald Eagles. The number of eagle eyries on Triangle is increasing. Using plumage coloration, feather loss pattern, and location (adults and chicks only) to distinguish individuals, I counted at least 23 eagles on the island in 1995. Rodway et. al. (1990) reference several island censuses which included eagles or evidence of nesting: Carl et. al. (1950) reported evidence of 2 nests but no nesting in 1949. Vermeer et. al. (1976) reported 4 nests in 1974-5. During the 1980's 1 or 2 nesting pairs were reported with the exception of 1989, when three nesting pairs were reported (Rodway et. al. 1990). In 1995, there were 5 active eyries, three of which could be observed from at or close to the cabin. Two of these, Khyber Pass and Calamity Cove were present in 1989. A new eyrie, located on the northern spire of Puffin Rock (Figure 1), fledged two chicks in 1995. Adults from this eyrie regularly brought back murres to their chicks (9 kills witnessed). Direct effects (i.e. predation) as well as indirect effects (i.e. eagle-facilitated egg predation by gulls and crows) was undoubtedly responsible for the reproductive failure on Murre Rock and parts of Puffin Rock. The murres which could be seen from the blind may represent the anomaly (i.e. success) rather than the norm (i.e. failure).

Murre-eagle-egg predator interactions are responsible for persistent reproductive failure of a large proportion of the breeders on Tatoosh Island (Parrish 1995a). On this colony, large subcolonies of murres located on exposed areas on the flat top of the island have failed in 4 out of the last 6 years (Parrish 1996). Eagle visitation to the island, and eagle territories on the mainland within 25 km of the island have also been increasing (Parrish & Paine, manuscript). In 1995, juvenile Bald Eagles were also reported on the largest Common Murre colony in Oregon - Three Arch Rocks - preventing the murres from settling and delaying phenology by at least three weeks (R. Lowe, D. Pitkin, pers. comm. to JKP). It is obvious that eagles can have an affect on murre demography. Whether large-scale longterm changes in murre abundance and distribution, especially in the depauperate regions of Washington and British Columbia, will be the result is not known.

Conclusions

Although the entire Triangle Island Common Murre colony was not monitored for either attendance or reproductive success in 1995, there are several conclusions which can be made from the preliminary data:

1. Censusing of the entire colony is possible, and can be carried out following Rodway (1990) with the use of a small inflatable and a camera.
2. Reproductive success can be monitored from one or more blinds set up on Puffin Rock.
3. Breeding success, and/or breeding areas may be habitat specific: rock areas generally had higher numbers of identifiable pairs with eggs/chicks than grass areas, although both habitats housed several hundred murres.
4. Reproductive success was low relative to other murre colonies on the west coast. This depression is probably due to a combination of factors including: food scarcity, gull direct effects, and eagle direct and indirect effects.
5. Chick residence time was longer than other monitored colonies in both the Atlantic and the Pacific.
6. Both gull and eagle effects can be monitored through observation. Food scarcity can be monitored indirectly with fish watches.

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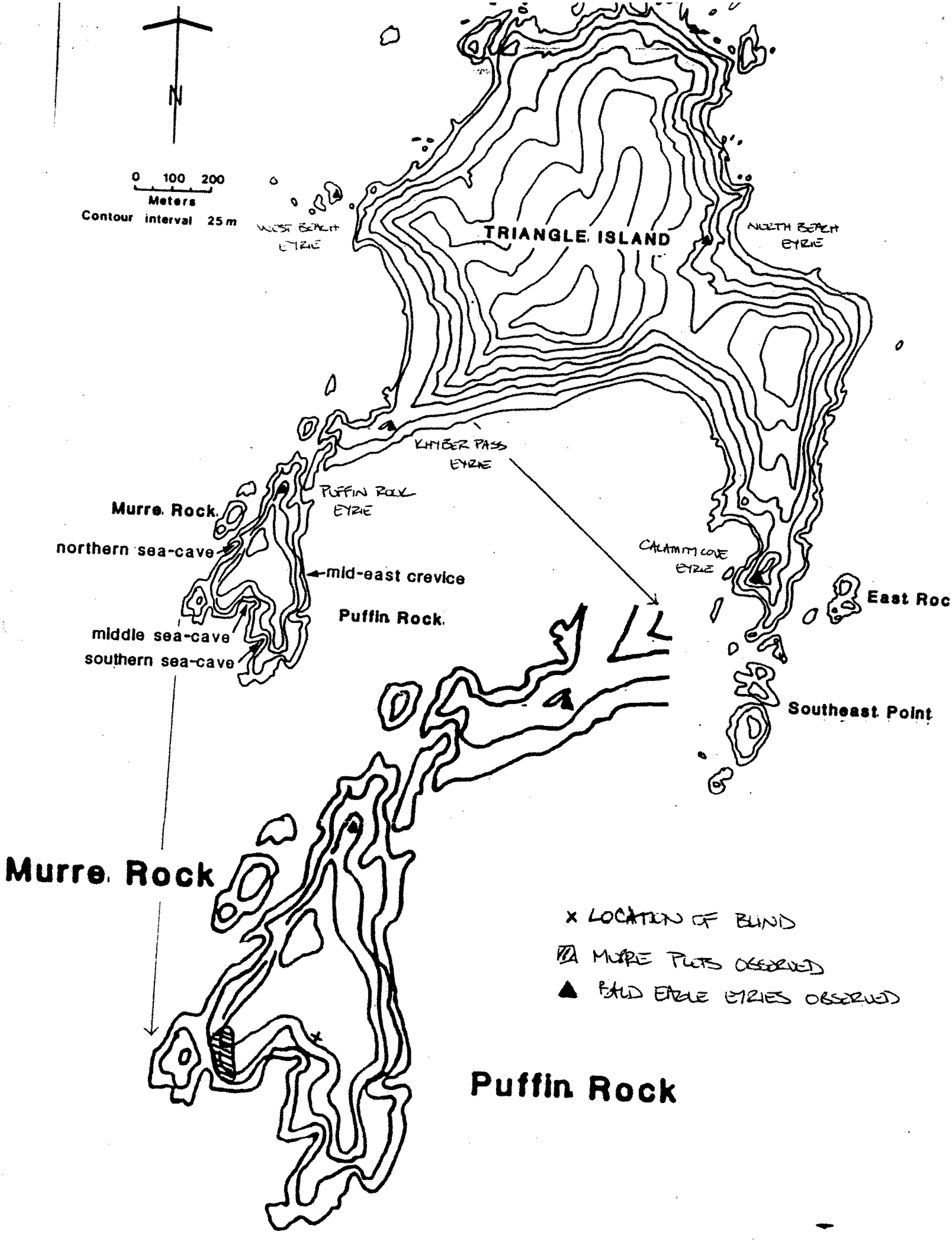
Figure Legends

Figure 1. Map of Triangle Island taken from Rodway (1990), showing the location of the blind, Common Murre observation areas and Bald Eagle eyries, Triangle Island, B. C., 1995.

Figure 2. Photographs of the Common Murre observation areas, Puffin Rock, Triangle Island, B. C. in 1995. Rock habitat outlined with solid line; grass habitat outlined with dashed line. Note location of reproductive success subplots (<u>L</u>ower <u>C</u>luster, <u>M</u>iddle <u>S</u>parse) in R2.

photo's → Fred/Tony for archiving

Figure 3. Diurnal patterns of Common Murre attendance in rock (A) and grass (B) habitat.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mid-east crevice
Puffin Rock
middle sea-cave
southern sea-cave
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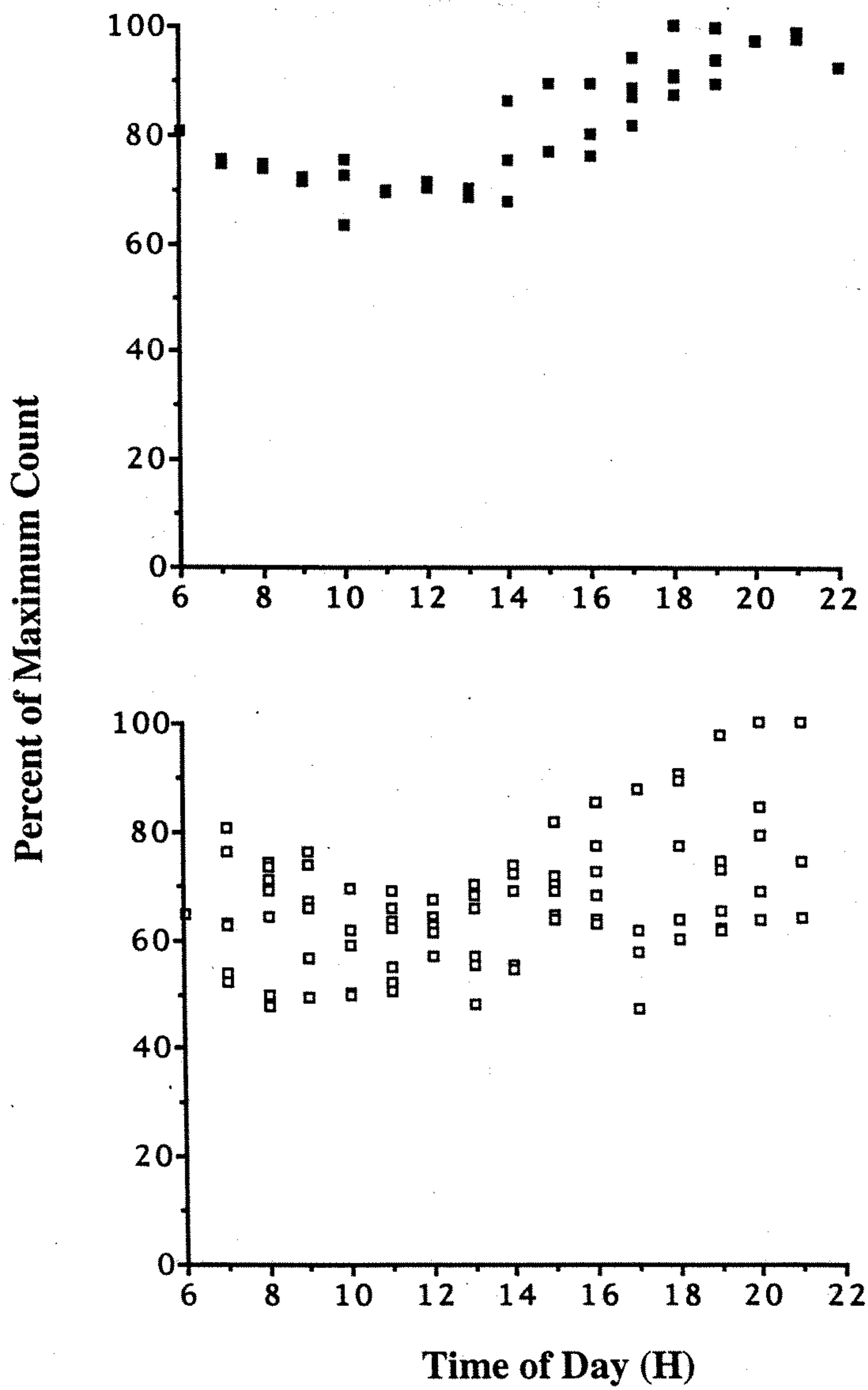

Figure 3A. The pattern of diurnal attendance of Common Murres in rock habitat, as observed from the Puffin Rock blind, Triangle Island, 1995. Closed symbols are during incubation (4 July - 10 July); open symbols are during brooding (13 July - 10 August). Each symbol is a single hourly count for all rock areas (i.e. Rock 2-3, Rock Top).

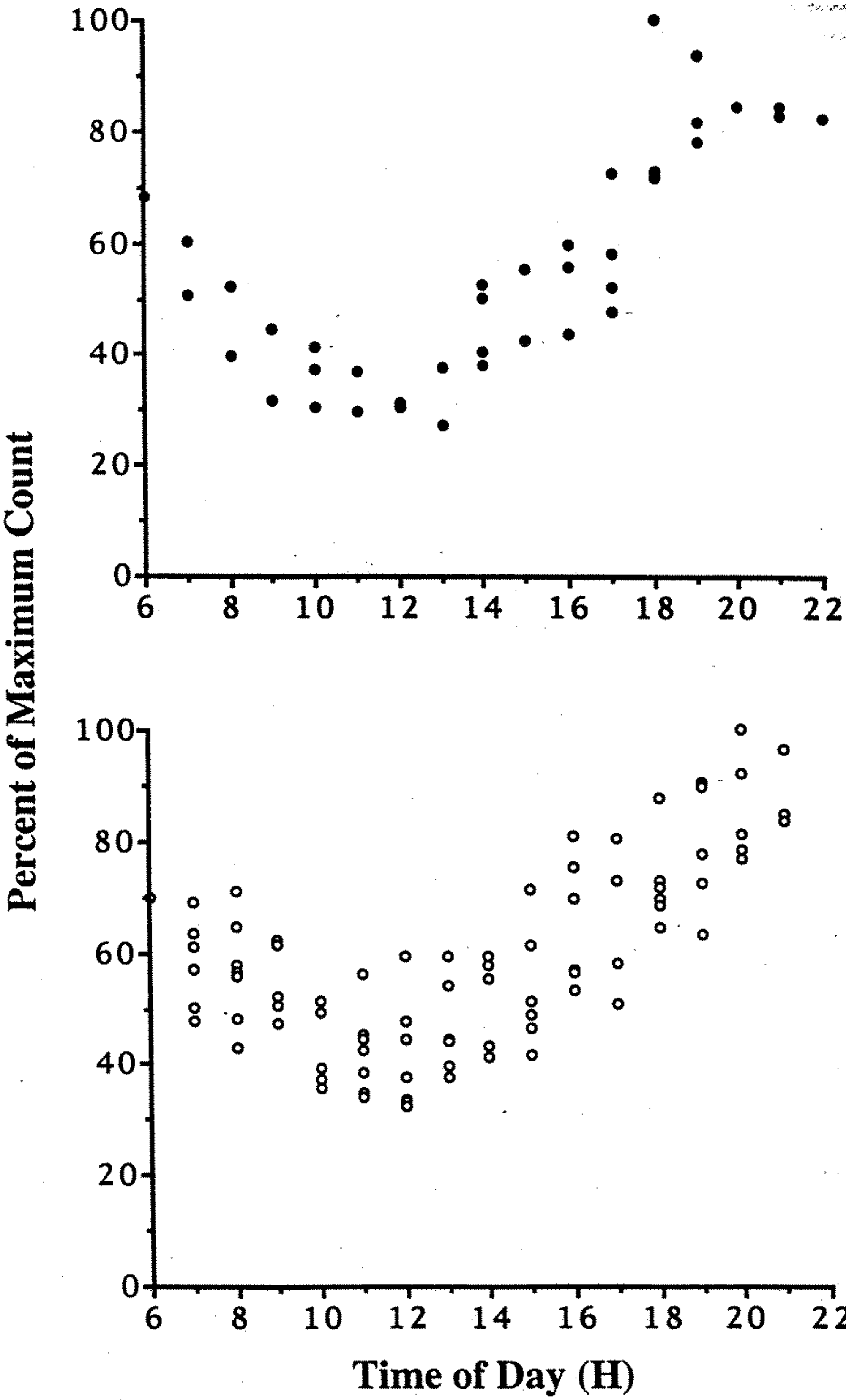

Figure 3B. The pattern of diurnal attendance of Common Murres in grass habitat, as observed from the Puffin Rock blind, Triangle Island, 1995. Closed symbols are during incubation (4 July - 10 July); open symbols are during brooding (13 July - 10 August). Each symbol is a single hourly count for all grass areas (i.e. Grass 1-4).

Table 1 - Mean attendance by area for Triangle Island Common Murres. A - time and season of maximum stability. B - time and season to match Rodway 1990.

A. 4 July to 1 August 1995; 0900-1400 hours*

Area	Mean	SD	SE	N
Rock 2	276.9	60.7	14.3	18
Rock 3	69.7	33.1	7.8	18
Rock Top	44.1	5.3	1.2	18
Grass 1	67.8	16.7	3.9	18
Grass 2	8.8	1.6	0.4	18
Grass 3	6.2	2.4	0.6	18
Grass 4	52.1	17.3	4.1	18

B. 27 July to 17 August 1995; 1800-2000 hours**

Area	Mean	SD	SE	N
Rock 2	262.0	27.6	6.9	16
Rock 3	150.1	34.1	8.5	16
Rock Top	64.1	14.5	3.6	16
Grass 1	121.2	23.9	6.0	16
Grass 2	18.4	3.2	0.8	16
Grass 3	16.4	3.4	0.9	16
Grass 4	117.9	20.8	5.2	16

* sample size is days, where multiple counts within each day have previously been averaged.
** sample size is number of hourly counts both within and among days.

Table 2 - Attendance of Common Murres on Puffin Rock, Triangle Island as a function of habitat type (rock versus grass), phenology, and time of day; 1995.

Rock

	Egg Period			Chick Period			Fledge Period		
Time	Mean	SD	N	Mean	SD	N	Mean	SD	N
600	438.00		1	391.00		1	361.00	77.78	2
700	407.00	2.83	2	392.50	70.49	6	317.00	7.07	2
800	402.50	3.54	2	388.86	67.48	7	330.75	69.93	4
900	388.00	2.83	2	393.33	63.32	6	326.20	59.91	5
1000	382.00	34.60	3	352.20	50.67	5	279.33	93.52	6
1100	376.50	0.70	2	353.00	48.35	8	272.50	82.76	4
1200	383.50	4.95	2	378.43	19.17	7	248.67	59.81	3
1300	376.50	6.36	2	368.17	52.21	6	217.75	33.54	4
1400	412.75	41.46	4	394.40	56.10	5	214.00	125.60	4
1500	451.00	48.08	2	425.67	39.90	6	193.00	147.36	5
1600	444.67	36.77	3	435.83	53.00	6	326.25	15.04	4
1700	477.00	28.08	4	386.25	104.89	4	271.20	138.55	5
1800	493.60	30.60	5	450.67	83.01	6	370.40	118.46	5
1900	511.67	28.68	3	440.33	82.13	6	351.17	164.62	6
2000	529.00		1	482.80	86.91	5	421.25	71.50	4
2100	534.00	4.24	2	484.00	113.71	3			0
2200	502.00		1			0			0

Grass

	Egg Period			Chick Period			Fledge Period		
Time	Mean	SD	N	Mean	SD	N	Mean	SD	N
600	215.00		1	226.00		1	253.50	61.52	2
700	174.50	21.92	2	188.17	26.36	6	240.50	16.26	2
800	144.50	27.58	2	183.71	30.46	7	236.75	18.39	4
900	119.50	28.99	2	177.20	21.61	5	200.20	42.09	5
1000	114.00	17.69	3	137.60	23.74	5	165.33	39.95	6
1100	104.50	16.26	2	133.13	25.22	8	149.00	41.78	4
1200	97.00	1.41	2	133.29	32.14	7	106.67	22.90	3
1300	101.50	23.33	2	150.83	27.65	6	121.25	21.00	4
1400	142.75	22.65	4	166.60	27.56	5	118.50	61.28	4
1500	154.00	28.28	2	173.50	35.66	6	131.40	72.65	5
1600	167.00	26.66	3	212.83	37.27	6	216.00	30.08	4
1700	181.75	34.45	4	213.25	44.18	4	207.60	76.81	5
1800	243.00	41.91	5	235.50	26.11	6	255.60	60.72	5
1900	267.33	25.54	3	262.33	37.30	6	270.67	74.96	6
2000	268.00		1	279.00	32.76	5	307.50	48.60	4
2100	265.00	4.24	2	287.67	22.85	3			0
2200	261.00		1			0			0

Table 3 - Phenology of Common Murres nesting in the three reproductive success subplots on Puffin Rock, Triangle Island, 1995.

	Lower Cluster	Middle Sparse	Rock Top
Observations Start	2-Jul	2-Jul	2-Jul
First Chick	18-Jul	13-Jul	23-Jul
Mean 1st Day Seen	1-Aug + 8.4	30-Jul + 9.0	30-Jul + 6.7
Mean Days Seen*	24.3 + 8.1 (3)	26.3 + 4.6 (10)	23.0 + 7.0 (3)
First Fledge	12-Aug	12-Aug	21-Aug
Mean Fledge*	20-Aug	23-Aug	25-Aug
Observations End	30-Aug	30-Aug	30-Aug
Chicks Remaining	1	1	1

* only birds which definitely fledged; mean + SD (N).

Table 5 - Patterns of turnover of adult Common Murres on the Rock 2 attendance plot, Puffin Rock, Triangle Island, 1995, and comparable data from Tatoosh Island, Washington 1993-1995.

Time of Day		Adult Turnover (leave/return)	Fish Turnover (hours)
0700	Mean	0.85	3.58
	SD	0.27	3.67
	N	8	7
1100	Mean	0.87	2.78
	SD	0.53	1.85
	N	13	11
1500	Mean	0.62	2.58
	SD	0.25	1.34
	N	6	5
1900	Mean	0.80	2.95
	SD	0.51	1.99
	N	12	10
Total	Mean	0.80	2.97
	SD	0.44	2.25
	N	39	33
Tatoosh Island			
1995	Mean		1.5
	SD		0.53
	N		14
1994	Mean		2.64
	SD		1.46
	N		8
1993	Mean		2.95
	SD		2.5
	N		4

Table 4 - Reproductive success of Common Murres in three subplots on Puffin Rock, Triangle Island, 1995.

	Lower Cluster	Middle Sparse	Rock Top	Total
Pairs Followed	31	26	20	77
Eggs Seen	31	26	20	77
Dud/Disappeared	4	5	5	14
Chicks	27	21	15	63
Definitely Died	9	4	5	18
Definitely Fledged	3	10	3	16
Probably Fledged	4	0	6	10
Possibly Fledged	5	0	1	6
Hatching Success	0.87	0.81	0.75	0.82
Fledging Success				
def/chicks	0.11	0.48	0.20	0.25
(def+prob)/chicks	0.26	0.48	0.60	0.41
(def+prob+poss)/chicks	0.44	0.48	0.67	0.51
Reproductive Success				
def/chicks	0.10	0.38	0.15	0.21
(def+prob)/chicks	0.23	0.38	0.45	0.34
(def+prob+poss)/chicks	0.39	0.38	0.50	0.42

The Use of Decoys to Manipulate Behavior: Common Murres on Triangle Island

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Introduction: Nearshore marine systems are becoming increasingly vulnerable to the negative impacts of human activity. Harvest, habitat loss, species introductions, pollution, and global warming all affect marine communities. As highly visible, upper trophic level species within marine systems, seabirds are often the harbingers of environmental change (Furness & Greenwood 1993). Common Murres (*Uria aalge*), in particular, are a "canary-in-the-coalmine." Over 70% of the carcasses recovered from the last four major oil spills on the west coast have been murres (47,000 birds; Burger & Fry 1993). Up to 80% of the bird carcasses recovered from gill-net fisheries have been murres (Takekawa et. al. 1990). In addition to lowered survival, murres are also subject to chronic reproductive losses. Parrish (1995) has shown that rising Bald Eagle (*Haliaeetus leucocephalus*) populations can have a significant effect on murre reproductive success through indirect facilitation of egg predation by Glaucous-winged Gulls (*Larus glaucescens*).

Although a minority of the Tatoosh Island murre population breeds in ledge locations sheltered from raptor introgression, the majority (75-80%) of the colony nests in exposed areas adjacent to vegetation. These latter, large, cliff-top subcolonies are regularly evacuated in the presence of raptors and eggs are lost to gulls. Pilot studies on Triangle Island murres, begun in 1995, indicate that this colony is also subject to regular reproductive failure, and that murre interactions with Bald Eagles and Glaucous-winged Gulls are a contributing factor (Parrish 1996). Like Tatoosh, murres on Triangle nest in rocky (= more protected) and vegetated (= less protected) habitat. Reproductive success of monitored pairs ranged from 0.42 to 0.21 fledglings per pair in rock habitat. Success in grass habitat was lower. This level of reproductive success is not sufficient to sustain the population without immigration. In 1995, eagle-induced flushing was observed on regular occasions, and the number of eagle eyries on Triangle is rising (Parrish 1996) suggesting that murre reproductive success may be further compromised in future.

There are hundreds of thousands of murres in both California and Oregon, respectively (Boekelheide et. al. 1990), and millions of murres in the Gulf of Alaska (Sowls et. al. 1978); however, the middle of the range is depauperate. Washington and British Columbia each support 10-15 thousand murres, and only one large stable breeding colony each (Tatoosh Island - WA, Triangle Island - BC). Murres are natally philopatric, returning to their birth colony to breed (Birkhead 1978). In such closed systems, elevated levels of adult mortality or chronic reproductive failure can cause the local extirpation of a colony, which may remain vacant for years to decades (Apex Houston restoration plan 1995). For Tatoosh Island murres, simple life table analyses based on known population size and reproductive success by habitat indicate that the indirect egg-predator facilitation of eagles will cause this colony to crash within the next 50-70 years (Parrish & Paine, manuscript). As the only large breeding colony of murres in British Columbia, the Triangle Island site is of obvious conservation interest.

Temple (1977) suggested that manipulation of inherent behavioral patterns might be a useful management tool for increasing endangered bird populations in situations where economic and/or social conflicts prevented a more proactive approach (e.g. removal of predators on a protected island such as Triangle). Parrish and Paine (1996) attempted to increase murre reproductive success on Tatoosh Island by manipulating the perceived risk of the murres (measured as the tendency to stay on-colony following an eagle overflight) in cliff-top habitat by setting out grids of artificial vegetation. Murres nesting under these "silk forests" remained after neighbors in control exposed areas had evacuated, and silk forest nesters had higher egg production (Parrish & Paine 1996). Thus, murre behavior, and ultimately demography, can be altered by manipulating context. Decoys have long been used to attract migratory waterfowl to hunting blinds; however, Kress (1983), in an attempt to restore locally extirpated stocks of Common terns, *Sternus hirundo*, adapted this approach to facilitate population restoration, by using decoys and playbacks to attract prospective breeders to former colony sites. Social facilitation has since been adapted to murres, and a project has recently been started on sites of extirpated murre colonies in California (Apex Houston Restoration Plan 1995). However, there have been no studies examining the effects of decoys on bird behavior in extant colonies.

Reported to be the densest nesting seabird in the world (Birkhead 1977), murres often nest within physical contact of their neighbors and densities of 20 pairs/m^2 are reported to be average (Harris and Birkhead 1985). Due to neighbor proximity, murres have developed a variety of behaviors mediating intraspecific aggression, including allopreening (Birkhead 1978) and alloparenting (Birkhead 1985). For such a highly gregarious bird, established subcolonies may act as an attraction source over optimal, but unoccupied, habitat. Thus, large subcolonies in suboptimal habitat may become population sinks (e.g. cliff-top subcolonies on Tatoosh; Parrish 1995).

Objective: I propose to systematically examine the effects murre decoys have on the behavior, and ultimately reproductive success, of murres nesting on Triangle Island. Specifically, this study will address whether decoys have an effect on:

1.) the timing of resettlement after raptor or gull-induced flushing (i.e., is latency to return faster than for control plots?)
2.) the spatial pattern of that resettlement (i.e. do returning murres settle in the vicinity of decoys with a higher than expected frequency?)
3.) the probability that murres will settle in previously unoccupied habitat (i.e. can decoys still act as an attraction source in the face of broader social cues such as occurs in a settled colony?)

Because murres are diurnal, gregarious, surface nesters, they can be easily monitored without direct intervention. Experimental manipulations of the habitat (i.e. decoy placement) can be accomplished before breeders settle, and ensuing observations to quantify decoy effects can be accomplished from blinds. The study will take place on Puffin Rock, in sites quantified for nesting in 1995 (Parrish, pers. obs.).

Methods: Standing and brooding decoys made of cast and painted fiberglas will be deployed in groups of six, arranged in a tight clump (a 'neighborhood'), in late May/early June. Decoys will be fixed to rebar set into the substrate. Four neighborhoods will be placed in known murre nesting habitat where fly-offs have been recorded (Parrish, pers. obs.). Control areas will be left unmanipulated. Experimental and control areas will be gridded and mapped (including physical features and pair placement) to facilitate data collection. Latency to return and pattern of resettlement will be recorded opportunistically after any evacuation using a set of behavioral benchmarks including (but not limited to): first fly-by, bounce-land, and land, 10 and 50 birds (Parrish 1995). Cause of evacuation will be noted (e.g. eagle, gull, unknown). Reproductive success of all pairs will be monitored and analyzed as a function of proximity to decoys for experimental plots, and compared to average reproductive success in control plots. Four identical neighborhoods will also be placed in potential but unused murre nesting habitat, and monitored for signs of interaction including (but not limited to): approach; courtship, appeasement, or aggressive behavior; settlement and/or nesting. All decoys will be removed at the end of the breeding season.

Significance: Although restoration ecology is fairly well developed for plant communities, it is a nascent science, at best, for animal populations. To date, the majority of conservation approaches to restoring depressed animal populations directly have involved predator or competitor removal, or captive breeding and re-introduction (Caughley & Gunn 1996). However, these approaches are not feasible in many systems. The use of ecology or behavior (e.g. social facilitation - Kress 1983) is still rare but will become increasingly important as the arsenal of conservation techniques grows (Reed & Dobson 1993). This study proposes to examine whether a behaviorally-based approach can be used to augment murre reproductive success on a colony that has not yet reached a crisis point, but may well in future.

Preliminary Budget

Salaries and Benefits	
Student hourly	2962.37
4 mos. @ 50%	
$8.34/hr; 11% benefits	
Equipment	
Nikon camera body	500.00
Supplies	
Decoys	1450.00
50 @ $15 each	
$700 casting fees	
Blind materials	300.00
wood, hardware, screening, guy wire	
Film & processing	300.00
Travel	
Rt helicopter to Triangle	400.00
anticipate a % of a 'doctor's run'	
Board	960.00
4 mos. @ $8/day	
Indirect Costs	1739.66
UW off-campus rate - 27.3%	
Total (in US$)	**8612.02**

Budget Justification: The budget was calculated (in US$) as if funds would pass through the University of Washington, and no charges would be defrayed (e.g. transit and board) by the Triangle Island Program. Student salary and benefits were calculated according to the pay scale at the University of Washington; however, as the student is currently non-matriculated, these values can be changed, or paid by another source (i.e. Simon Fraser). Therefore, it is possible to lower the cost of this project substantially. A camera body is needed, although my lab will supply lenses, binoculars, and a spotting scope. Decoy prices are estimated from 1995 quotes and include two extra birds. A second blind will need to be set up on Puffin Rock, overlooking the experimental site, which is out of view of the murre and puffin monitoring area.

Project Tenure: May 1996 - September 1996. Final report by January 1997.

Personnel: I have a non-matriculated student in my lab, Suzanne Romain, in mind for this project. She has an undergraduate degree in Biology from Evergreen College in Washington, and field experience on tropical seabirds, as she volunteered for a U. S. Fish and Wildlife Service project on Tern Island. Since she finished school, Suzanne has decided that she wants to go on to graduate school in the Biological Sciences, and particularly in the fields of ecology and conservation biology, and will be applying to our new Master's Program in Conservation Biology. She applied to work in my lab in order to gain needed experience - although her USFWS work involved the collection of seabird demographic data, she did not have the opportunity to learn data analysis techniques, or scientific writing skills, nor was she exposed to the relevant literature. At present, Suzanne is learning our database programs and is responsible for murre data entry for both Tatoosh and Triangle. She is scheduled to take our GIS seminar class, a rock-climbing class, and will learn the statistical analysis skills she will need to accomplish this project. She will also accompany me to Tatoosh during the spring season, to learn the observation protocols and help set up a murre restoration experiment. I have informed her that if we obtain funding for this project, she may be spending 50% of her time as a volunteer working on Tufted Puffins and Glaucous-winged Gulls.

Other Species

Glaucous-winged Gulls: The gull population on Puffin Rock will be censused and reproductive success monitored visually for nests within site of the blind(s).
Northwestern Crows: Crow counts will be made opportunistically from the south beach, in transit to and from Puffin Rock.
Bald Eagles: Eagle eyries will be censused opportunistically over the course of the summer as active or inactive. The number of chicks will be noted for active nests. For eyries visible from the Puffin Rock trail and/or the cabin porch (Calamity Cove, Puffin Rock, Khyber Pass), reproductive success and prey types will be monitored during systematic observations throughout the day following a protocol developed in 1995. A record will be kept of all eagles positively identified as known individuals (distinguished by plumage, feather loss pattern, and location) throughout the summer, to estimate population size.

As outlined, the murre monitoring protocol will require a halftime person present throughout the nesting season, and very occasional participation by other personnel (e.g. boat surveys, chick banding). If the decoy study is funded, the student assigned to that project can also monitor the murres without much extra work, as most of the data are essential for the decoy study and the only extra equipment required is a boat, which the Triangle Program already possesses. Some optics and photographic equipment can be provided by my lab, although film processing will need to be paid. I propose the student used to monitor murres also be available to collect Tufted Puffin data. As murres and puffins both occur on Puffin Rock, this arrangement would minimize researcher effects by limiting the number of personnel on the Rock. Furthermore, gull census and reproductive success data are useful for both murre and puffin work.

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