Corvid Management to Restore Common Murres at Point Reyes National Seashore
2013 Annual Report

Prepared by: David Press, Wildlife Ecologist, Point Reyes National Seashore

Submitted to: Luckenbach Trustee Council

December 3, 2013

2013 Accomplishments

Raven monitoring at PRNS continued for a fourth year in a row at ranches nearest the Point Reyes Headlands (A, B, and C Ranches), at the Point Reyes Headlands common murre colonies, and at common murre colonies within Drakes Bay. The final 2013 common murre monitoring report is included with this report. We are still working on a draft report for the ranch monitoring which will summarize our data collected since October 2010. The monitoring has helped to focus our raven management efforts. The final ranch report is still pending.

PRNS contracted with USDA Wildlife Services again in 2013 for targeted removal of ravens adjacent to the common murre colonies.

The riparian fences at A, B, and C Ranches were completed in fall 2012. See attached maps. One pay period of time for Devii Rao, Range Management Specialist, was needed for project management and oversight. We were also required to pay a $114 permit fee to the Regional Water Quality Control Board.

Our ranch surveys identified that the calf huts at B Ranch, which number up to 45 huts at certain times, are a major attractant to ravens. The calf huts are small structures where individual calves are housed and fed from open buckets. Although each calf hut is fenced with the feed buckets placed inside the fencing, the design does not prevent ravens from accessing the continuous supply of grain in the buckets. Moreover, several cypress trees directly adjacent to this area provide abundant cover as a 'staging' area for ravens between foraging bouts. In FY12, we purchased and installed six new calf huts, which are designed so that the feed buckets are mounted inside the huts. During subsequent surveys, we did not observe any ravens going inside the new calf huts to access the feed and all raven activity was concentrated at the huts with the open feed buckets. Because of the success of these new huts, we moved forward with a larger order of calf huts in FY13 in order to replace all of the calf huts that have open feed buckets. Forty-five new calf huts were purchased and delivered to B Ranch in July 2013 at a cost of $17,010. The results from our October 2013 surveys are so far very encouraging. The maximum number of ravens seen at any one time around the calf huts was half of what it was previously and the average count was reduced 82% compared to previous survey months.

Delays continued in 2013 with installation of covered feed bins at the ranches. During the initial design of this project, the feed bins at A Ranch were identified as a significant raven attractant. The park's former Range Management Specialist, John DiGregoria, worked with the rancher and the park's engineer to design covers that would work for the specialized, concrete feed bins that

are built into the ranch complex. However, A Ranch subsequently sold the majority of its herd after deciding to transition the dairy to organic. There is no current need for covered feed bins at A Ranch. Our ranch surveys have not identified a need for covered feed bins at C Ranch either. At B Ranch, however, there are a series of new feed bins that are attracting ravens. In FY13, we worked with the rancher to design a prototype covered feed bin. We plan on building and installing the prototype in early FY14.

We initiated a contract with Conservation Corps North Bay (CCNB) for cleanup of three ranch debris piles – two at B Ranch and one at A Ranch – at a cost of $16,720. The work occurred in August and September 2013. With considerable support from ranch staff, CCNB removed 1520 lbs of concrete, 6840 lbs of metal, and 36,740 lbs of mixed debris including roofing material, wood, and household items. Included were 65 tires, 11 refrigerators, and 7 televisions. Much of the metal was scraped. Tires, appliances, and treated lumber required special disposal following applicable laws. Some additional clean-up days in FY14 will be required to complete the project.

2013 Budget: $70,787

1. Raven monitoring at ranches during October 2012 and January, April, July 2013. Raven monitoring at common murre colonies from May – August. **Total: $17,926**

2. USDA Wildlife Services targeted raven removal adjacent to common murre colonies during breeding season (April through August). **Total: $15,000**

3. Riparian fencing. Regional Water Quality Control Board permit fee. 1 pay period for PRNS Range Management Specialist for project management and oversight. **Total: $3,656**

4. Forty-five new calf huts purchased and installed at B Ranch in order to keep ravens out of the calf feed buckets. **Total: $17,010**

5. Debris removal at A and B Ranches: asbestos sampling and contract with Conservation Corps North Bay. **Total: $16,848**

6. Vehicle repairs. **Total: $347**

Total remaining in account at end of FY2013: **$37,743**

2014 Work Plan

Raven monitoring will again be implemented in FY14 at A, B, and C Ranches and the common murre colonies at Point Reyes Headlands and within Drakes Bay.

USDA Wildlife Services will again be contracted for targeted raven removal during the common murre breeding season.

PRNS staff have designed a prototype cover for the feed bins at B Ranch. The prototype will be constructed and installed early in FY14. Monitoring efforts will identify the success of the covers in keeping ravens out of the feed bins. Modifications to the cover design may be required. Up to five additional feed bins will be constructed later in the FY once the design is finalized.

Additional money will be obligated to the contract with Conservation Corps North Bay to complete debris removal at A and B Ranches. Only a couple more days of clean-up are required to complete the project.

2014 Schedule and Budget

1. Raven monitoring at ranches during October 2013 and January, April, July 2014. Raven monitoring at common murre colonies from May – August 20143. Request: **$20,000**

2. USDA Wildlife Services targeted raven removal adjacent to common murre colonies during breeding season (April through August). Request: **$15,000**

3. Complete debris removal at A and B Ranches. Request: **$5,000**

4. Covered feed bins will be installed at B Ranch. Costs include materials and labor for design, construction, and installation. Request: **$9,600**

5. Covered feed bins will be installed at A Ranch as needed when dairy increases herd size. All remaining funds will be held for this purpose. Request: **$21,223**

FY 2014 Request:	$70,823
Remaining from FY 2013:	$37,743
Final Adjusted FY 2014 Request:	**$33,080**

Point Reyes National Seashore
Summer 2013 Raven Disturbance Monitoring
Kaitlin Harrigan, Biological Technician

Summary

Weekly observations of common raven (*Corvus corax*) predation and disturbance events were conducted at two common murre (*Uria aalge*) colonies within Point Reyes National Seashore (PRNS). The observations were conducted at six established viewing points of ten predefined sub-colonies surveyed once a week from May through August of 2013. Thirty-six disturbance and eleven predation events were observed during 114 survey hours. Raven disturbances occurred on all Point Reyes Headland sub-colonies and at one Arch Rock sub-colony. Results from this year and previous years indicate the proximity to ranch lands may play a role in the amount of corvid predation on common murre colonies. Continued monitoring of corvid presence and activity in the headlands, as well as effective short- and long-term corvid population management, is recommended to determine and reduce the degree of impact on common murre productivity.

Methods

The two monitored common murre colonies at PRNS, Point Reyes Headlands (PRH) and Arch Rocks, were divided into 10 sub-colonies (Table 1, Figures 1-8) through consultation with USFWS Biologist G. McChesney in 2010. Observations took place for 2 to 4 hours between 0600 and 1800 hours, from the middle of May when egg laying commenced until early August when common murres were no longer roosting on the sub-colony rock. The objective was to monitor each site weekly for a minimum of 2 hours on a rotating schedule, so that all hours of the day were covered in a six-week monitoring period. The twelve-hour survey time frame was designed to capture the peak activity of common ravens, which feed mostly in the morning and afternoon (Boarman and Heinrich 1999).

Table 1: Observation points and respective monitored common murre sub-colonies.

Observation Point	Sub-colonies Observed
Point Reyes Headlands Colony	
PRH Lighthouse Building	Lighthouse Rock
Boulder Rock	Boulder Rock
East Seal Cove	Middle Rock, East Rock, Flattop Rock, Beach Rock, Pointy Rock
Arch Rock Colony	
Millers Point	Millers Point South Rock
Arch Rock	Sea Stack
Point Resistance	Point Resistance Rock

For each day that a sub-colony was monitored, the following information was recorded on a data sheet: date, observer, start and end time of survey, observation point, visibility,

approximate number of common murres on the rock, type of survey, and maximum count of common ravens seen at one time, as well as general notes (Appendix A). Survey type was categorized as either a full survey or a colony check. A full survey was classified as any survey conducted for disturbance monitoring. A colony check survey was classified as a brief survey for the presence of common murre eggs at the beginning of the season or for the presence of common murre adults on the rocks at the end of the season.

During a full survey, the monitor would continuously scan the rocks using a combination of unaided vision and binoculars until a disturbance was observed, which would then be followed using a spotting scope. A disturbance event was defined as any action by common ravens that caused common murres to flush from the sub-colony or resulted in loss of eggs or chicks. The beginning of a disturbance event was defined as the time when a raven landed on the sub-colony rock and the end of the event was defined as the time when the raven left the sub-colony rock. A predation event was categorized as a disturbance event during which common ravens were observed taking common murre eggs or chicks from the sub-colony. Once an event was observed, the monitor recorded the following information on the aforementioned datasheet: start and end time of the event, number of ravens involved, the technique used by the raven (Table 2), characteristics of sites attacked, outcome of the event, and other anecdotal observations. Site characteristic data classified the disturbed location within the sub-colony as an edge site or interior site, noted the number of vertical rock faces around the site, and noted the number of neighboring sites. An edge site was located within 5 m of the edge of the occupied area, while an interior site was located more than 5 m from the edge of an occupied area. The number of vertical rock faces was intended to categorize the 'remoteness' (and therefore accessibility to predators) of a common murre nest site by quantifying its proximity to colony edge rock ledges. Vertical rock faces were always between zero and three faces located within one common murre width of the disturbed location. The number of neighboring sites included any murre-occupied site located within one common murre width of disturbance location. The outcome of the disturbance included number of common murres flushed, number of eggs taken, and number of chicks taken. Examples of anecdotal observations included permanent markings on ravens, ravens roosting or nesting in the area, and disturbances by other bird species such as western gulls or turkey vultures which influenced common raven activity and predation.

Table 2: Techniques used by common ravens to take common murre eggs or chicks.

Technique	Explanation
Lunge	Lunging at common murre with beak to force common murre from its site
Pull	Pulling the common murre off site by a wing, foot or beak
Snatch	Snatching an unattended or poorly guarded egg or chick without driving the parent off the site
Easy Picking	Taking unattended eggs or chicks following a flushing event
Air Attack	Taking an adult common murre from the air
Incidental Loss	Egg rolled away from sited during flushing and broke, egg snatched by gull

Common ravens typically lay clutches in March or early April, consisting of 1 to 5 eggs (Boarman and Heinrich 1999). Their chicks fledge around 5 weeks, so early detection of nest locations is beneficial to controlling raven population numbers. Adult common ravens that appear aggressive towards intruders on their territory can be good indicators of nesting locations and pair boundaries, especially during the breeding season (Webb et al. 2003). Early-season efforts were made to locate common raven nests in the study area before raven clutches hatched and before common murre egg-laying was fully underway. Though no raven nests were located during search efforts this season, when a common raven nest is discovered near the study area, the location would be recorded using a Global Positioning System (GPS) and plotted on a map of the study site so that the nesting pair could be easily located in the future.

Results

Over the course of the 2013 season, 56 surveys were conducted during 114 hours of observations. Thirty-one surveys were conducted at the PRH colony and 25 were conducted at the Arch Rock colony. All sub-colonies with the exception of Sea Stack were monitored, due to the absence of common murres on that rock throughout the season. Common raven activity was observed at all monitored sub-colonies with the exception of Sea Stack, and disturbance was observed during 14 of the 56 surveys. A total of 36 disturbance events were observed in 2013 (Table 3). Twenty-nine of these disturbances occurred at the PRH complex, while seven events happened at one of the three Arch Rock sub-colony groups, Miller's Point South. Of the ten sub-colony rocks, eight experienced raven disturbance. The overall disturbance rate per hour was 0.32 for all PRNS colonies, 0.14 for Arch Rock colony, and 0.46 for PRH colony (Table 3). Eleven of the 36 disturbances were predation events (Table 4). One predation event occurred on Lighthouse Rock, two on Boulder Rock, one on Middle Rock, five on Beach Rock, and two on Miller's Point South (Table 4). The other 25 disturbances were common murre flushing events that did not result in observed egg or chick loss. Three such events occurred on Lighthouse Rock, five on Boulder Rock, three on Middle Rock, three on Flattop Rock, two on Pointy Rock, and five on Miller's Point South (Table 5).

Of the 36 disturbance events, 28 were observed when visibility was clear, four when visibility was hazy, and four during foggy conditions. Disturbance events occurred at most hours of the day, with the exception of 800-1000 and 1600-1800 observation periods. Four disturbance events occurred between 0600 and 0800, zero between 0800 and 1000, eleven between 1000 and 1200, eleven between 1200 and 1400, ten between 1400 and 1600, and zero between 1600 and 1800. Of the 36 disturbance events, 12 occurred during the month of May, 3 during June, and 14 during July. No disturbance events were observed in August as most common murre sub-colonies were abandoned by the first week of the month.

Common ravens were observed flying by all monitored sub-colonies at least once during the season. An absence of raven activity was observed during 15 out of the 56 surveys conducted, three of which occurred during foggy or rainy days with poor visibility. The maximum number of common ravens recorded during a survey ranged from one to four. All of the observed disturbance events involved only one or two common ravens. Thirty-two disturbance events

Table 3. Total number of disturbances, surveys conducted, hours surveyed and percent disturbance events per hour for PRNS common murre colonies.

Survey Area	Number of Surveys Conducted	Number of Hours Surveyed	Number of Disturbance Events	Rate Disturbance Events per hr
All PRNS	**56**	**114**	**36**	**0.32**
PRH Colonies	**31**	**62.4**	**29**	**0.46**
Lighthouse Rock	11	23	4	0.17
Boulder Rock	10	19.4	7	0.36
Middle Rock[1]	10	20	4	0.2
East Rock[1]	10	20	1	0.05
Flattop Rock[1]	10	20	3	0.15
Beach Rock[1]	10	20	8	0.4
Pointy Rock[1]	10	20	2	0.1
Arch Rock Colonies	**25**	**51.6**	**7**	**0.14**
Millers Point South	13	27	8	0.30
Sea Stack	0	0	0	0
Point Resistance	12	24.6	0	0

[1] Middle Rock, East Rock, Flattop Rock, Beach Rock and Pointy Rock are surveyed simultaneously from the same observation point.

Table 4. Total number predation events, disturbance events, percent predation per disturbance event, and rate of predation events per hour.

Survey Area	Number of Disturbance Events	Number of Predation Events	Percent Predation Per Disturbance	Rate Predation Events per hr
All PRNS	**36**	**11**	**0.31**	**0.10**
PRH Colonies	**29**	**9**	**0.31**	**0.14**
Lighthouse Rock	4	1	0.25	0.04
Boulder Rock	7	2	0.29	0.10
Middle Rock[1]	4	1	0.25	0.05
East Rock[1]	1	0	0	0
Flattop Rock[1]	3	0	0	0
Beach Rock[1]	8	5	0.63	0.25
Pointy Rock[1]	2	0	0	0
Arch Rock Colonies	**7**	**2**	**0.29**	**0.04**
Millers Point South	8	2	0.25	0.07
Sea Stack	0	0	0	0
Point Resistance	0	0	0	0

[1] Middle Rock, East Rock, Flattop Rock, Beach Rock and Pointy Rock are surveyed simultaneously from the same observation point.

Table 5. Total number of common murre flushing and predation events caused by common ravens for the 2010, 2011, 2012, and 2013 monitoring seasons.

Survey Area	Number of Flushes				Number of Eggs				Number of Chicks			
	2010[2]	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
All PRNS	N/A	11	44	35	7	6	27	7	1	3	9	4
PRH Colonies	N/A	11	43	28	3	6	27	5	1	3	9	4
Lighthouse Rock	N/A	2	10	4	0	4	7	1	0	2	3	0
Boulder Rock	N/A	4	23	7	2	2	18	2	1	1	6	0
Middle Rock[1]	N/A	1	3	4	0	0	0	1	0	0	0	0
East Rock[1]	N/A	0	0	1	0	0	0	0	0	0	0	0
Flattop Rock[1]	N/A	3	4	3	1	0	2	0	0	0	0	0
Beach Rock[1]	N/A	0	0	7	N/A[3]	0	0	1	N/A[3]	0	0	4
Pointy Rock[1]	N/A	1	3	2	N/A[3]	0	0	0	N/A[3]	0	0	0
Arch Rock Colonies	N/A	0	1	7	4	0	0	2	0	0	0	0
Millers Point South	N/A	0	1	7	0	0	0	2	0	0	0	0
Sea Stack	N/A	0	0	0	0	0	0	0	0	0	0	0
Point Resistance	N/A	0	0	0	4	0	0	0	0	0	0	0

[1] Middle Rock, East Rock, Flattop Rock, Beach Rock and Pointy Rock are surveyed simultaneously from the same observation point.

[2] Flushing events were not recorded during the 2010 season.

[3] Beach Rock and Pointy Rock did not have common murre colonies on them during the 2010 season.

took place at an edge site, while four events were categorized as occurring in the interior of a sub-colony. These interior events actually happened on the edge of a fragmented murre group, towards the interior of Beach Rock at East Seal Cove. Only four of the 36 disturbance events lasted longer than five minutes. The two most utilized techniques used by ravens to try to obtain eggs or chicks were "lunge" and "snatch."

Full surveys were conducted on a routine schedule during twelve weeks of observation from May 13 until August 6. At the end of the season, after complete absence of common murres at a sub-colony was noted during at least one half hour of full survey, one more colony check was conducted to verify that the birds had left for the season. During the 2013 monitoring season, no roosting or nesting common murres were observed at the Sea Stack sub-colony, which was therefore not monitored after the absence of birds was verified during two colony checks in May. Nesting common murres were observed on Miller's Point South during the 2013 season, a change from the 2012 season.

Unfortunately, active raven nests were not located during nest search efforts early this season, though the presence of juvenile common ravens, especially at East Seal Cove, indicates that there were in fact active nests in 2013. Plans for the 2014 season include a specific, targeted effort to locate common raven nests and to work with our USDA partner to remove found nests prior to the common murre breeding season.

In comparison with the 2010, 2011, and 2012 monitoring seasons, which reported 8, 9, and 23 predation events respectively, 11 predation events were observed in 2013 (Table 5). Flushing events were not reported during the 2010 monitoring season but were recorded during the 2011, 2012, and 2013 monitoring seasons. The number of flushing events was 11 in 2011, 44 in 2012, and 35 in 2013. The number of eggs lost to common ravens in 2013 was 7, as compared to 27 in 2012, 6 in 2011, and 7 in 2010. The number of chicks taken by ravens was 4 in 2013, compared to 9 in 2012, 3 in 2011 and only one in 2010. During the 2010 monitoring season, half of the recorded predation events occurred at Point Resistance Rock, with four eggs lost to ravens. No disturbance events were observed at Point Resistance Rock during the 2011, 2012, and 2013 monitoring seasons, and ravens were rarely seen at this site in 2013. During the 2010 monitoring season, two eggs and one chick were taken at Boulder Rock and one egg was taken at Flattop Rock. During the 2011 monitoring season, four eggs and two chicks were taken at Lighthouse Rock and two eggs and one chick were taken at Boulder Rock. In 2012, seven eggs and three chicks were predated at Lighthouse Rock, 18 eggs and six chicks were taken at Boulder Rock, and two eggs were taken at Flattop Rock. In 2013, one egg was taken from Lighthouse Rock, two eggs were taken from Boulder Rock, one egg was taken from Middle Rock, one egg and four chicks were predated at Beach Rock, and two eggs were taken from Miller's Point South (Table 5). Brown pelican-related disturbances were not noted in 2010 and 2011, observed frequently in 2012, but did not occur during survey hours in 2013. This important difference may account for the high number of predation events in 2012.

Discussion

The increase in common raven population numbers at PRNS over the past two decades is thought to contribute to increased disturbance of common murre colonies and other avian species populations throughout PRNS. This observed rise in common raven numbers highlights the need for an established management plan for the coming years (Engle and Young 1989, Stiehl and Trautwein 1991, Marzluff et al. 1994).

Eleven predation events and 36 disturbance events were recorded during 114 hours of monitoring in 2013, a decrease from the 2012 season, when 23 predation events and 52 disturbance events were observed. The effect of brown pelican disturbance in 2012 is important to remember when considering these numbers. The 2013 season predation and disturbance event numbers increased in comparison to 9 predation events and 20 disturbances in 2011. Eight predation events were observed in 2010. There is a possibility that more events occurred outside of the monitoring window. The total predation rate for all ten sub-colonies was 0.10 per survey hour, resulting in approximately 1.2 predation events per day (a day equaling a twelve-hour time period). The total disturbance rate for all ten sub-colonies was 0.32 per survey hour, resulting in approximately 3.84 disturbances per day.

Common ravens and other types of non-anthropogenic disturbances may play a role in common murre productivity and selection of breeding colony location (Eigner et al. 2011). Two main factors appear to impact the frequency of observed corvid disturbances of common murre colonies at PRNS: proximity of the murre colony to a pair of nesting ravens and distance of murre colony to the nearest ranches where ravens forage. During the 2010 monitoring season, half of the documented disturbances occurred at the Point Resistance Rock sub-colony. A territorial pair of common ravens was observed taking eggs and the pair's nest was located 0.09 km south of the sub-colony. The pair and their nest were subsequently removed from that location late in the 2010 season. During the 2011, 2012, and 2013 monitoring seasons, no raven disturbances were documented at Point Resistance Rock (Table 5).

During the 2011 monitoring season, all common murre sub-colonies at which disturbance events were observed were located within 3 km of the nearest dairy ranch. In contrast, during the 2011 season no disturbances were observed at all sub-colonies located more than 5 km away from ranching areas (Table 6). In 2012, only one disturbance was observed at a murre sub-colony located more than 5 km away from the nearest ranch. This disturbance was caused by three raven fledglings that flew from the observation point to Miller's Point South and remained on the rock for the entire duration of the survey (four hours). Similarly, in 2013, the only disturbances observed at a murre sub-colony located more than 5 km away from the nearest ranch were observed at Miller's Point South. Eight disturbances and two egg predation occurred during surveys of Miller's Point South, and the common raven pair responsible was likely the same territorial pair observed there in 2012. Removal of this established pair would be effective in preventing common raven disturbance at Miller's Point South, as evidenced by the 2011 results at Point Resistance Rock following the removal of the raven pair near the area in late 2010.

Table 6. Number of disturbances in 2013, distance to nearest ranch, and area of each sub-colony.

Survey Area	Number of Disturbances	Distance from Nearest Ranch (km)	Area of Colony (m^2)
PRH Colonies			
Lighthouse	4	2.56	1684.4
Boulder Rock	7	1.96	381.8
Middle Rock	4	0.80	237.1
East Rock	1	0.79	465.4
Flattop Rock	3	0.77	176.2
Beach Rock	8	0.80	1054.8
Pointy Rock	2	0.73	104.9
Arch Rock Colonies			
Millers Point South	8	5.07	1014.0
Sea Stack	0	5.02	306.2
Point Resistance	0	5.77	585.7

The large increase in disturbance and predation rates in 2012 compared with previous monitoring seasons and the 2013 monitoring season can be largely attributed to disturbances by brown pelicans that increased availability of common murre eggs and chicks to predators (U.S. Fish and Wildlife Service, unpublished data). Though brown pelicans were not observed disturbing common murres in 2013, other species were observed flushing murre adults and predating common murre chicks and eggs. Western gulls in particular were observed at all monitored colonies flushing adult murres, and in two cases predating murre chicks. Gull activity was observed as contributing to several cases of raven predation of murre chicks and eggs, primarily by flushing adult murres off nesting sites. Aggressive and territorial peregrine falcon pairs living near murre colonies may inhibit raven activity and possible raven disturbance of murre colonies, but falcons were also observed flushing large numbers of common murres. Fishing boat and helicopter traffic were additional noted disturbances. Common ravens may therefore affect common murre productivity by reducing it during normal years as well decrease it even further when it is already compromised by other factors. Productivity failure may induce common murres to abandon sub-colonies in subsequent breeding seasons (Eigner et al. 2011).

High common raven numbers have been documented in the Western U.S. and have been attributed to this species' ability to adapt and exploit a variety of food resources and thrive in human-structured environments (Engle and Young 1989, Stiehl and Trautwein 1991, Marzluff et al. 1994). Breeding common ravens construct nests throughout the landscape, and may feed their young at least partially with forage obtained at anthropogenic resources (Kristan 2001). During a study examining common raven nest distance from anthropogenic resources in the western Mojave Desert, higher survival rates of juvenile non-breeding common ravens were observed for nests located closer to anthropogenic resources (Webb et al. 2003). At PRNS, dairy and cattle ranches provide a year-round anthropogenic food source. Common ravens have been observed feeding at livestock feed bins, water troughs, and calving pens, where they can obtain nutrients more easily from scavenging instead of hunting. Consistent access to these food and water sources may permit larger common raven clutch sizes or recruitment with the result being higher numbers of non-breeding common ravens moving around in flocks. However, breeding ravens were found to be reluctant to contract their territories simply in order to nest near anthropogenic resources, even though the natural resources within their territories may be scarce (Webb et al. 2003). Instead, breeding birds have smaller home ranges than non-breeding ravens with more localized movement patterns and specialization for other, more proximal food sources, such as common murre eggs, chicks, and adults, for example (Roth et al. 1999).

Four seasons of observations at the monitored common murre sub-colonies between 2010 and 2013 have revealed that almost all disturbances at common murre colonies were caused by lone ravens or raven breeding pairs, not large flocks, thus supporting the hypothesis presented in previous publications that territorial individuals have learned to capitalize on the common murre colonies (Roth et al. 1999). In 2011 and 2012, only one instance of common murre disturbance by a group of three ravens was observed during each monitoring season. In 2013, no disturbances involving more than 2 ravens were observed. It would be difficult to investigate this hypothesis further at PRNS without placement of permanent identifying markers (i.e. leg bands, telemetry tags) on individual common ravens. However, maximum count data has shown group sizes of up to six ravens in 2012 and up to four ravens in 2013 flying past common murre sub-colonies. These groups may potentially include juvenile birds that may be breeding and foraging in these areas in the future. The large group sizes may reflect the proximity of the ranch lands that likely improves juvenile raven survival and recruitment into the population, contributing to increasing predation pressure on common murre colonies.

Recommendations

Conclusively determining the effect of common raven predation on common murre productivity will remain a challenge without collection of data on the total number of eggs laid at the colonies and the total number of eggs and chicks lost to predation by ravens and other bird species, abandonment, non-viable eggs, etc. (Roth et al. 1999). Although collaboration with common murre researchers from USFWS has been invaluable in providing common murre productivity estimates from productivity plots, it is difficult to obtain precise numbers due to the logistic infeasibility of monitoring entire colonies from land-based vantage points. Instead, a

correlation between predation and productivity can be established by comparing rates of common raven predation with murre productivity estimates for model sub-colonies across monitoring seasons (Table 7; Eigner et al. 2011; U.S. Fish and Wildlife Service, unpublished data).

A study conducted by PRBO, Audubon Canyon Ranch, USFWS, and PRNS on the ecosystem-level management of common ravens, recommended alteration of land-use practices (i.e. ranching) and the possible use of controlled taste aversion (CTA) to control the common raven population and reduce depredation, respectively (Roth et al. 1999). CTA could be effective if administered to territorial common ravens near common murre colonies, but accessibility and disturbance issues make the task of placing treated eggs in common murre colonies at PRNS difficult (Roth et al. 1999). In addition, such a management plan may require significant implementation time. Instead, immediate changes could be made by ranches to reduce common raven attraction, such as covering food troughs and calf housing areas, erecting exclusion fencing to keep cows away from sensitive areas, and prompt removal of raven food sources (e.g. uneaten or scattered feed, placentas, and carcasses).

Table 7. Number of disturbances by common ravens and common murre productivity at Lighthouse Rock during 2010, 2011, 2012, and 2013.

Monitoring season	Number of Disturbance Events	Number of Predation Events	Productivity Estimate*
2010	0	0	0.730
2011	8	6	0.150
2012	13	6	0.006**
2013	4	1	###

*number of chicks fledged per common murre pair
**U.S. Fish and Wildlife Service, unpublished data

Lethal control of territorial or paired common ravens in the vicinity of these and other sub-colonies is another short-term management option. However, removal of territorial pairs may allow larger numbers of non-territorial common ravens to depredate the previously defended colonies, and should therefore be carefully monitored (Nicolaus 1987). In addition, logistical and public relations factors may affect lethal control of common ravens at PRNS, such as close proximity of monitored locations to high-use visitor areas like the Lighthouse and Arch Rock and difficulty accessing common raven nests for removal. Despite these limitations, lethal control has proven to have successful effects at PRNS.

In particular, lethal control of territorial ravens at the Point Resistance Rock appears to have reduced disturbances observed post-removal in 2011, 2012 and 2013. Additionally, the prediction of a large group entering a previously defended area was not observed for the Point Resistance sub-colony. Common ravens were rarely seen at Point Resistance during the 2011, 2012, or 2013 monitoring seasons. A nesting peregrine falcon pair contributed to excluding ravens from the area in 2012 and 2013 due to its highly territorial and aggressive behavior. While ravens were seen flying past the trail near Point Resistance, they were never observed near the murre colony, likely due to exclusion by the falcon pair. Further monitoring of Point Resistance Rock should continue to determine if a new territorial raven pair appears.

In order for lethal control to be an effective method for decreasing disturbances, removing common raven nests and/or nesting pairs early in the season would be advantageous. Common murres begin to lay their first eggs between mid-April and late May, while common ravens can start buildings nests between late January and mid-April (Boarman and Heinrich 1999). In future years, cliffsides near common murre sub-colonies should be monitored for common raven nests and territorial pairs in early April. The pairs and their nests should be removed if they are observed causing common murre disturbance in order to reduce predation and disturbance throughout the season.

In order to further determine the effects that ravens are having on common murre populations at PRNS, an ongoing raven monitoring and management program is warranted. Part of this program should involve monitoring the effects of implementing the National Park Service's Best Management Practices on ranches (i.e. covered food bins, exclusion fencing, and debris removal) adjacent to the Headlands (A, B, and C Ranches). The impacts of lethal removal should also be monitored under this program in order to determine the most effective methods of decreasing raven predation pressure on common murre colonies.

Acknowledgments

Natalie Gates and Gerry McChesney provided help in determining project goals and important monitoring locations. Corey Shake, Jason Tappa, and the USFWS common murre team provided information on the Common Murre Restoration Project and background on Common Murre breeding behavior. David Press provided logistical assistance throughout the season, data analysis suggestions, and editing of the yearly report. Carolyn Campbell and Jane Khudyakov provided monitor training as well as helpful input and support. Tanya Baxter served as the biological technician for this project from March through early July, contributing many hours of work to the project.

Figure 1: Point Reyes Headlands Colony

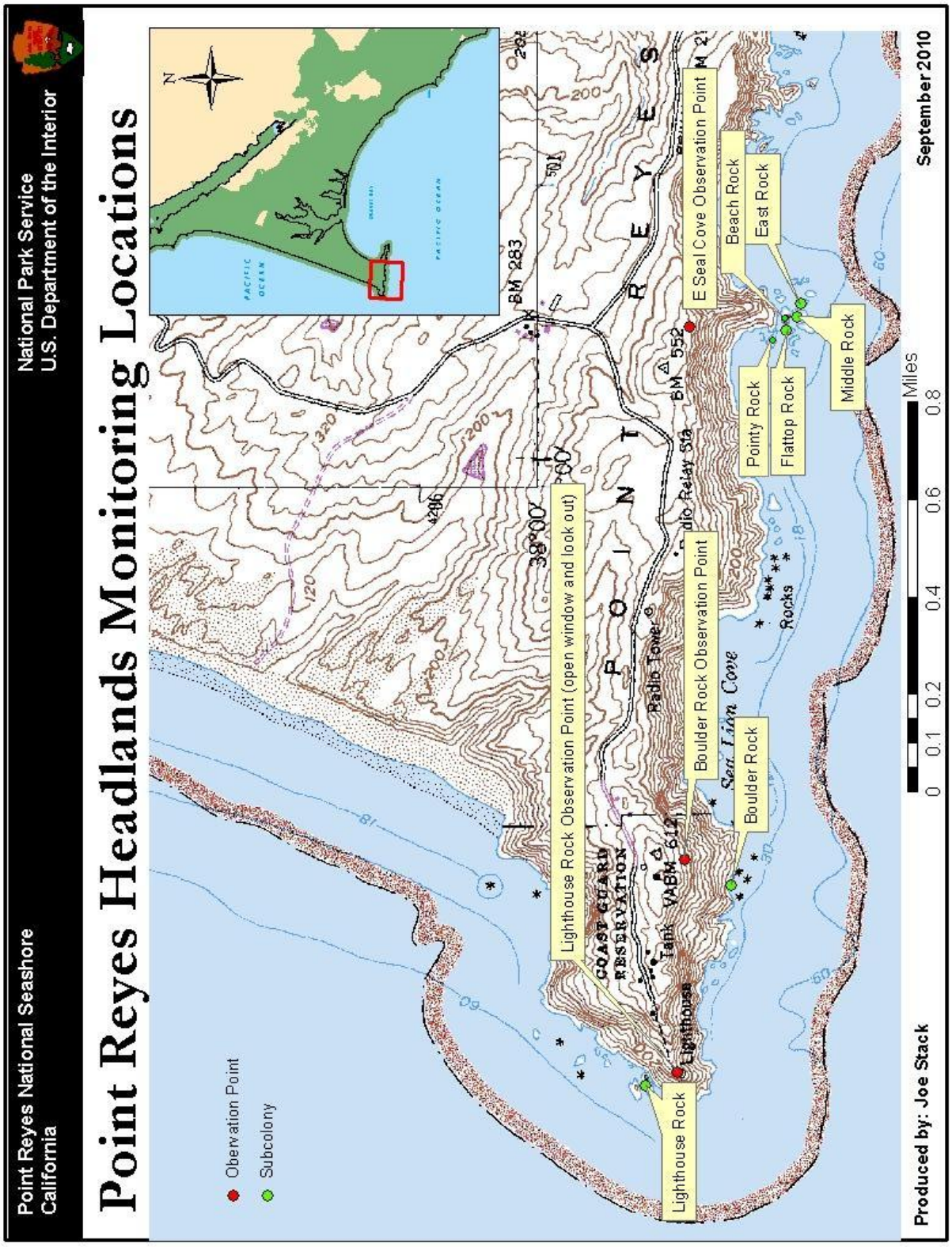


Figure 2: Lighthouse Rock Sub-colony

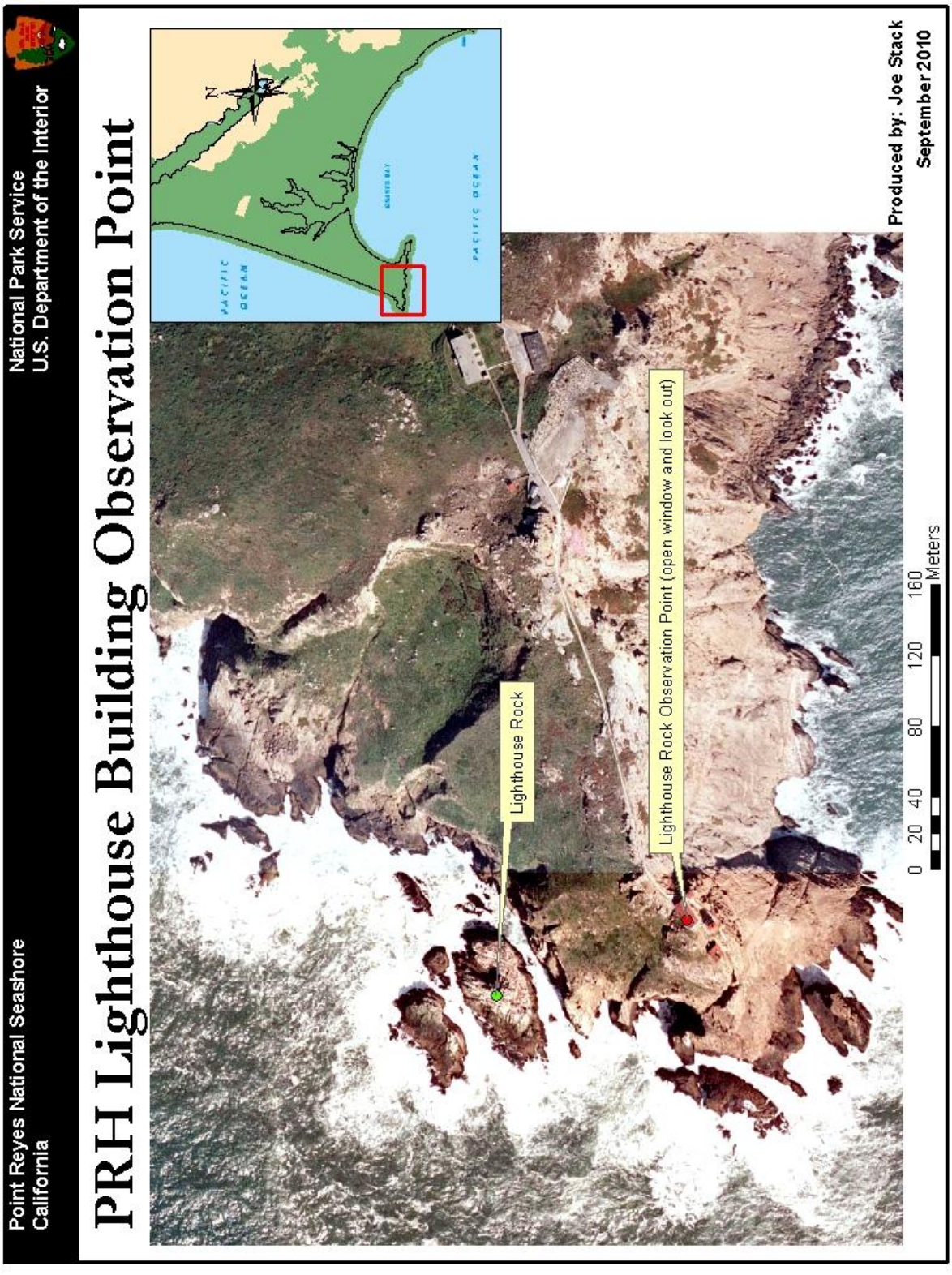


Figure 3: Boulder Rock Sub-colony

Figure 4: East Seal Cove Sub-colonies

Figure 5: Arch Rock Colony

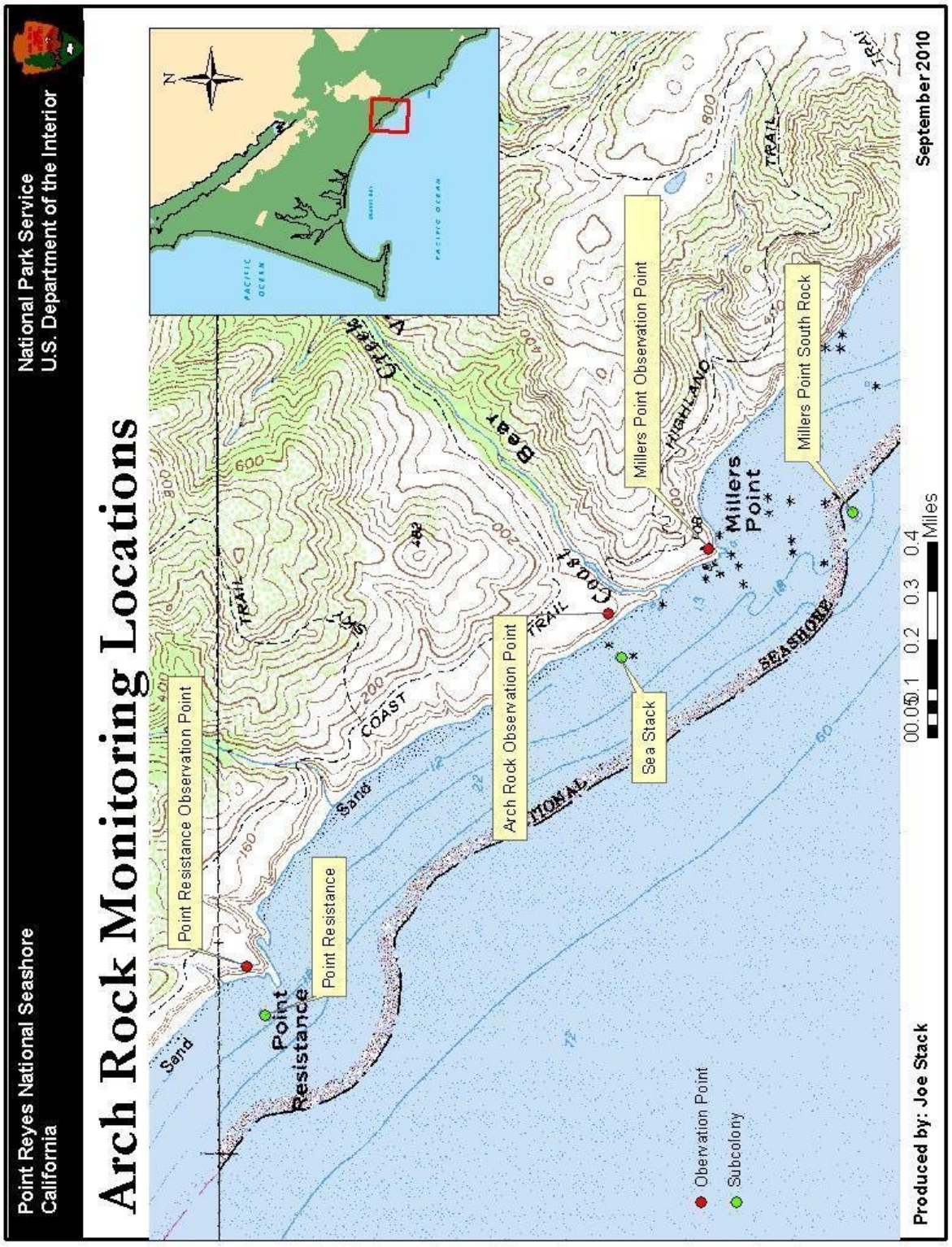


Figure 6: Millers Point South Rock Sub-colony

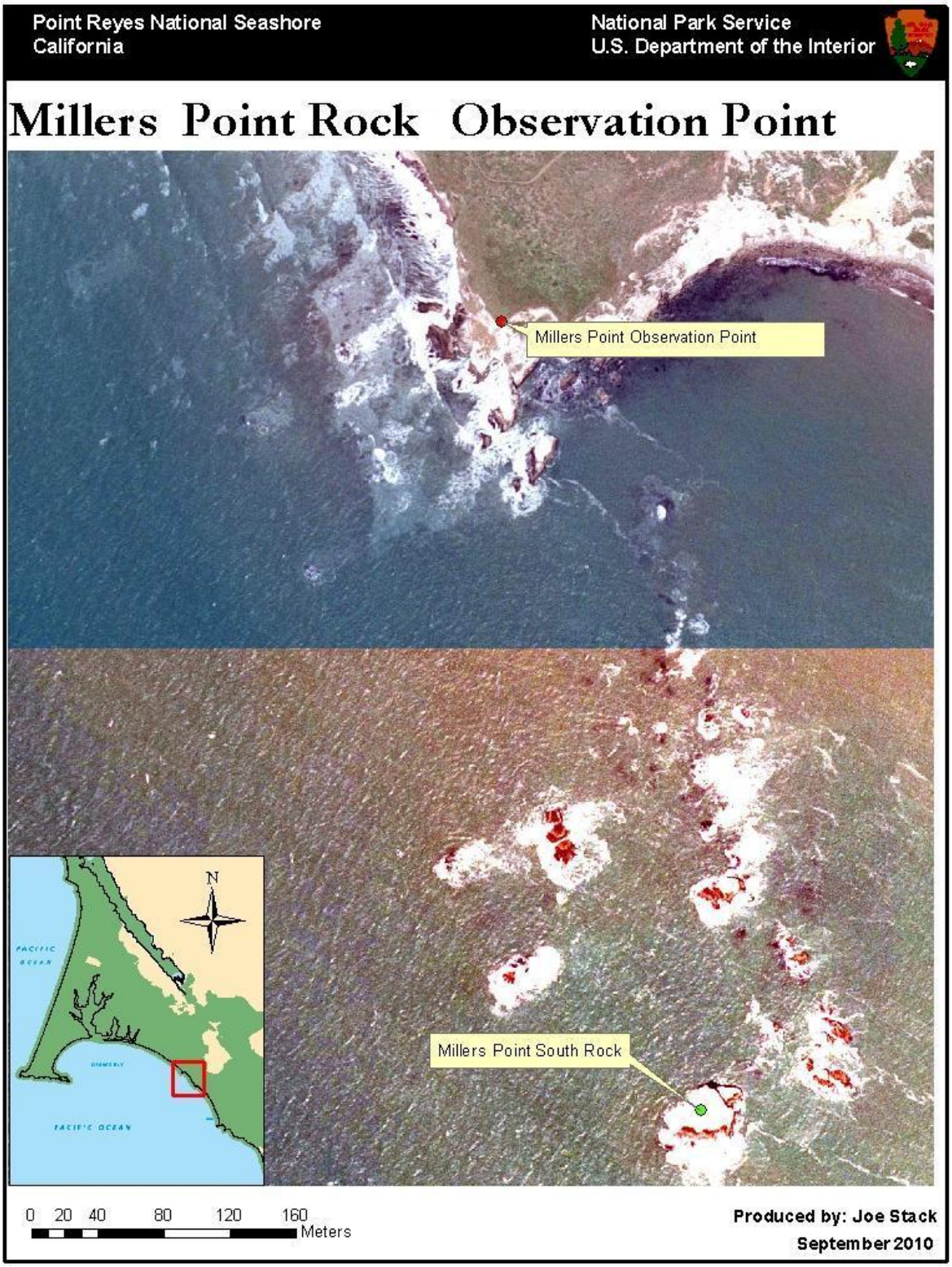


Figure 7: Sea Stack Sub-colony

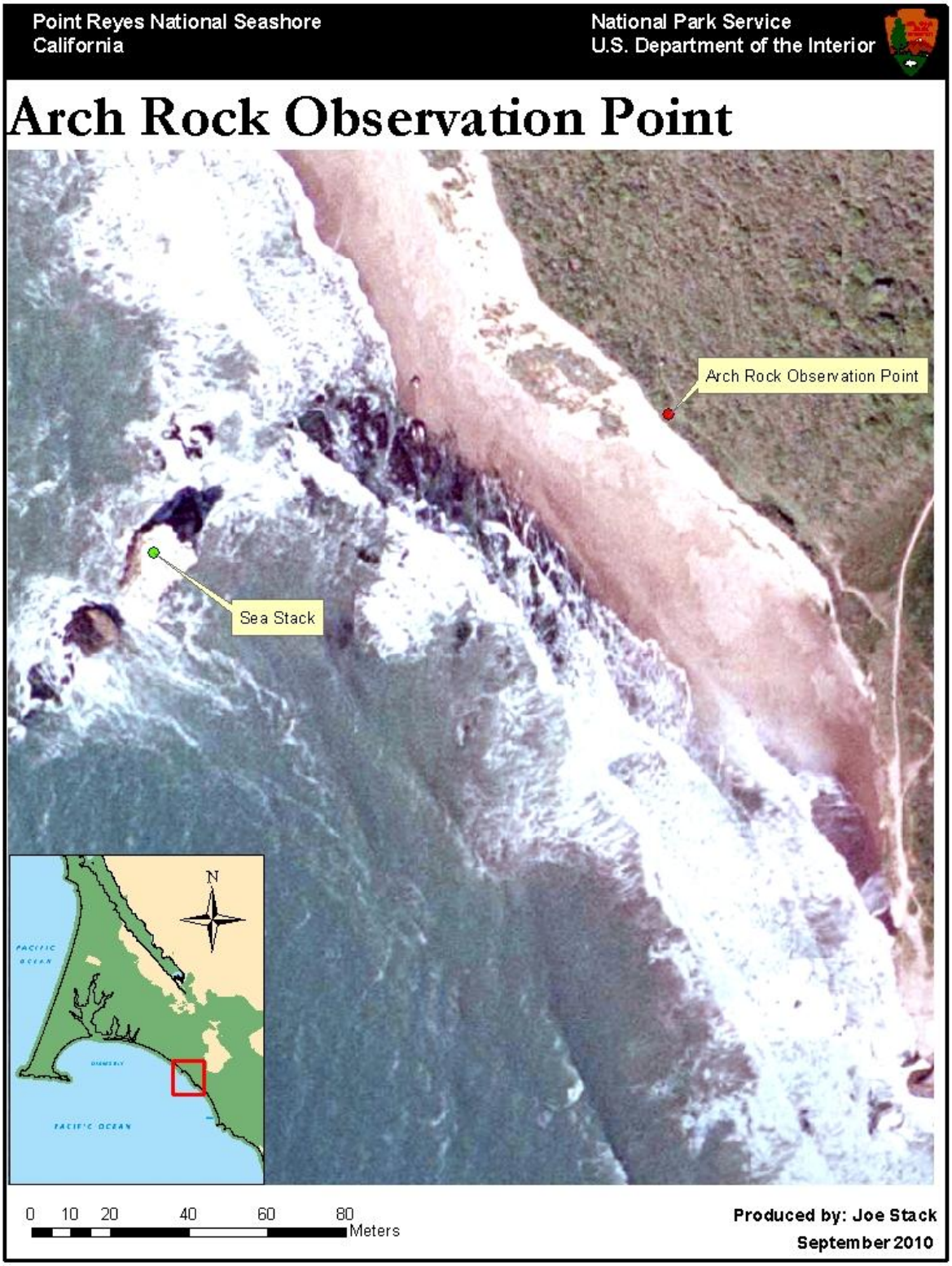
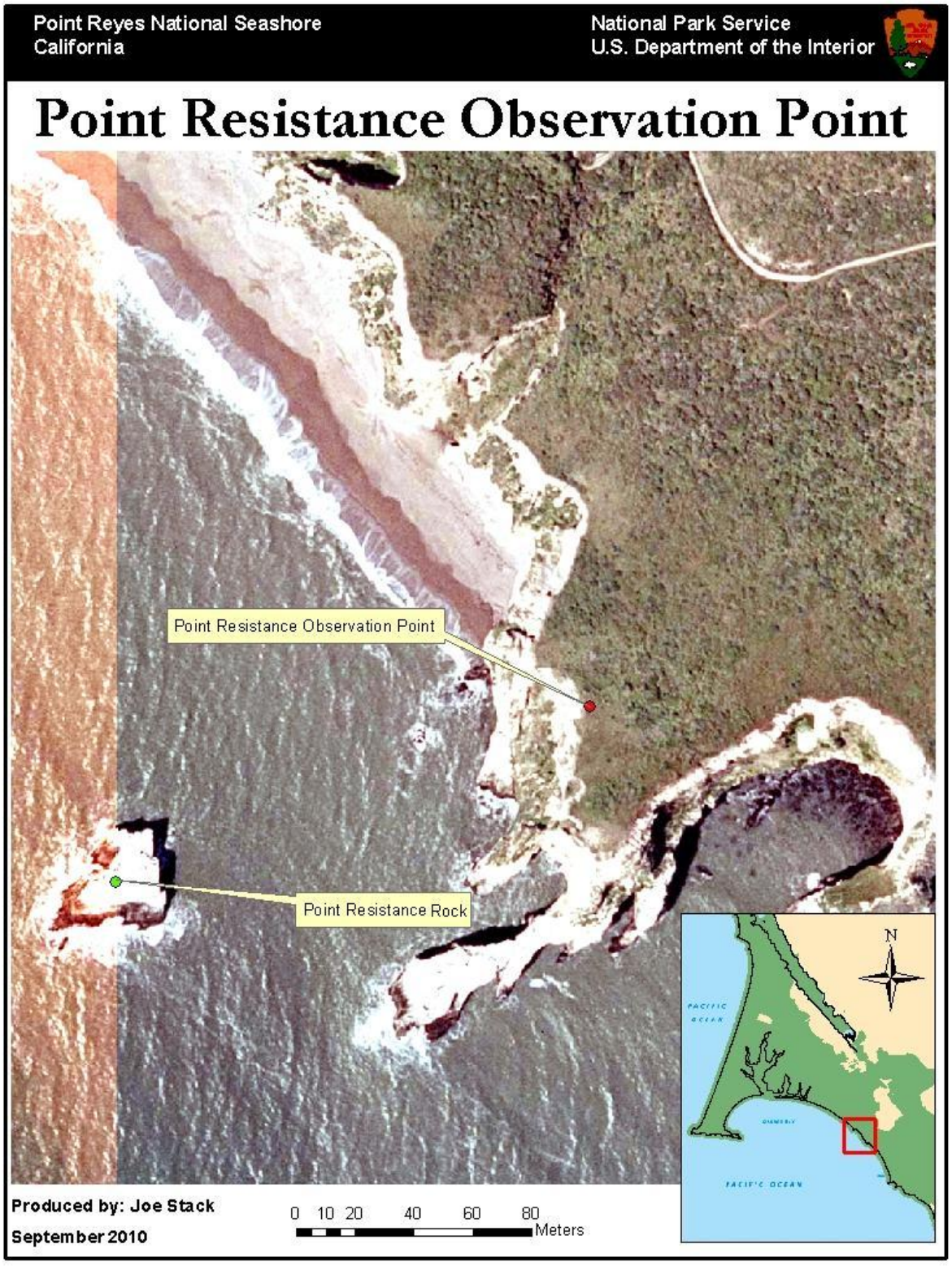


Figure 8: Point Resistance Rock Sub-colony



Appendix A: Example of Raven Disturbance Monitoring PRNS data sheet

Raven Disturbance Monitoring PRNS

Date: _____ Observer: _____ Time: _____to _____

Observation Point: ☐ PRH Lighthouse Building ☐ E Seal Cove Obs. Point ☐ Boulder Rock Obs. Point

☐ Arch Rock Obs. Point ☐ Miller's Point Rocks Obs. Point ☐ Point Resistance Obs. Point

Visibility (circle): Clear Hazy Foggy Rainy Survey type Full Check

Murres on Rock: 0 1-100 100+ Max Raven Count _____

Notes:

Time: _____to _____ No. of Ravens Involved: _____ Event ID: _____

Subcolony: ☐ Lighthouse Rock ☐ Boulder Rock ☐ Flattop Rock ☐ Middle Rock ☐ East Rock

☐ Sea Stack ☐ Point South ☐ Point Resistance

Techniques: Lunge Pull Snatch Easy Picking Air Attack Incidental Loss Unknown

Site Characteristics: Edge Site Interior Site No. of Vertical Rock Faces: _____

No. Neighboring Sites:	Notes:
No. Birds Flushed:	
No. Eggs Taken:	
No. Chicks Taken:	