Corvid Management to Restore Common Murres at Point Reyes National Seashore
2012 Annual Report

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2012 Accomplishments

Raven monitoring at PRNS continued for a third 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 2012 common murre monitoring report is included with this report. We also completed our first draft report for the ranch monitoring that we have conducted 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 2012 for targeted removal of ravens adjacent to the common murre colonies.

Riparian fence construction at A, B, and C Ranches were scheduled for late summer 2012, but the contractor (CMS Developer Services Inc.) delayed initiation until November 2012.

Delays continued in 2012 with installation of covered feed bins at the ranches. Delays were due to the departure of the project manager (Range Management Specialist John DiGregoria) in 2011 and subsequent delay in rehiring that position, the unavailability of the park engineer to design and construct a prototype cover, and the reluctance of A Ranch to install covers during their transition to an organic dairy.

Ranch surveys identified that the calf huts at B Ranch, which number up to 45 huts at certain times, were 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 2012, we purchased and installed six new calf huts, which are designed so that the feed buckets are mounted inside the huts which are accessed by a small door from the outside. During subsequent surveys, we did not observe any ravens going inside the new calf huts to access the feed bins.

Removal of ranch debris that attracts ravens has not yet been implemented. The delay was another result of the departure of the park’s Range Management Specialist.

PRNS hired a new Range Management Specialist, Devii Rao, in 2012. She began in March 2012 and has been taken over as project manager for the Luckenbach fencing projects at A, B, and C Ranches.

2012 Budget: $36,984

1. Raven monitoring at ranches during October 2011 and January, April, July 2012. Raven monitoring at common murre colonies from May – August. 2012 monitoring partly paid from remaining 2011 monitoring funds. **Total: $16,328**

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

3. Six new calf huts purchased and installed at B Ranch in order to pilot a new design that keeps ravens out of the calf feed buckets. **Total: $1,911**

4. Project management. 1 pay period for PRNS Wildlife Ecologist. **Total: $3,745**

Total remaining in account at end of FY2012: **$41,923**

2013 Work Plan

Raven monitoring will again be implemented in FY13 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.

CMS Developer Services Inc. is scheduled to complete the riparian exclusion fencing project by December 2012. During the compliance process for the project, we identified that a biological monitor would have to be on site for periods of fence construction. Luckenbach funds will pay for one pay period of time for a biological monitor. Attached maps provide outline the newly fenced areas.

PRNS staff have designed a prototype cover for the feed bins at A Ranch. The prototype will be constructed and installed by PRNS staff early in FY13, pending cooperation with the rancher. 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. The remaining feed bins will be covered later in the FY once the design is finalized.

Pending the continued success of the new calf huts at B Ranch, an additional 40 calf huts will be purchased so that their entire stock can be replaced with calf huts that allow for feed buckets on the inside of the huts and out of reach of the ravens.

Range management staff will work with A and B Ranches to identify and schedule for removal debris and other trash piles that are raven attractants. The debris removal project may be extended to C Ranch if financially feasible. Debris removal work will be conducted under

contract, likely with either Conservation Corps North Bay or American Conservation Experience.

2013 Schedule and Budget

1. Raven monitoring at ranches during October 2012 and January, April, July 2013. Raven monitoring at common murre colonies from May – August 2013. 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. Completion of exclusion fencing at A, B, and C Ranches. Fencing is scheduled for completion by December 2012. Costs include project oversight by the PORE Range Management Specialist and costs needed for an on-site biological monitor during construction. Request: **$4,530**

4. Debris removal on A, B, and C Ranches through contract. Request: **$20,000**

5. Covered feed bins will be installed at A Ranch. Costs include materials and labor for design, construction, and installation. Request: **$33,000**

6. An additional 40 calf huts will be purchased and delivered to B Ranch. Request: **$16,000**

FY 2013 Request:	$104,530.00
Remaining from FY 2012:	$41,923.00
Final Adjusted FY 2013 Request:	**$66,607**

Point Reyes National Seashore
Summer 2012 Raven Disturbance Monitoring
Jane Khudyakov, 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 on a weekly basis from May through August 2012 at six established viewing points of ten predefined common murre sub-colonies. Fifty-two disturbance events were observed in 121.7 hours of surveying. Twenty-three of these events were predation events during which murre eggs or chicks were taken by ravens. All of the disturbances with the exception of one occurred in the Point Reyes Headland (PRH) colony complex. Juvenile brown pelicans were observed at PRH sub-colonies between mid-June and early July, creating 15 disturbance events that caused loss of eggs and/or chicks to ravens. Results indicate that 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 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. Observations took place for 2 to 4 hours between 0600 and 1800 hours, from the middle of May when egg laying commenced until common murres were no longer roosting on the sub-colony (early August). The objective was to monitor each site weekly for a minimum of 2 hours and on a rotating schedule so that all hours of the day were covered in a six-week monitoring period.

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: start and end time of survey, location, visibility, approximate number of common murres on the rock, type of survey, and maximum count of common ravens seen at one time (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 for at least two hours. 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 examined with a spotting scope. A disturbance event was categorized as any action by common ravens that caused common murre(s) to flush from the sub-colony or resulted in loss of egg(s) or chick(s). A predation event was categorized as a disturbance event during which common ravens were observed taking common murre egg(s) or chick(s) 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 (site not close to a vertical ledge) and three faces (site on corner edge of rock) located within one common murre width of 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 marking on ravens, ravens roosting or nesting in the area, and disturbances by other bird species such as brown pelican or turkey vulture 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 can be expected to 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. When a common raven nest was discovered near the study area, the location was 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

During the 2012 monitoring season, 57 common murre disturbance surveys were conducted during 121.7 hours of observation. Thirty-eight surveys were conducted at PRH headlands colony and 19 were conducted at the Arch Rock colony. Common raven activity was observed at all monitored sub-colonies with the exception of Point Resistance, and disturbance was observed during 20 of the 57 surveys. A total of 52 disturbance events were observed in 2012 (Table 3). One disturbance occurred at the Arch Rock colony while the remainder occurred at the PRH colony. Out of the ten sub-colonies, seven (70%) had recorded disturbance events. The overall disturbance rate per hour was 0.43 for all PRNS colonies and 0.70 for the PRH colony specifically (Table 3). Twenty-three of the 52 (44%) disturbances were predation events (Table 4). Six predation events occurred on Lighthouse Rock, 16 on Boulder Rock, and one on Flattop Rock (Table 4). The other 29 of the 52 (56%) disturbances were common murre flushing events that did not result in observed egg or chick loss. Seven such events occurred on Lighthouse Rock, twelve on Boulder Rock, three on Middle Rock, three on Flattop Rock, one on Pointy Rock, and one on Miller's Point South (Table 5).

Of the 52 disturbance events, 44 were observed when visibility was clear, six when visibility was hazy, and two during foggy conditions. While disturbance events occurred during all survey hours, they were most frequent between 0800 and 1000 (11 events) and between 1400 and 1600 (19 events). Six disturbance events occurred between 0600 and 0800, seven between 1000 and 1200, six between 1200 and 1400, and three between 1600 and 1800. Of the 52 disturbance events, 17 occurred during the month of May, 21 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, with the exception of Point Resistance, at least once. An absence of raven activity was observed during only four out of 49 surveys conducted at the other sub-colonies, two of which occurred during foggy days with poor visibility. The maximum number of common ravens recorded during a survey ranged from one to six. The majority of disturbance events involved only one or two common ravens. A group of three common raven fledglings was observed causing disturbance at Miller's Point South once. Thirty-four disturbance events took place at an edge site, while 14 were categorized as occurring in the interior of a sub-colony. The number of rock faces near the site of disturbance was not recorded during the first six-week monitoring period. The median number of rock faces for disturbed sites during the second six-week monitoring period was one, suggesting that most

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	**57**	**121.7**	**52**	**0.43**
PRH Colonies	38	72.8	51	0.70
Lighthouse Rock	13	23.8	13	0.55
Boulder Rock	12	23.0	28	1.22
Middle Rock[1]	13	26.0	3	0.12
East Rock[1]	13	26.0	0	0
Flattop Rock[1]	13	26.0	4	0.15
Beach Rock[1]	13	26.0	0	0
Pointy Rock[1]	13	26.0	3	0.12
Arch Rock Colonies	19	48.9	1	0.02
Millers Point South	10	24.0	1	0.04
Sea Stack	1	2.20	0	0
Point Resistance	8	22.7	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	52	23	44.2	0.19
PRH Colonies	51	23	45.1	0.32
Lighthouse Rock	13	6	46.2	0.25
Boulder Rock	28	16	57.1	0.70
Middle Rock[1]	3	0	0	0
East Rock[1]	0	0	0	0
Flattop Rock[1]	4	1	25	0.04
Beach Rock[1]	0	0	0	0
Pointy Rock[1]	3	0	0	0
Arch Rock Colonies	0	0	0	0
Millers Point South	0	0	0	0
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, and 2012 monitoring seasons.

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

disturbed sites were located near a rock ledge at the outskirts of the colony. (see methods for a longer description of the category) Most events occurred in less than ten minutes, with the majority lasting only one or two minutes. The techniques most commonly used by common ravens to try to obtain eggs or chicks were “easy picking” (10 events), “lunge” (7 events), and “pull” (3 events). Four lunge attempts and one pull attempt did not result in any egg or chick loss. A predation event involving the “snatch” technique was only observed once, and one raven disturbance event was characterized as an “incidental loss” as it resulted in an egg take by a gull. Thirty disturbance events were categorized by “unknown” techniques, which included predation events during which the method was not observed, as well as disturbance events involving flushing but no egg/chick takes.

The 2012 monitoring season was characterized by an unusually high number of juvenile brown pelicans disturbing PRNS common murre colonies between the second week of June and the first week of July (C. Shake, USFWS, personal communication). Brown pelicans were observed roosting in murre sub-colonies in numbers ranging from one to twenty-two. Common murres flushed from nests or sub-colonies during pelican flyover, landing, taking off, preening, flapping wings, walking through colonies, and direct approach. In a few cases juvenile pelicans were observed deliberately chasing off adult murres and picking up exposed eggs and chicks. During several surveys, pelicans created continuous common murre disturbance throughout the entire monitoring period (2-3 hours), causing between 30% and 90% of nesting murres to flush from the colony rock. Such disturbances resulted in loss of common murre eggs and chicks to common ravens and gulls, as well as to crushing or falling of eggs off ledges, greatly reducing common murre productivity (C. Shake, USFWS, personal communication). At the PRH colony, brown pelicans caused disturbances during eight surveys, with 15 flushing events causing exposure of murre eggs and chicks to “easy picking” predation by common ravens. Five such events occurred at the Lighthouse Rock sub-colony (5 eggs and 3 chicks taken), nine at Boulder Rock (12 eggs and 5 chicks taken), and one at Flattop Rock (2 eggs taken). Brown pelican disturbances were also observed during 2 surveys at Miller’s Point South and 4 surveys at Point Resistance. During one Point Resistance survey, two juvenile brown pelican carcasses on the rock attracted 6 turkey vultures, which flushed at least half of the nesting common murres from the sub-colony. Common ravens were not involved in these disturbance events and their effect on murre productivity is unknown since productivity is not monitored at the Arch Rock colony (C. Shake, USFWS, personal communication).

During the 2012 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 a full survey in May. While no nesting common murres were observed on Miller’s Point South during the 2012 season, small numbers of roosting birds remained on the rocks between mid-May and late July, and this sub-colony was regularly monitored.

Full surveys were conducted on a routine schedule during twelve weeks of observation from May 15 until August 1. At the end of the season, after complete absence of common murres at a sub-colony was noted during at least one hour of full survey, one more colony check was conducted to verify that the birds had left for the season.

Two common raven nests were located during the 2012 monitoring season. One nest was found in the Chimney Rock area while the second was located near the East Seal Cove observation point. The locations of both nests were recorded with GPS points. The Chimney Rock nest location was UTM: E 501270 N 4205159. The East Seal Cove nest location was UTM: E 500501 N 4205096. Both raven nesting pairs were observed flushing common murre adults and taking murre eggs. The East Seal Cove raven nest was located within close flying distance to Middle Rock, East Rock, Flattop Rock, Beach Rock, and Pointy Rock, and the common raven pair was directly observed causing disturbance at some of these sub-colonies.

In comparison with the 2010 and 2011 monitoring seasons, which reported 8 and 9 predation events respectively, 23 predation events were observed in 2012 (Table 5). Flushing events were not reported during the 2010 monitoring season but were recorded during the 2011 and 2012 monitoring seasons. The number of flushing events increased from 11 in 2011 to 44 in 2012. The number of eggs lost to common ravens increased to 27 during 2012, as compared to 6 in 2011 and 7 in 2010. The number of chicks taken by ravens increased to 9 in 2012, compared to 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 and 2012 monitoring seasons, and ravens were absent from this site entirely in 2012. 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, 7 eggs and 3 chicks were predated at Lighthouse Rock, 18 eggs and 6 chicks were taken at Boulder Rock, and 2 eggs were taken at Flattop Rock (Table 5). Brown pelican-related disturbances were not noted in 2010 and 2011.

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 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). Twenty-three predation events and 52 disturbance events were recorded during 121.7 hours of monitoring in 2012, an increase from 9 predation events in 2011 and 8 predation events 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 0.19 per survey hour, resulting in approximately 2.28 predation events per day (a day equaling a twelve-hour time period). The total disturbance rate for all ten sub-colonies was 0.43 per survey hour, resulting in approximately 5.16 disturbances per day. 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).

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. During the 2011 and 2012 monitoring seasons, no raven disturbances were documented at Point Resistance Rock (Table 5). During the 2012 monitoring season, a raven nest was located just below the East Seal Cove observation point 0.24 km from the East Rock, Middle Rock, Flattop Rock, Beach Rock, and Pointy Rock murre sub-colonies. While a total of ten flushing events were observed at these five sub-colonies, only two eggs were taken by ravens at Flattop Rock and no chicks were lost after the raven pair and their nest were removed half-way through the monitoring season. Another raven nest was located in the Chimney Rock area 0.73 km from the nearest monitored common murre sub-colony and removed early in the season. In contrast, territorial raven pairs were responsible for 16 predation events at Boulder Rock and 6 at Lighthouse Rock. While the nests of these raven pairs were not discovered from the ground, common murre biologists have noted raven nests on cliff-sides near murre sub-colonies during boat-based surveys (C. Shake, USFWS, personal communication). Removal of these nesting raven pairs early in the season before egg laying or incubation has commenced may aid in reducing the amount of predation on common murres at Boulder Rock and Lighthouse Rock.

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, 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). While no other disturbance event was documented at Miller's Point South, a pair of territorial ravens has been seen near the observation point and should continue to be monitored for potential disturbance of the common murre sub-colony, especially if the murres use the area for nesting in the future.

The 2012 monitoring season was unique from the two previous seasons in that juvenile brown pelican disturbances were observed at all monitored common murre sub-colonies and contributed significantly to predation of murre eggs and chicks by common ravens at the PRH colony. Between mid-June and early July, disturbance of nesting common murre adults by brown pelicans was observed during 5 surveys, causing 15 incidents of unattended egg and/or chick take by common ravens using the "easy picking" predation technique. Pelican disturbance events were also observed on four occasions at Point Resistance and twice at Miller's Point South, but ravens were not present at these sub-colonies, although eggs and chicks were lost to gulls and pelicans during these events. Brown pelican presence at common murre sub-colonies caused large numbers of adult murres to flush from the rocks and remain away from their nests for longer than usual, exposing eggs and chicks to predation. Common ravens appeared to capitalize on pelican disturbances at the PRH headlands, and the highest number of corvid disturbance events were observed during surveys when brown pelicans were present. The highest number of corvid disturbance events during a single two-hour survey was eleven, when a raven pair took 13 eggs and 6 chicks at Boulder Rock when brown pelicans were present. At Lighthouse Rock, 4

Table 6. Number of disturbances in 2012, 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	13	2.56	1684.4
Boulder Rock	28	1.96	381.8
Middle Rock	3	0.80	237.1
East Rock	0	0.79	465.4
Flattop Rock	4	0.77	176.2
Beach Rock	0	0.80	1054.8
Pointy Rock	3	0.73	104.9
Arch Rock Colonies			
Millers Point South	1	5.07	1014.0
Sea Stack	0	5.02	306.2
Point Resistance	0	5.77	585.7

eggs and 3 chicks were taken by a raven pair within a period of 36 minutes during which pelicans were present. The large increase in disturbance and predation rates in 2012 compared with previous monitoring seasons 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). 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 number 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).

Three seasons of observations at the monitored common murre sub-colonies between 2010 and 2012 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. 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 flying past common murre sub-colonies, potentially 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, and 2012.

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**

*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 successful at PRNS with the Point Resistance Rock and Flattop Rock sub-colonies by reducing disturbances observed post-removal. Additionally, the predication 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 or 2012 monitoring seasons. A nesting peregrine falcon pair contributed to excluding ravens from the area in 2012 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 and East Seal Cove area should continue to determine if a new territorial raven pair appears.

Two common raven nests documented during the 2011 monitoring season were discovered by USFWS and USDA staff members late in the season. Neither was located near a monitored common murre sub-colony, resulting in irregular observations. One of the common raven pairs was observed predating a common murre colony in the vicinity of its nest. The pair was subsequently removed. The other pair consisted of one common raven missing a middle tail feather. Three of the disturbances that occurred on Boulder Rock in 2011 were conducted by a common raven missing a middle tail feather. However, after these predation events were observed, the pairs' brood had fledged and there was no longer an opportunity for removal. In

2012, two raven nests containing eggs near the PRH common murre colony were located in mid-May. Unfortunately, unfavorable weather conditions, difficult site accessibility, and presence of visitors delayed removal until early July, when the raven chicks had already fledged. Although the fledglings were not observed to approach murre colonies, they may do so in future seasons. 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 murres 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.

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Natalie Gates and Gerry McChesney provided help in determining project goals and important monitoring locations. Corey Shake 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 provided monitor training as well as helpful input and support.

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Figure 1: Point Reyes Headlands Colony

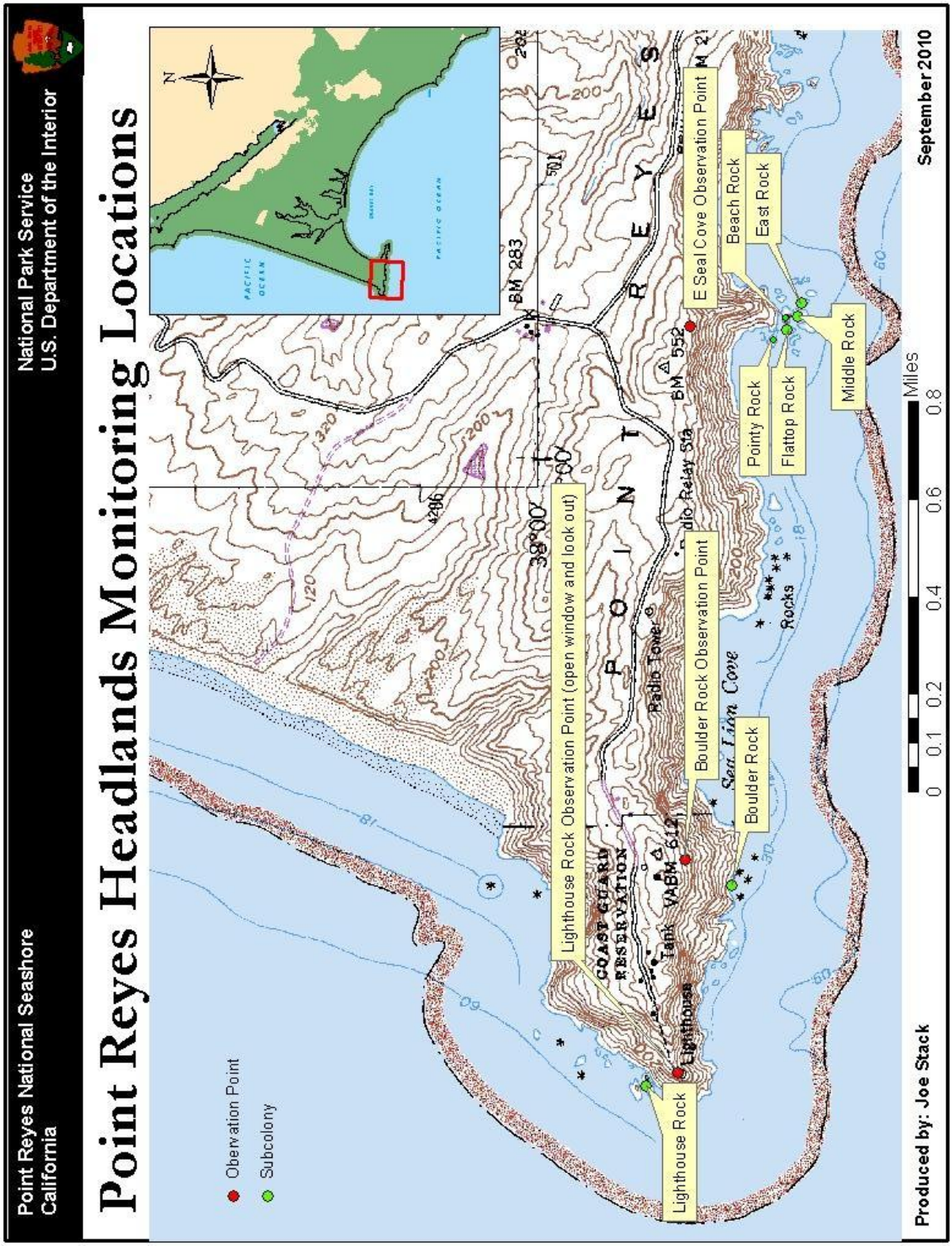


Figure 2: Lighthouse Rock Sub-colony

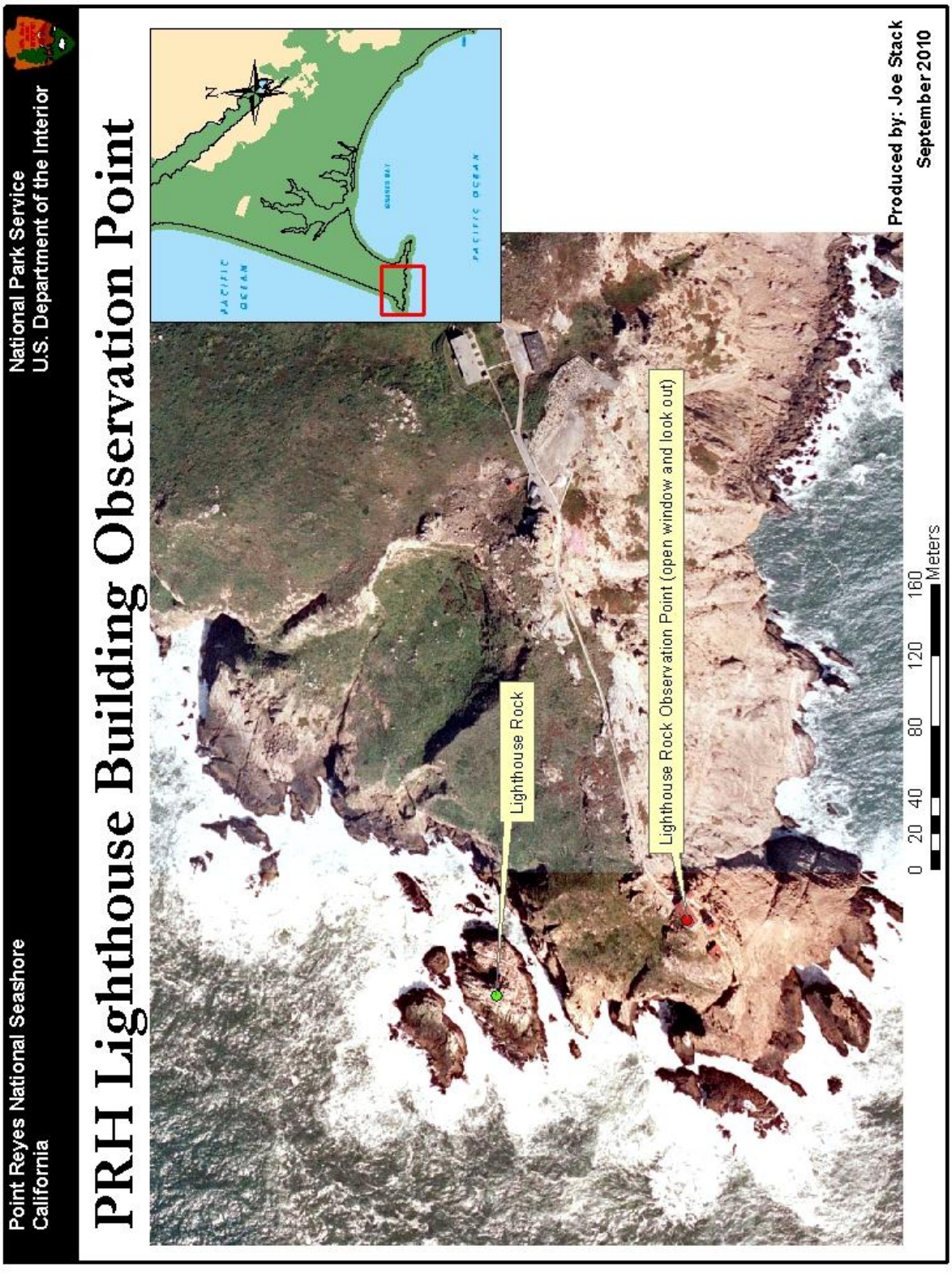


Figure 3: Boulder Rock Sub-colony

Figure 4: East Seal Cove Sub-colonies

Figure 5: Arch Rock Colony

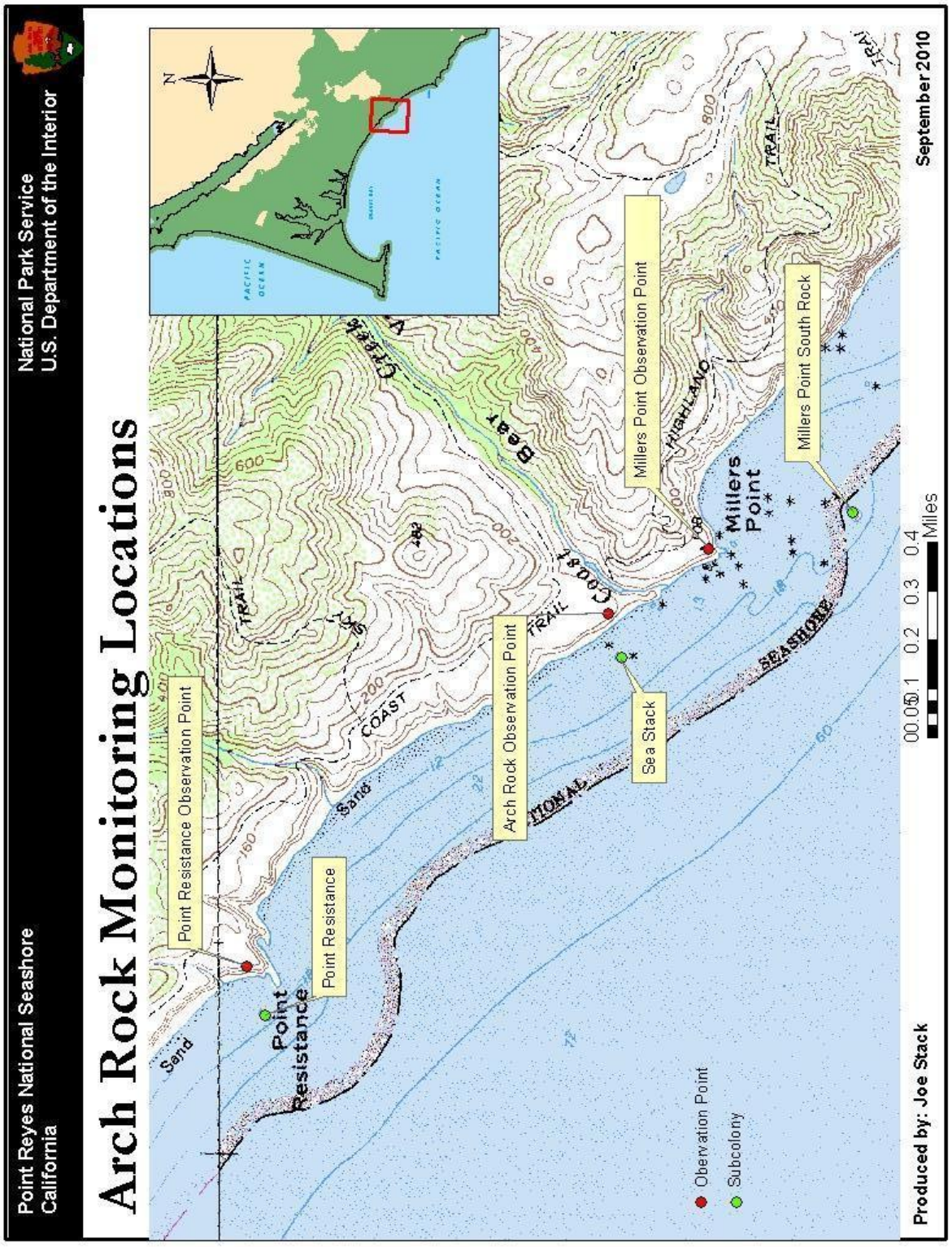


Figure 6: Millers Point South Rock Sub-colony

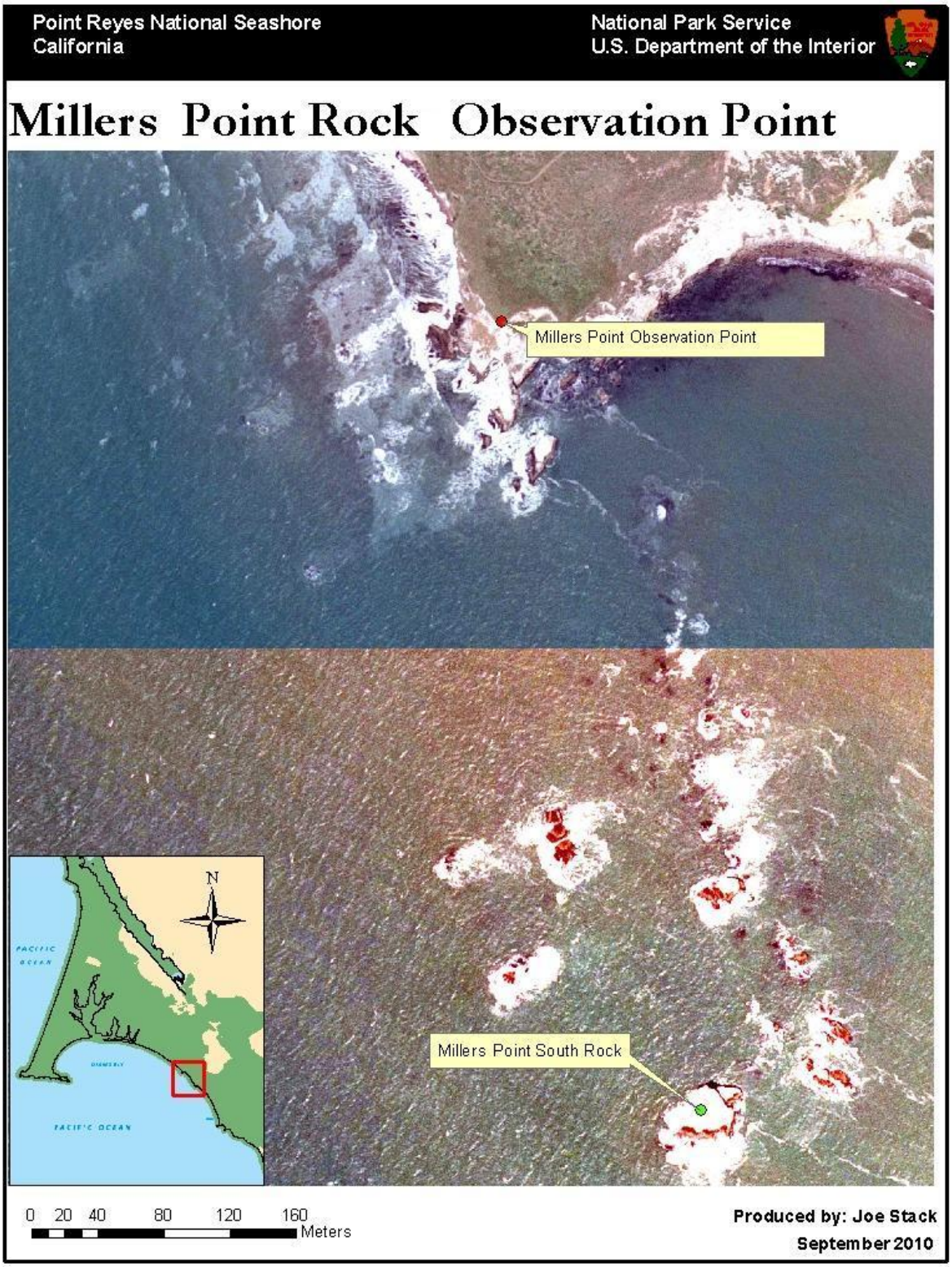


Figure 7: Sea Stack Sub-colony

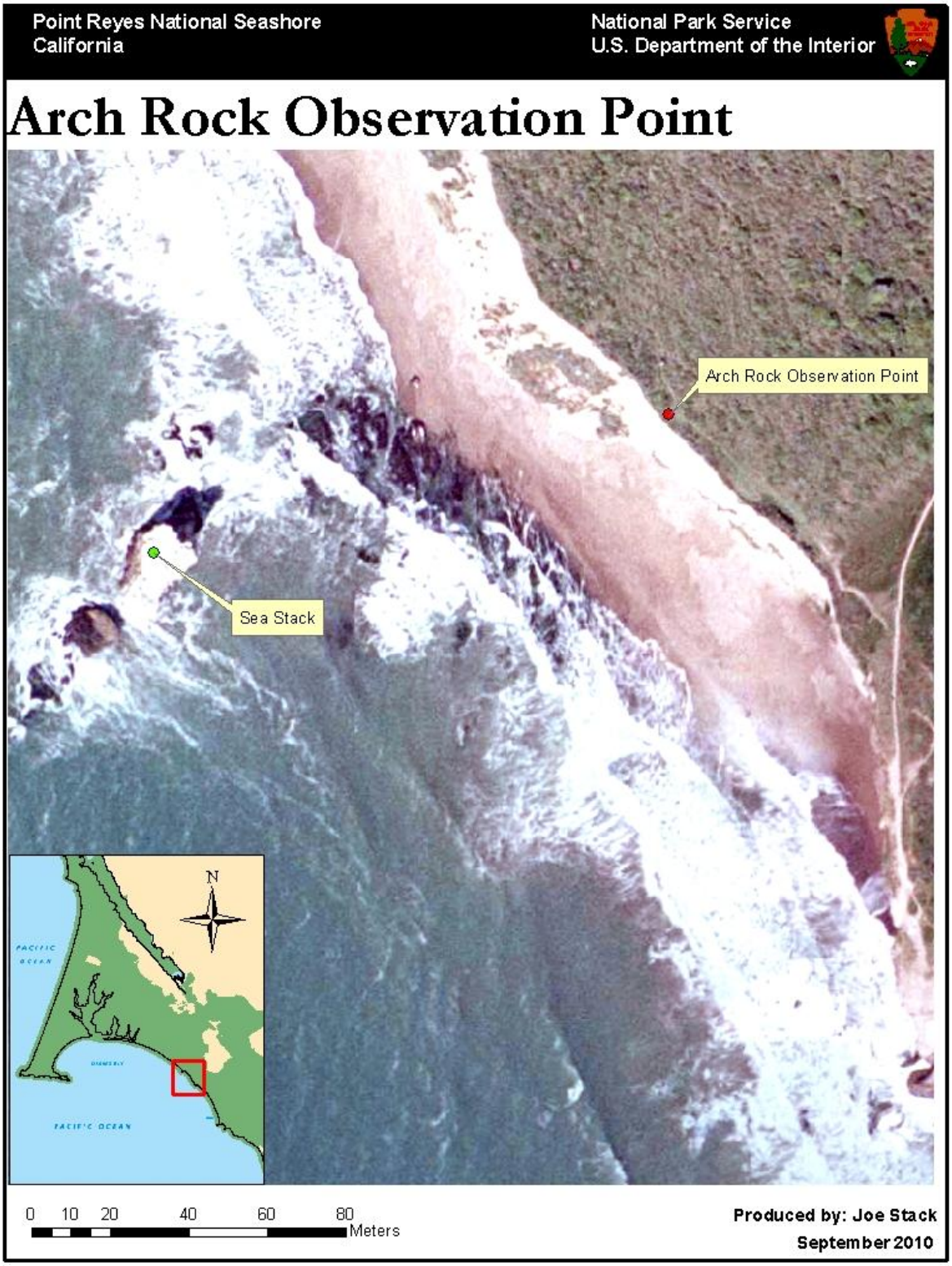
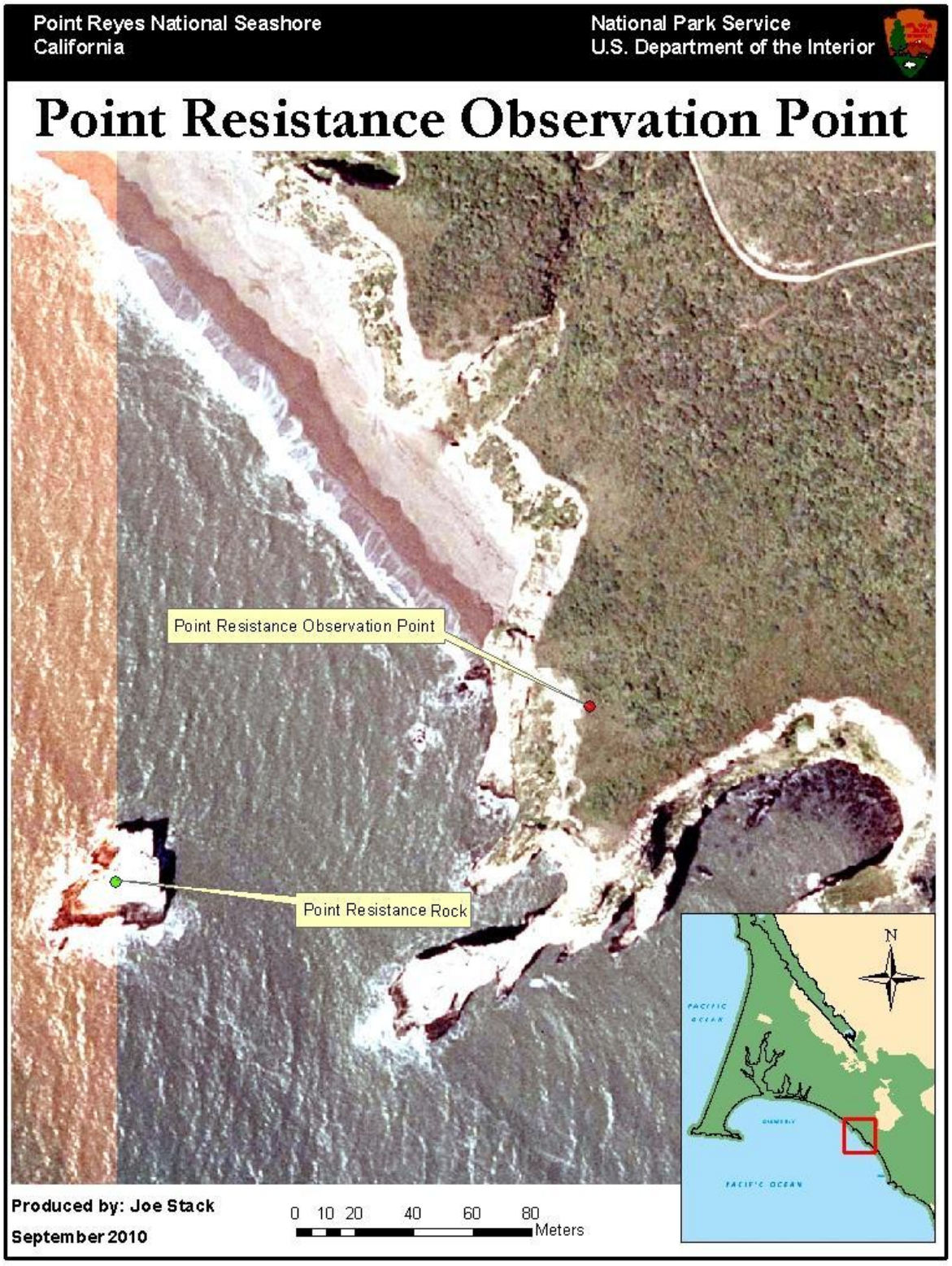


Figure 8: Point Resistance Rock Sub-colony



Appendix A: 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:	

Main C Ranch

National Park Service
Point Reyes National Seashore
Marin County, CA

1 inch = 1,050 feet

N
W E
S

0 750 1,500 2,250 3,000
Feet

- Proposed Fence Line
- Major Roads
- Existing Fence
- Existing Gate
- 10 Foot Contours
- Ranch Boundary

Plot date: 09/07/2012 Imagery: 2009 NAIP

Addition 2 (B Ranch) & Addition 3 (B/C Ranch)

National Park Service
Point Reyes National Seashore
Marin County, CA

1 inch = 600 feet

N
W E
S

0 430 860 1,290 1,720
Feet

- Proposed Fence Line
- Major Roads
- Existing Fence
- Existing Gate
- 10 Foot Contours
- Ranch Boundary

Plot date: 09/07/2012 Imagery: 2009 NAIP

B Ranch Main

National Park Service
Point Reyes National Seashore
Marin County, CA

1 inch = 425 feet

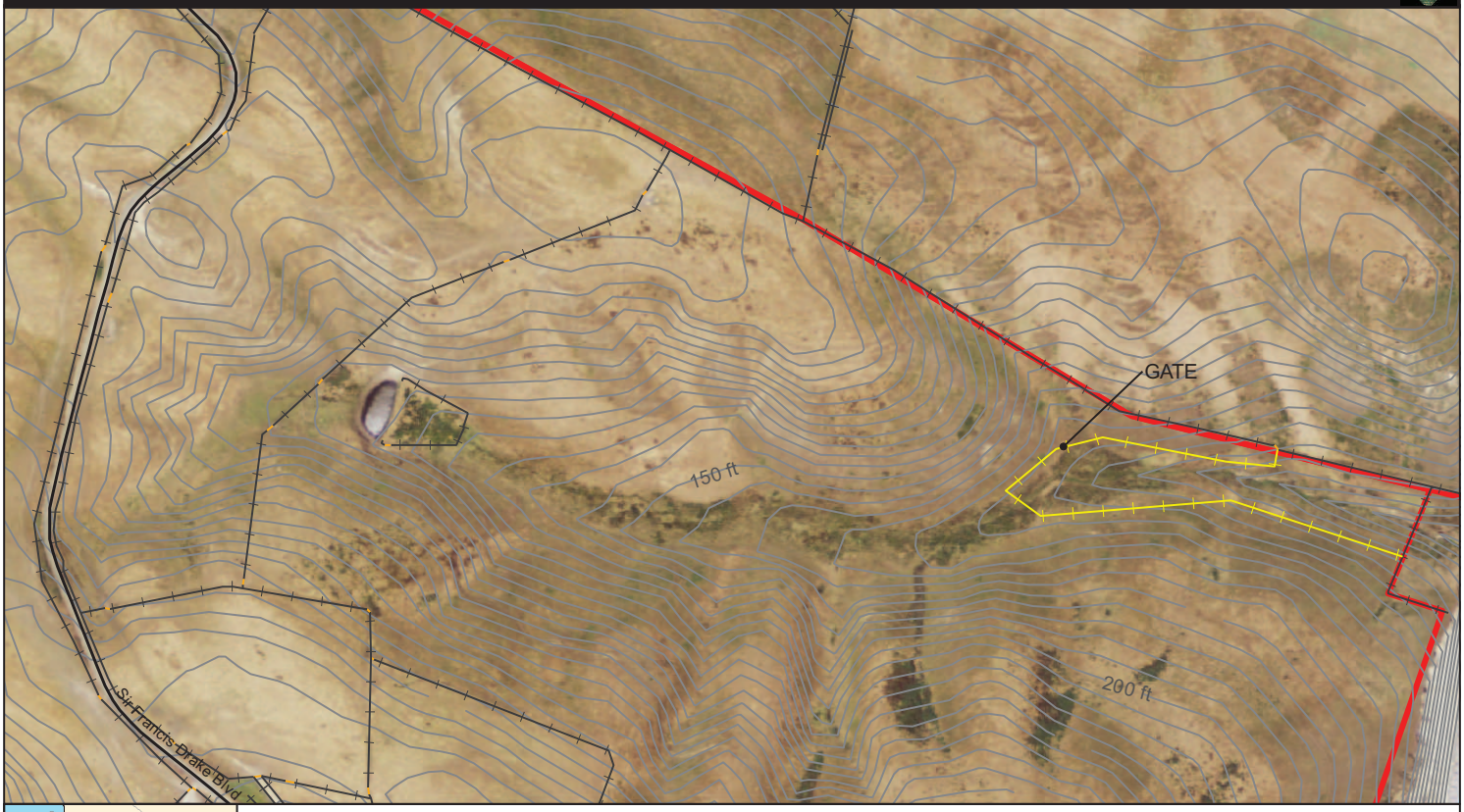
N
W E
S

0 300 600 900 1,200
Feet

- Proposed Fence Line
- Major Roads
- Existing Fence
- Existing Gate
- 10 Foot Contours
- Ranch Boundary

Plot date: 09/07/2012 Imagery: 2009 NAIP

Addition 1 - A Ranch



National Park Service
Point Reyes National Seashore
Marin County, CA

1 inch = 425 feet

0 300 600 900 1,200
Feet

Proposed Fence Line
Major Roads
Existing Fence
Existing Gate
10 Foot Contours
Ranch Boundary

Plot date: 09/07/2012 Imagery: 2009 NAIP

A Ranch Main

National Park Service
Point Reyes National Seashore
Marin County, CA

1 inch = 425 feet

N
W E
S

0 300 600 900 1,200
Feet

- Proposed Fence Line
- Major Roads
- Existing Fence
- Existing Gate
- 10 Foot Contours
- Ranch Boundary

Plot date: 09/07/2012 Imagery: 2009 NAIP