# Naval Auxiliary Landing Field, San Clemente Island

# **Black Abalone** (*Haliotis cracherodii*) **Survey**



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# Executive Summary

The U.S. Naval Base Coronado's San Clemente Island (SCI) historically supported a large population of black abalone (*Haliotis cracherodii*). Along with coastal California as a whole, SCI's population suffered from years of overfishing during the last century and mass mortalities from a fatal wasting disease termed "withering syndrome" starting in the late 1980's. The black abalone is a relatively shallow water species occurring mainly in the intertidal and shallow subtidal zones throughout California and occurred in its greatest densities within the Southern California Bight and the Channel Islands. The black abalone is currently a candidate species for listing under the Endangered Species Act of 1973 [16 USC Sec. 1531-1544], as amended (ESA).

In response to concerns regarding the federal listing of black abalone, the Department of the Navy (DoN) initiated an island wide investigation to determine the current extent of remaining black abalone populations on SCI. Experienced abalone biologists (Table 1) used methods previously utilized by federal, state, and academic abalone researches and described in the California Department of Fish and Game (CDF&G) abalone recovery plan to perform timed searches at SCI during low tides at 61 locations, from January 18$^{th}$ to January 21$^{st}$, 2008. Locations of previously documented abalone populations were weighted for selection to provide comparative analysis and reference. Each of the 61 locations surveyed covered approximately 1500 $m^2$ of potential habitat that was mapped, photographed, and biologically evaluated.

Ten black abalone ranging in size from 100- 130 mm, averaging 117.4 mm, were observed over the course of the survey. Suitable black abalone habitat on SCI was divided into 19 sub sections, each encompassing approximately two kilometers of coastline, teams surveyed two to five random 100 m. sections of primary habitat within each subsection to estimate population densities. Excluding unsuitable abalone habitat such as cliff areas and sand/cobble beaches within each subsection, the actual amount of primary habitat searched within the island sub sections was approximately 20-25 percent of the total available habitat island wide. Estimating the area searched, the density of black abalone at SCI is approximately one abalone per 9150 $m^2$. The research team making observations were professional biologists with a minimum of 15 years and up to 25 years of experience identifying suitable habitat and searching for black abalone throughout the Channel Islands. Selected biologists greatly reduced any variability attributed to observers or search effort. Populations on SCI are at less than 0.1 percent of historic levels and individuals within the population likely represent abalone that were either isolated from diseased populations or resilient to the bacterium thought to cause withering syndrome. No signs of recruitment were observed during the investigation. The survey focused on non invasive sampling of emergent animals. Cryptic habitat, where small recruits are usually found, was only partially included during the survey.

Future surveys within the isolated areas not included in this effort should be conducted to confirm the status of the black abalone population on San Clemente Island.

# 1 Introduction

Naval Air Landing Field San Clemente Island (NALF SCI) historically supported a large population of black abalone (*Haliotis cracherodii*) that was heavily harvested during different time periods by Native Americans, Chinese immigrants, and commercial fishermen prior to their drastic decline in the 1990s. The black abalone is a relatively shallow water species occurring mainly in the intertidal and shallow subtidal zones throughout its range (Haaker et al. 1986). Black abalone historically ranged from Coos Bay, Oregon to Cape San Lucas, Baja California (Cox, 1962). Off the coast of California they were found in great abundance at all of the Channel Islands (Sheperd et al. 1992). Densities historically ranged from 25-40 per $m^2$ on the central California mainland, to over 120 per $m^2$ in the Channel Islands (Douros, 1987). Withering syndrome (WS) decimated the southern California black abalone population starting in the mid 1980s and migrated throughout the Channel Islands and California mainland coast over the next 15 years (McShane, 1992). In 1993, commercial fishing harvest was suspended. In fewer than twenty years, black abalone that had dominated rocky intertidal zones at densities of more than 100 per $m^2$ disappeared from most of their former range south of Point Conception (Richards et al. 1993). In 2006 The Center for Biological Diversity formally requested that the Secretary of Commerce, through the National Marine Fisheries Service ("NMFS" or "NOAA Fisheries"), list the black abalone (*Haliotis cracherodii*) as Endangered under the federal Endangered Species Act (ESA), 16 U.S.C. § 1531 – 1544. The Center also requested that black abalone critical habitat be designated concurrently with its listing.

Black abalone populations on SCI have been previously studied by the California Department of Fish and Game (CDF&G) (1988- 1993) in defined areas on the west shore of the island where suitable habitat and food are abundant (Ian Taniguchi, CDF&G pers comm.). During field investigations in March and October 1988 robust populations showed no signs of WS; however, during return visits in 1990, population decline from WS was well underway and evident from numerous fresh shells located at sampling sites. Investigations at established sites near Eel Point, in 1993, recorded densities less than $1m^2$ (CDF&G, 1993). In response to concerns regarding the federal listing of black abalone, the Department of the Navy (DoN) initiated an SCI-wide investigation to determine the current extent of remaining Black abalone populations. Experienced researchers with collaboration from the CDF& G performed timed searches during low tides within primary habitat over four days at 61 locations.

# 2 Methods

The eastern shore of the island is the upslope side of the San Clemente Island Escarpment and is an active strike skip fault zone, therefore the shoreline associated with this portion of the island is steeply sloped with only scattered narrow bands of intertidal habitat available for potential abalone inhabitance. In contrast the western shore is dominated by shallow sloping marine terraces shaped from wave exposure that extend offshore in the form of broad intertidal and subtidal habitat. Considering the lack of historical documentation, limited available habitat, and lack of potential operational conflicts minimal effort was concentrated on the eastern side of the island. Identified primary abalone habitat throughout the island was

divided into coastal subsections approximately 2 kilometers long labeled A-S (Figure 1). Teams of two or more people headed by an experienced marine biologist performed 30 minute timed searches within defined 100 meter sections of primary habitat, identified by the biologist of each team, within each subsection. Survey teams consisted of one experienced biologist and one recorder (Table 1).

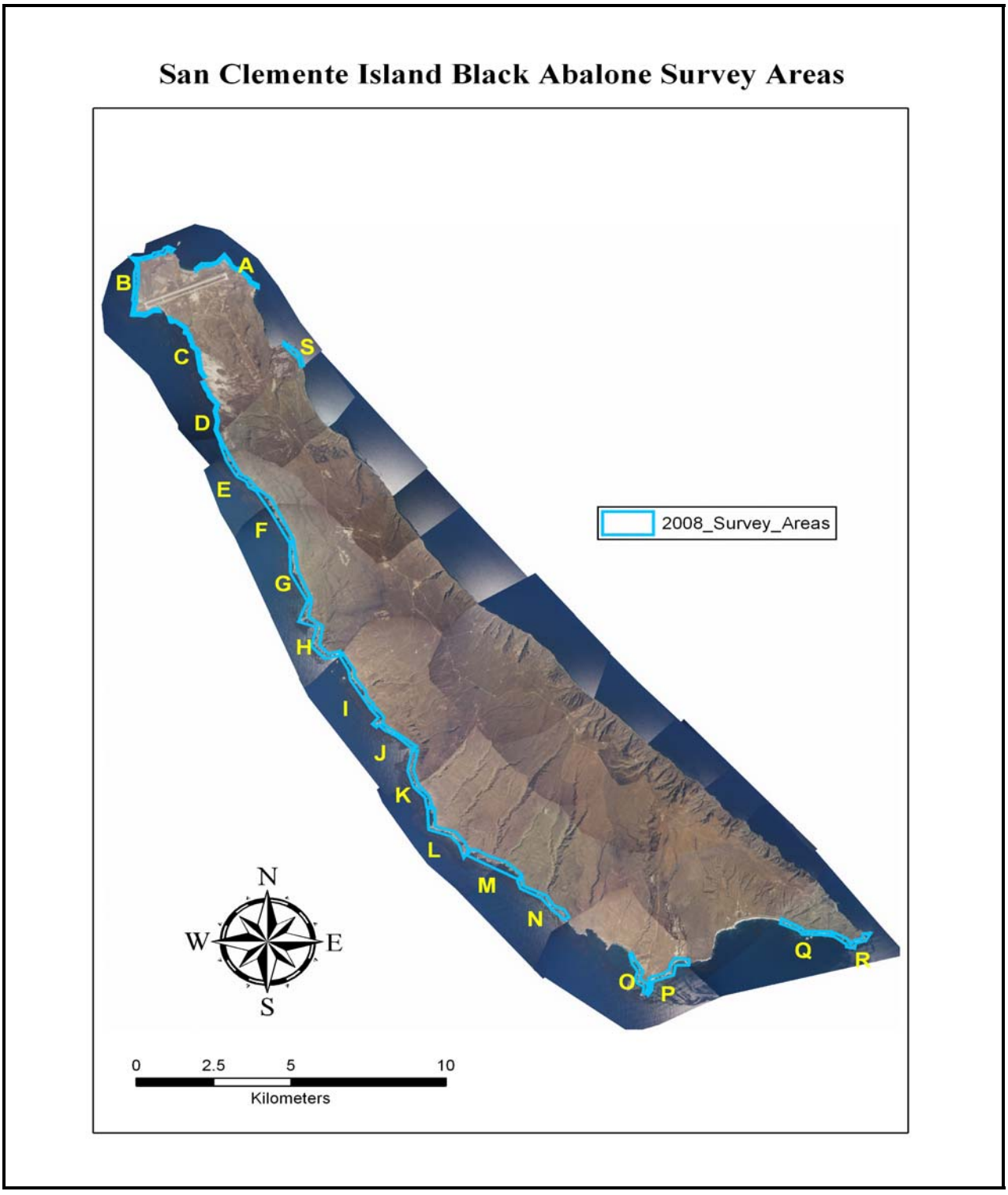



*Figure 1. San Clemente Island Black Abalone Survey Subsections.*

Two to five timed searches were surveyed within each subsection depending on the available habitat, access, and time. No sampling took place within Impact Areas where potential unexploded ordnance was known to exist. Each team was equipped with a hand held PDA/GPS loaded with maps in Arc Pad, digital camera, radio, measuring device, and data sheets. Transportation to coastal access points was by 4 X 4 vehicles or helicopter and was coordinated with range operations (SCORE) to allow for access to restricted areas. Upon arrival to assigned subsections (A-S) each team worked along the coastal bluff or coastline enabling the lead biologist to select primary habitat to begin timed searches. Primary habitat was selected based upon available substrate, exposure, access, and associated biological indicators.

| Team 1 | Team 2 | Team 3 | Team 4 |
|---|---|---|---|
| Derek Lerma<br>Senior Marine Biologist<br>Tierra Data Inc<br>15 years Abalone exp. | Ian Taniguchi<br>Senior Marine Biologist<br>CA Dept. of Fish & Game<br>20 + years Abalone exp. | Mike Moss<br>Marine Biologist<br>National Park Service<br>12 years Abalone exp. | Jesse Altstatt<br>Science Director/Biologist<br>Santa Barbara Channel Keeper<br>14 years Abalone exp. |
| J.T. Hesse<br>CNRSW Environmental | Sandy Baldwin<br>NAVFAC SW | Nicole Olmsted<br>NAVFAC SW | Ruben Guieb<br>NAVFAC SW |
| Logistical Support | | Helicopter Pilot | |
| Mitch Perdue, Senior Biologist<br>NAVFAC SW | | Gregory Mattson<br>Cherry Helicopters, San Diego, CA | |

*Table 1. Survey teams and support personnel utilized during the surveys.*

Locations of previously documented abalone populations (CDF&G and LA County) were weighted for selection. Upon selection of a site a weighted flag was dropped, near the high tide mark, and another placed 100 meters up or down coast. The lead biologist immediately began searching for 30 minutes within the delineated habitat moving in one direction along the coast. The other team member completed the various portions of the data sheet (time, date, physical conditions, etc) and took pictures from the four corners of the site created by both flags and the lowest tidal area safely accessible directly seaward of the flags. Pictures were taken facing the two points up or down coast from the current position to document the site and its associated topography (Figure 2). Once the site was identified a team member logged GPS points at the two flags defining the search area and labeled the file by subsection (A-S) and timed search number A1, A2, etc. A team member filled out a data sheet for each timed search and conferred with the lead biologist for biological information and comment. The lead biologist categorized each site with regards to type of habitat, quality of habitat, and the biological characteristics that defined the site.

When a live abalone was located the size was estimated into one of three size categories (<40mm, 41-90mm, >91 mm). If more than one individual was located at a single location an estimate of the number and sizes was listed on the data sheet. A team member then took a picture and GPS location of each live individual or group of individuals labeling the GPS file A1_1, A1_2, etc. The health condition of the observed abalone was noted. Empty shells within timed search areas were identified as old or new and sized according to defined categories.

The survey was designed to access as much of the primary habitat as possible within tide, time, and safety limitations. Surveys were designed using standard methods described by CDF&G (CDF&G, 2005) and required investigators to move quickly and consistently throughout timed search areas. No invasive sampling was allowed (i.e. moving rocks). The focus of the investigations was to identify populations in as many areas as possible. Each team was provided hard copy maps of their assigned subsections. If areas were cliff, inaccessible, sandy beach, or had marine mammals that should not be disturbed those areas were identified on the maps and sampling moved on.

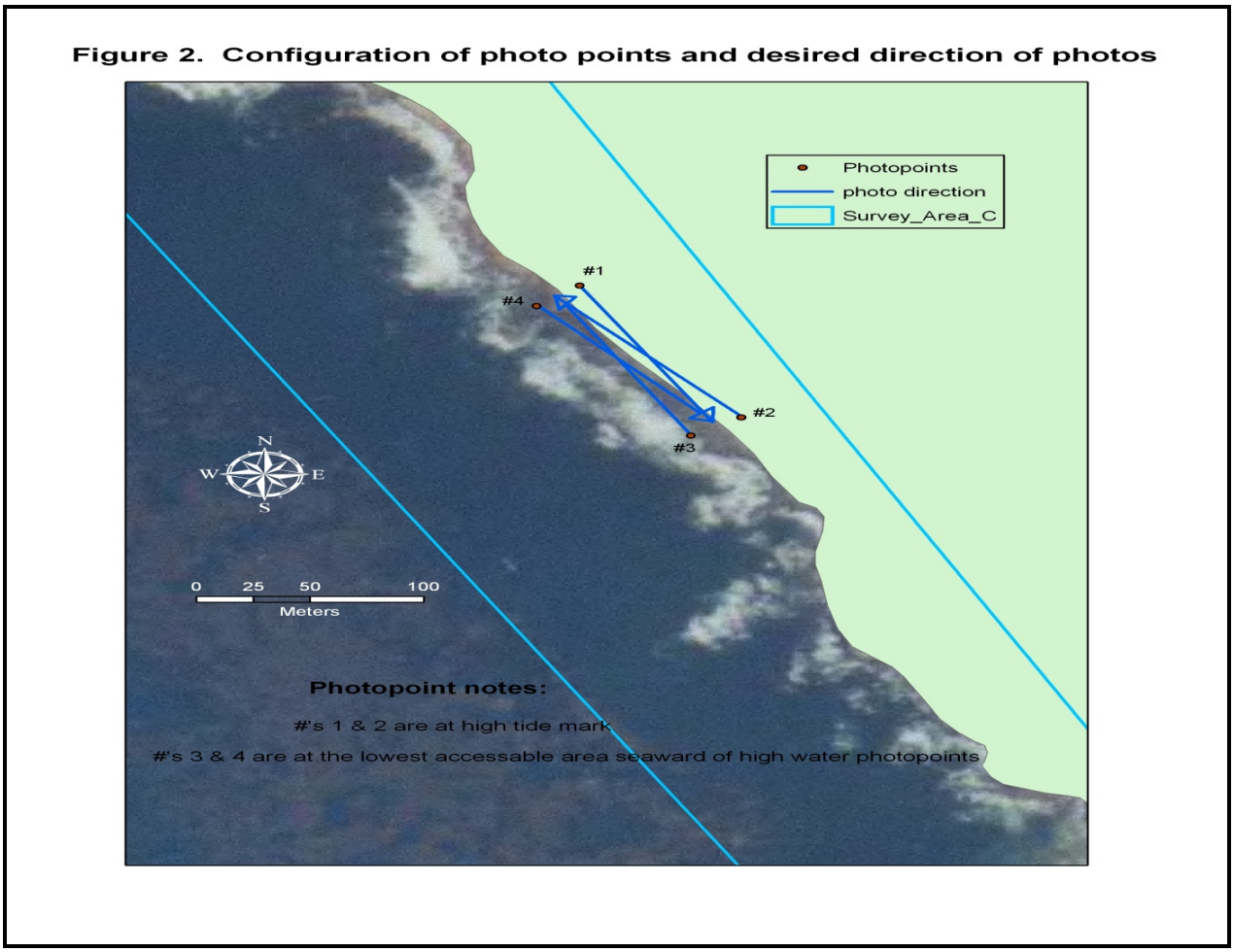



*Figure 2. Configuration of photo points and desired direction of photos.*

# 3 Results

Black abalone (*Haliotis cracherodii*) primary habitat was abundant, diverse, and well represented in all survey subsections. San Clemente Island (SCI) has a total coastline of approximately 91 linear kilometers of which the survey subsections represented about fifty linear kilometers. The 19 sub sections selected for sampling represent approximately 90% of all suitable black abalone habitat island wide. Site specific surveys of primary habitat within each subsection covered about 20-25 percent of the highest quality habitat of each subsection.

Considering the variability in the quality of habitat and using a conservative estimate that 20-25% of each subsection is low quality or unsuitable habitat (cliff or beach area). The site specific surveys effectively sampled approximately 20-25% of the total available habitat island wide. Sixty-one, 30 minute timed searches, covering approximately 100 meters of coastline each, were performed over a four day period from January 18$^{th}$- 21$^{st}$, 2008 (Figure 3). Subsections A, S, and part of B were not surveyed due to operational restrictions or time but general species surveys performed in 2005 documented no occurrences of black abalone within significant portions of subsections A and S (DoN, 2006). Habitat varied from rough volcanic basalt to sandstone rocky benches. Overall SCI is primarily dominated by dark basalt rocky headlands and boulder fields eroded to varying degrees and textures.

A total of 10 black abalone ranging in size from 100- 130 mm, averaging 117.4 mm were observed over the course of the investigation (Table 2). All abalone appeared healthy and void of any signs of withering syndrome. All observed black abalone were found in the middle intertidal area typically associated with articulated coralline algae, *Tetraclita rubescens*, and crustose coralline algae (Photos 1&2). Locations of all survey starting and ending points and observed abalone were mapped in UTM, NAD 83, Zone 11 meters. All individual abalone were mapped and photographed for future reference and appear to be adult animals. Several of the individual abalone were encrusted with large barnacles and crustose algae inferring that these animals are remaining exposed for a significant amount of the time. One of the survey sites contained a grouping of two abalone within a vertical crack while the other individuals were either solitary within crevice habitat or conspicuous and easily observed. Areas previously surveyed by the CDF &G and Los Angeles County over the past 20 years and documented to support robust populations of black abalone overlapped noticeably with the 2008 survey results (Figure 4). Taking into account the areas surveyed during the timed searches varied, based on the width of the intertidal and frequency of accessible offshore reefs, a conservative area estimate of 1500 $m^2$ was surveyed at each site. Using this rough estimate of area searched, the density of black abalone at SCI is approximately one abalone per 9150 $m^2$.

Black abalone are cryptic invertebrates, especially at smaller sizes, and there is a probability that a few individuals may have been overlooked due to the sampling design. However, all the participating biologists have extensive experience identifying suitable habitat and searching for black abalone throughout the Channel Islands, greatly reducing any observer variability or search effort.

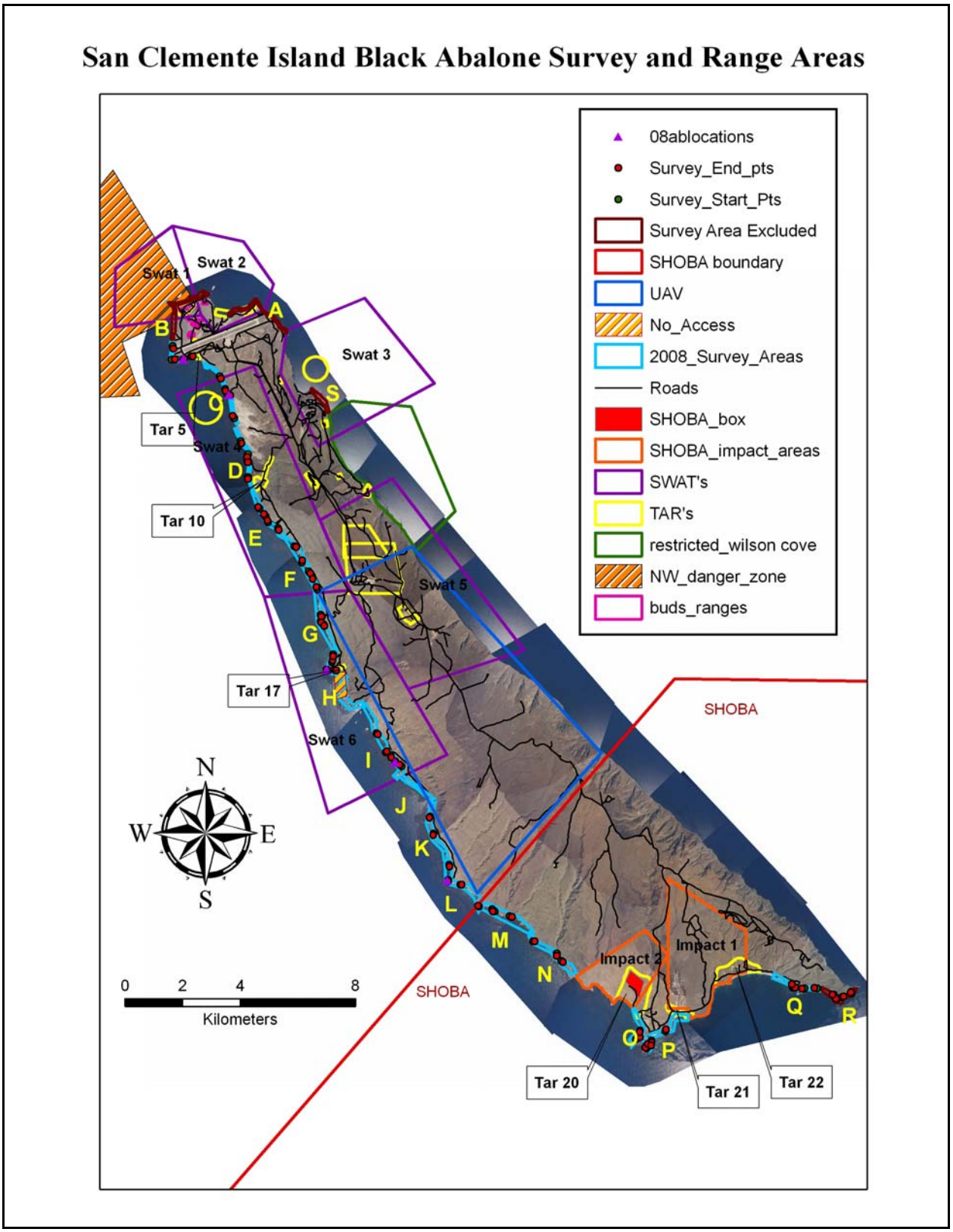



*Figure 3. San Clemente Island NALF survey and range areas.*

| Number | Site | Observer | Size (mm) | Lat (UTM) | Lon (UTM) | Comments |
|---|---|---|---|---|---|---|
| 1 | B10 | M. Moss | 125 | 350404.6948460 | 3654068.9417600 | Open crack |
| 2 | B10 | M. Moss | 110 | 350389.9412980 | 3654055.3886400 | Open crack |
| 3 | B10 | M. Moss | 100 | 350394.3680280 | 3654060.2036800 | Deep Crack |
| 4 | C2 | M. Moss | 130 | 351968.6110110 | 3652812.7049100 | Open crack/small pool |
| 5 | H2 | J. Altstatt | 130 | 355382.9903130 | 3643257.1064600 | All 3 abalone in open crack |
| 6 | H2 | J. Altstatt | 100 | 355369.4997280 | 3643250.2906600 | 5&6 together in Shallow crack |
| 7 | H2 | J. Altstatt | 105 | 355360.9035920 | 3643242.0881900 | Deep Crack |
| 8 | J1 | I. Taniguchi | 124 | 357744.2761660 | 3640054.136510 | Deep Crack |
| 9 | J1 | I. Taniguchi | 120 | 357744.2761660 | 3640034.640460 | Exposed/out in open |
| 10 | L2 | J. Altstatt | 130 | 359558.0808590 | 3635932.0187900 | Deep Crack |

*Table 2. Black abalone (Haliotis cracherodii) size and location of individuals recorded within survey sites.*

*All coordinates Locations are in UTM, NAD 83, Zone 11 meters*



*Photo 1. Black abalone within deep crevice habitat with associated invertebrates. Photograph is taken from above looking down into a vertical crack.*

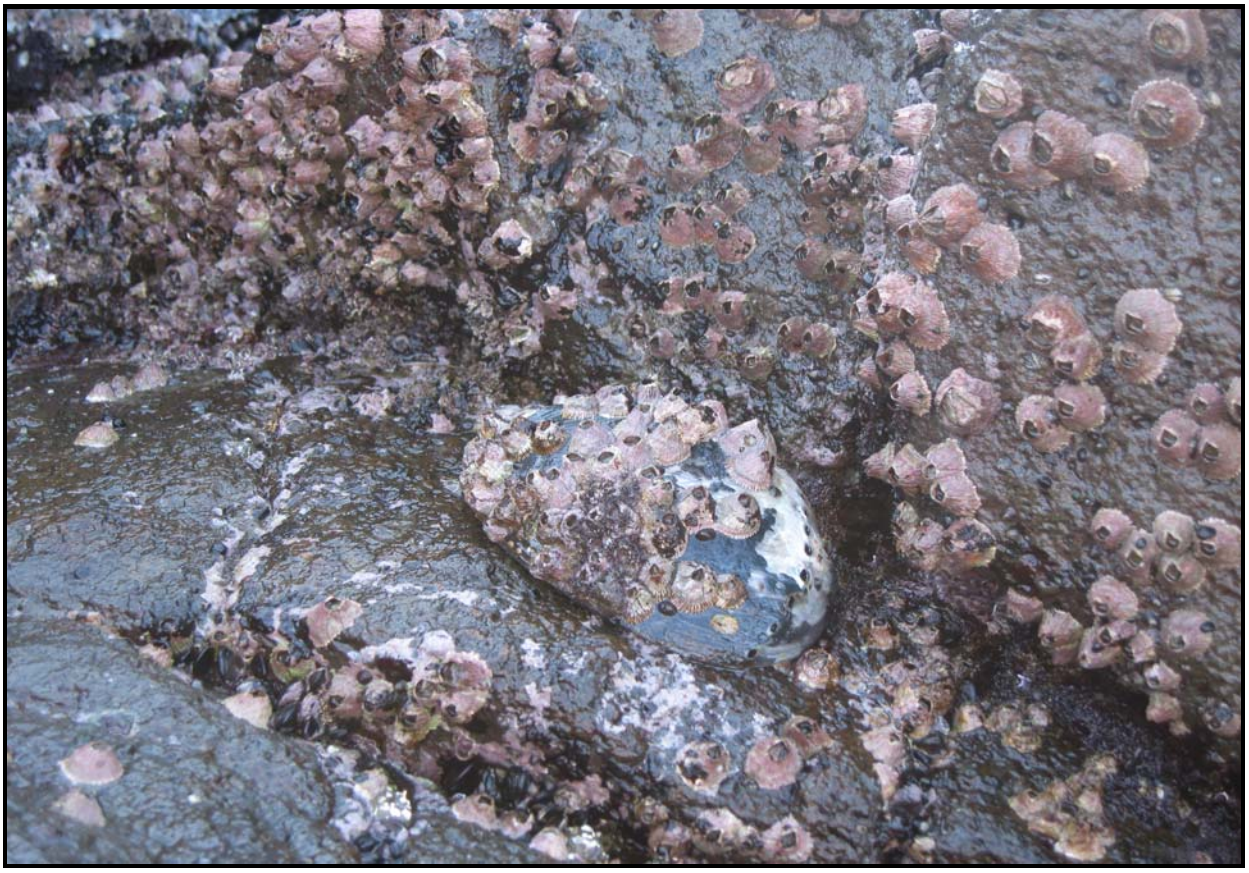


*Photo 2. Black abalone in an exposed open location with the barnacle Tetraclita rubescens.*

Survey effort among subsections and survey sites was consistent, with surveys beginning approximately two hours prior to maximum low tide and ending approximately two hours after the maximum low tide. Conditions during the surveys were optimal with a small west swell of 2-4 feet, depending on the day, and warm sunny conditions. Excellent low tides ranging from -0.7 ft on January 18$^{th}$, 2008 to -1.6 ft on January 21$^{st}$, 2008 provided easy access to expansive low intertidal to shallow subtidal habitat, as well as offshore rocks and reefs typically isolated during swell events or more moderate low tides. The quality of habitat searched was ranked on a 0-3 scale with 3 being excellent habitat and 0 being no habitat. All survey locations recorded habitat quality as 2 or 3, by the lead biologists selecting the sites.

Representative biological indicator species within each tidal zone were utilized to characterize each survey site. Relative abundances were recorded and conspicious and dominant species were cited . Indicator species were defined according to the Marine Rocky Intertidal Monitoring Group (MaRINE), which is a working group of federal, state, and private research entities that monitors rocky intertidal assemblages throughout California (Table 3).

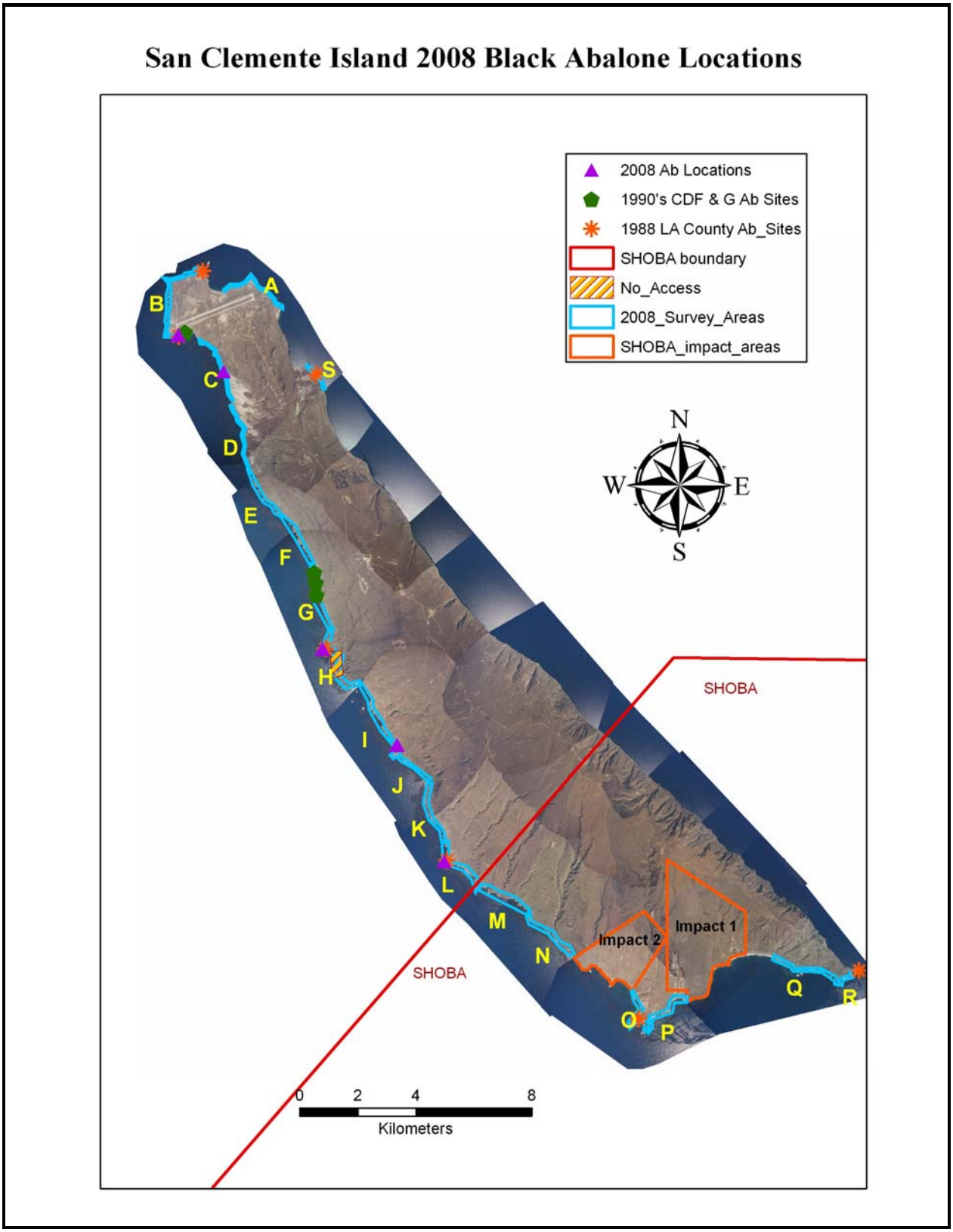



*Figure 4. Locations of observed Black abalone (Haliotis cracherodii) from 2008 surveys and previously documented sites.*

| Common Name | Genus | Species |
|---|---|---|
| Anemones | *Anthopleura* | *elegantissima/solia* |
| Barnacles | *Pollicipes* | *polymerus* |
| Barnacles | *Tetraclita* | *rubescens* |
| Barnacles | *Chthamalus* | *dalli/fissus* |
| Barnacles | *Balanus* | *glandula* |
| Black abalone | *Haliotis* | *cracherodii* |
| Owl limpets | *Lottia* | *gigantea* |
| California mussels | *Mytilus* | *californianus* |
| Seastars | *Pisaster* | *ochraceus* |
| Boa Kelp | *Egregia* | *menziesii* |
| Rockweed | *Hesperophycus* | *californicus* |
| Rockweed | *Silvetia* | *compressa* |
| Turfweed | *Endocladia* | *muricata* |
| Surfgrass | *Phyllospadix* | *scouleri/torreyi* |
| Red Algae* | *Gelidium* | *coulteri* |
| Red Algae* | *Mazzaella* | *Spp.* |
| Red Algae* | *Mastocarpus* | *Papillatus* |
| Red Turf* | Various | species |
| *Four species or species groups though chosen for fixed plot monitoring at a few sites are not official target species for MARINe. | | |

*Table 3. MARINe group indicator species used to describe survey locations at San Clemente Island*

# 4 Discussion

Black abalone are considered a large and conspicuous invertebrate within a intertidal habitat dominated by small cryptic or sessile invertebrates and attached algae. The noticeable absence of this once plentiful species has spurred researchers to more intensively investigate the current status of black abalone populations and the mechanisms that play a role in their potential recovery. Initial recovery plans developed in 2005 by the California Department of Fish and Game (CDF&G) highlighted the need to document the current status of the black abalone population throughout its range and this survey provided critical information of the species status on San Clemente Island. Most experts agree that the current range of black abalone extends from Point Arena (Mendocino County, California) to Northern Baja California (NOAA, 2008).

Post decline investigations of previously documented high density population sites reported similar sizes and densities to the ones found on San Clemente Island (SCI) during the 2008 survey. In 2002 a survey for black abalone was conducted in Mexico at Bahia Tortugas, just south of Punta Eugenia and only four individuals were found, ranging in size from 121 to 152

mm (Sierra Rodriguez *et al*. 2006). The SCI survey methods followed prescribed techniques used to enumerate low density abalone populations and utilized well trained biologists to validate the effort. The survey findings documented that SCI's current black abalone population is merely a remnant of previous populations and that current individuals are unlikely to provide significant natural recovery through reproduction in the near future. As intertidal organisms on exposed rocky shores, black abalone typically release gametes into environments of extreme turbulence. As a consequence, eggs and sperm must be released from adults in relatively close spatial and temporal proximity in order to have any chance of union and fertilization before rapid dispersal and loss of opportunity (NOAA, 2008).

Gruenthal (2007) has characterized larval dispersal in black abalone as consistent with the stepping-stone model of dispersal (Kimura and Weiss, 1964). Given that most abalone larvae are in the plankton for a period of about 3-10 days before settlement and metamorphosis (e.g., McShane, 1992), it seems clear that abalone in general and black abalone in particular have limited capacity for dispersal over distances beyond a few kilometers, and are able to do so only rarely. The potential for significant recruitment of individuals from the only nearby notable population at San Nicolas Island, upwind and up current from SCI, is a low probability considering current information on dispersal. Additionally, California mussels (*Mytilus californianus*) were noticeably absent at many of the sites and this is important because thier presence has been inferred to be prime area for black abalone recruitment.

San Clemente Island black abalone are afforded a high level of protection from potential poachers, pollution, and habitat degradation do to the fact that the island is 50 miles from the mainland, controlled by the U.S. Navy, and access to intertidal habitat by the general public is strictly controlled. The location of the documented black abalone found during the survey have minimal potential for interacting with U.S. Navy operations considering all individuals occurred on rocky benches and headlands along the west shore where surf zone access is difficult and dangerous. Black abalone habitat along the SCI shoreline is similar to much of the habitat found throughout the Channel Islands and supports robust intertidal and sub tidal communities. The surveys provided in-depth information on physical and biological characteristic of intertidal habitat rarely visited and difficult to access.

# 5 Acknowledgements

Special thanks to the biologists who participated in the surveys and their input and review of sampling protocols and methodologies utilized throughout the survey. Participation by Navy Facilities Command South West (NAVFAC SW) personnel and J.T. Hesse (CNRSW Environmental) as recorders and guides was greatly appreciated. Thanks to Mitch Perdue (NAVFAC SW) for providing logistical support with helicopter operations and range clearance information. Cherry helicopter pilot Greg Mattson provided outstanding piloting and access to otherwise inaccessible areas allowing survey teams to cover an extremely large amount of area. Many thanks Les Stone and Abel Holguin of SCORE for providing communications, range clearance, and logistical assistance with access to restricted areas.

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Sheperd, S.A., M.J. Tegner, and S.A. Guzman del Proo, editors. 1992. Abalone of the World. Blackwell Scientific Publications, Oxford, England. xiv + 608 pp.

Sierra-Rodriguez, P., M Muciño Díaz, J.L. Gutiérrez González, and J.R. Turribates Morales. 2006. La Pesquería de Abulón. Pages 3-38 *in*: J. Cueller P. and C.O. Cadena (editors). Sustentabilidad y Pesca Responsable en México. Evaluación y Manejo. Instituto Nacional de la Pesca. México, D.F., México.

# A Appendix A - Survey Subsections

## *A.1 Subsection A – Eastern portion of Northwest Harbor*

No sampling was performed in subsection A due to closure from Naval Special Warfare training. The majority of the black abalone habitat within subsection A is marginal with about 30 percent being east exposure cliff and 10-15 percent encompassed by graduation beach within Northwest Harbor. Areas of Special Biological Significance (ASBS) surveys performed over much of this area in 2006 found no evidence of black abalone populations (DoN, 2006). Several isolated headlands and rocky benches could potentially support black abalone populations and should be investigated during future surveys.

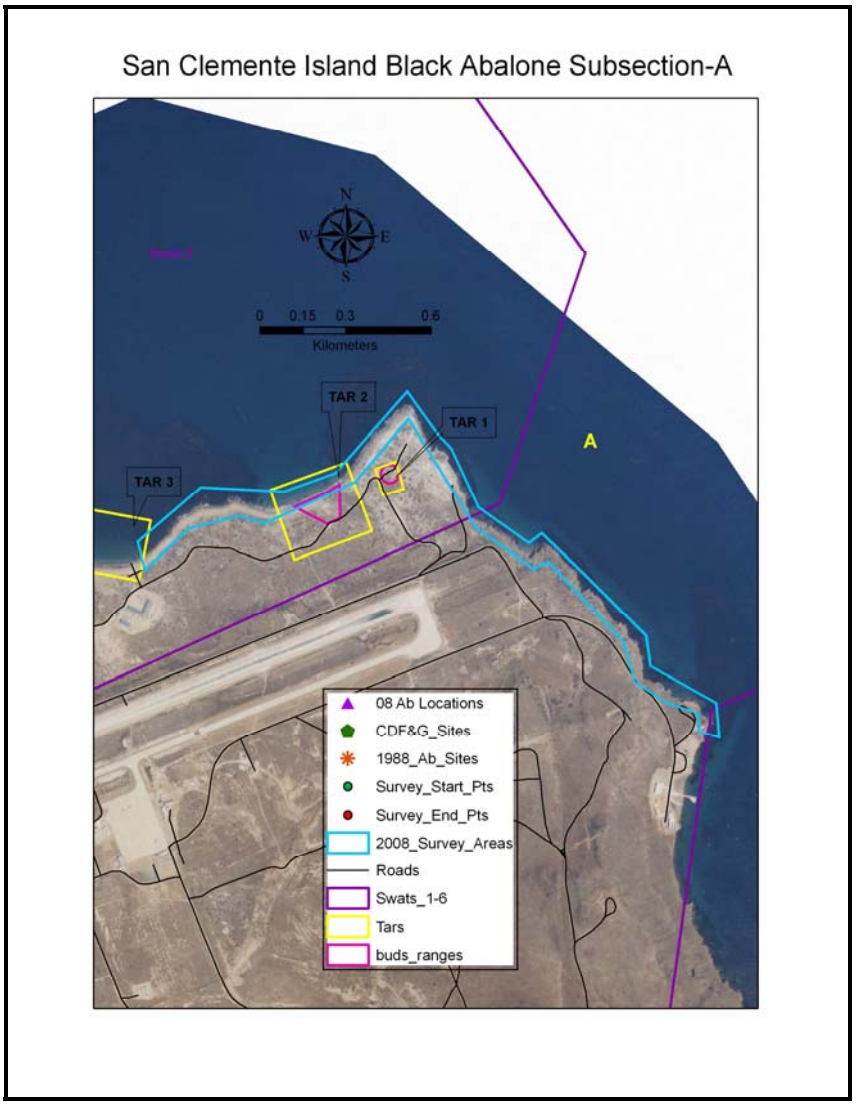



*Figure A-1. Subsection A survey area and associated ranges.*

## *A.2 Subsection B – Western portion of Northwest Harbor to Northern most area of West Cove.*

Sampling was performed on January 21, 2008 at four locations from the northern area of West Cove to just north of the terminus of the airfield. Live fire at the nearby range precluded any surveys north of the airfield. Unique substrate, smooth sandstone rocky benches, dominated much of the area and provided excellent habitat for black abalone (Photo A-2). Three black abalone (125, 110, 100 mm) were found at B10. Habitat quality throughout this subsection was excellent to moderate depending on location and previous survey markers (stainless steel bolts with washers) were found at B1. This area previously contained survey sites established by CDF & G. B1, B2, and B10 were all excellent black abalone habitat made up of stepped sandstone rocky benches.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D Lerma | B1 | 350660.565519 | 3654159.630390 | 350726.855891 | 3654156.404350 |
| D Lerma | B2 | 349981.206541 | 3654043.554640 | 350089.878375 | 3654050.768100 |
| M. Moss | B10 | 350375.412616 | 3654037.873640 | 350424.375733 | 3654084.449710 |
| M. Moss | B11 | 350011.882402 | 3654511.102050 | 350038.581313 | 3654429.377550 |

*Table A-2. Subsection B Observers and Transect locations in UTM's.*



*Photo A-2. Survey site B10*




*Figure A-2. Subsection B survey starting and ending points with documented abalone locations.*

## *A.3 Subsection C – Southern portion of West Cove to Middle of Dunes*

Sampling was performed on January 21, 2008 at four locations. Access to this subsection was from a poor road just south of the air terminal. Quality habitat varied between rough rugose rocky headlands with defined surge channels and low lying boulder habitat with frequent tide pools. Relief varied from less than 1 m to 2.5 meters in height. Old black abalone shells and fragments were common. One black abalone was observed in C2 (130 mm) and appeared healthy.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| M. Moss | C1 | 352156.645535 | 3652007.716430 | 352106.080475 | 3652085.384920 |
| M. Moss | C2 | 351934.427235 | 3652818.377400 | 352006.982722 | 3652803.644010 |
| D Lerma | C11 | 351658.136880 | 3653458.019430 | 351685.975471 | 3653383.294010 |
| D Lerma | C12 | 351851.568314 | 3653024.796780 | 351852.517113 | 3652963.785920 |

*Table A-3. Subsection C Observers and Transect locations in UTM's.*



*Photo A-3. Survey site C2.*

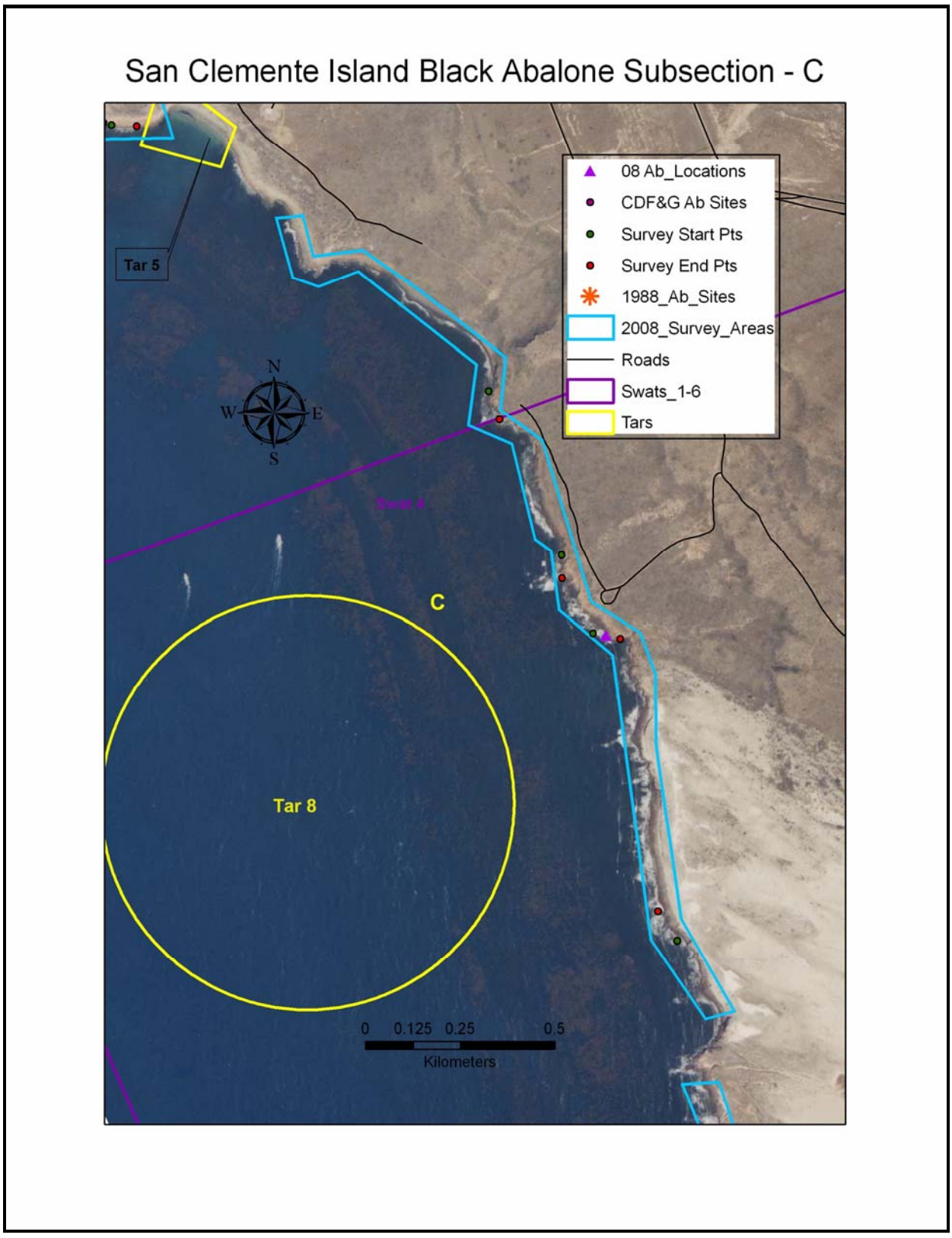



*Figure A-3. Subsection C survey starting and ending points with documented abalone locations.*

## *A.4 Subsection D – Middle of dunes south to TAR 10.*

Access to this subsection is from the Eel point road going north along the coastal bluff. The road turns inland and uphill at Flasher road then splits off left towards the dunes. This subsection was dominated by low lying rocky reef that varied between rough benches to boulder habitat, Quality of habitat was good to moderate and upper intertidal zones were compressed with the sandy coastal bluffs spilling over into the upper intertidal. Midden sites and old shells were common at all sites and algal assemblages were diverse and robust. Kelp rack was thick near D2 and beach trash was common throughout. No live abalone were observed within this subsection.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D Lerma | D1 | 352384.192018 | 3651207.184660 | 352411.234176 | 3651134.581260 |
| D Lerma | D2 | 352633.411010 | 3650763.998680 | 352601.048373 | 3650660.177640 |
| I. Taniguchi | D3 | 352609.321981 | 3650569.890290 | 352635.998510 | 3650478.883500 |
| I. Taniguchi | D4 | 352629.888186 | 3649965.166590 | 352630.368590 | 3649891.187850 |

*Table A-4. Subsection D Observers and Transect locations in UTM's.*



*Photo A-4. Survey site D3.*

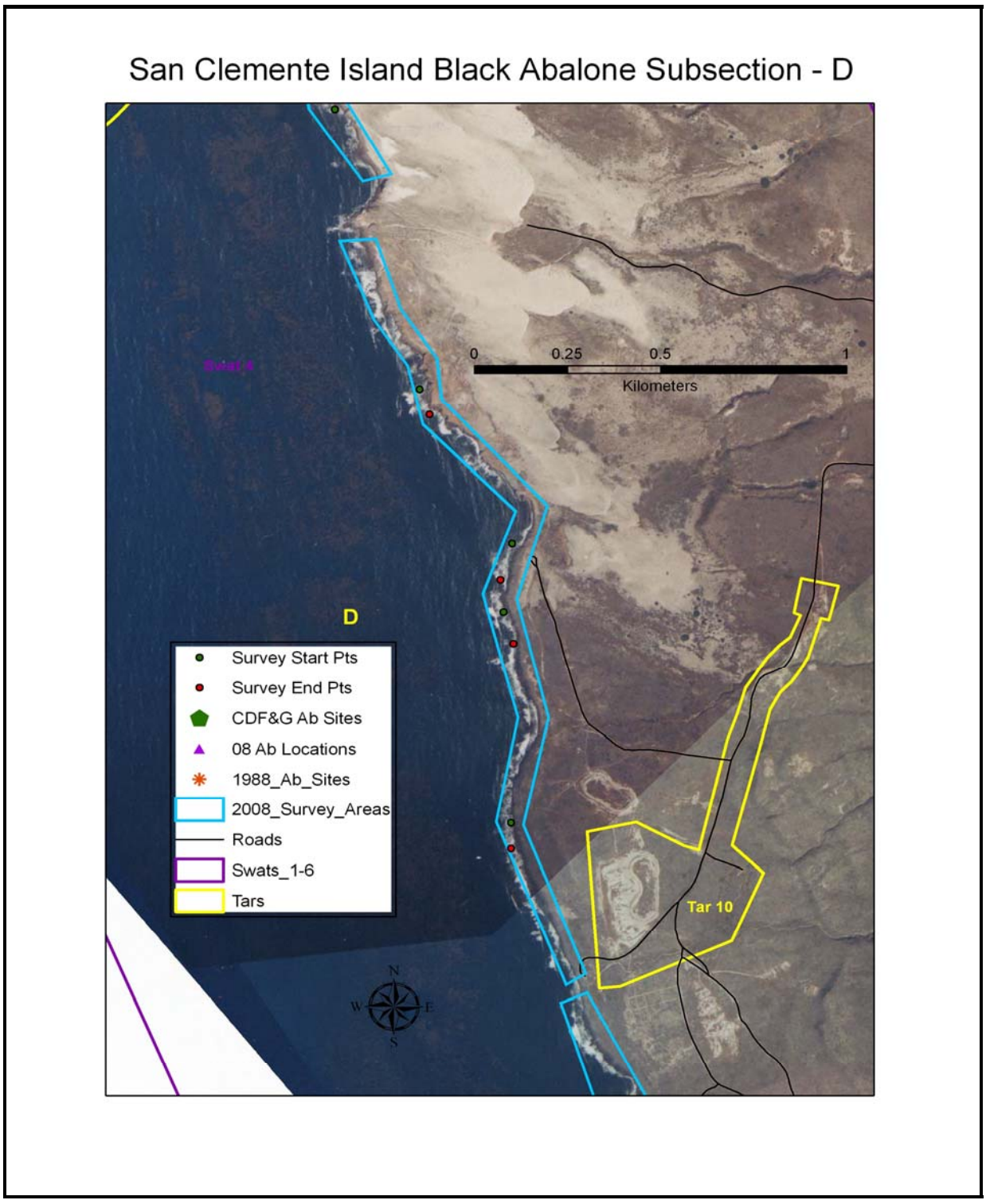



*Figure A-4. Subsection C survey starting and ending points with documented abalone locations.*

## *A.5 Subsection E – Southern extent of TAR 10 to Terrace Canyon*

A small commercial urchin boat lies near the middle of this subsection. Subsection E was mostly low relief rocky bench and boulder habitat that was of moderate quality as abalone habitat. Boulders showed evidence of rolling movement and high intertidal areas were compressed and contained low density and diversity of expected species. Similar to Subsection D the red algal zone contained abundant and diverse assemblages with associate invertebrates. Old black abalone shells were common to abundant and midden sites were obvious and extensive near access points. No live black abalone were observed within this subsection.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| J. Altstatt | E1 | 353247.413479 | 3648580.562450 | 353183.812349 | 3648668.538870 |
| J. Altstatt | E2 | 353033.798688 | 3648868.535570 | 352985.122336 | 3648922.919640 |
| M. Moss | E11 | 353679.102452 | 3648184.507360 | 353704.443862 | 3648115.704670 |
| M. Moss | E10 | 353335.598002 | 3648396.452210 | 353308.333685 | 3648451.018610 |

*Table A-5. Subsection E Observers and Transect locations in UTM's.*

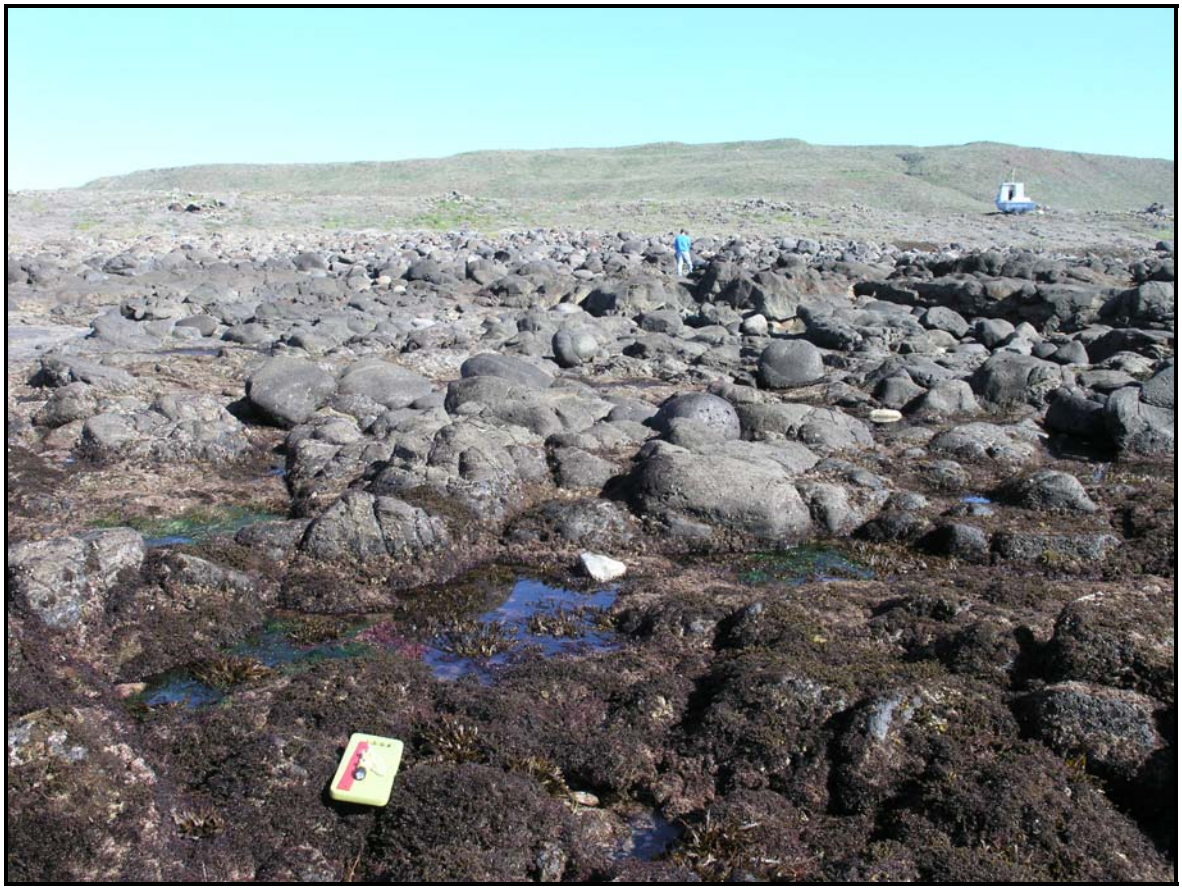


*Photo A-5. Survey site E2.*

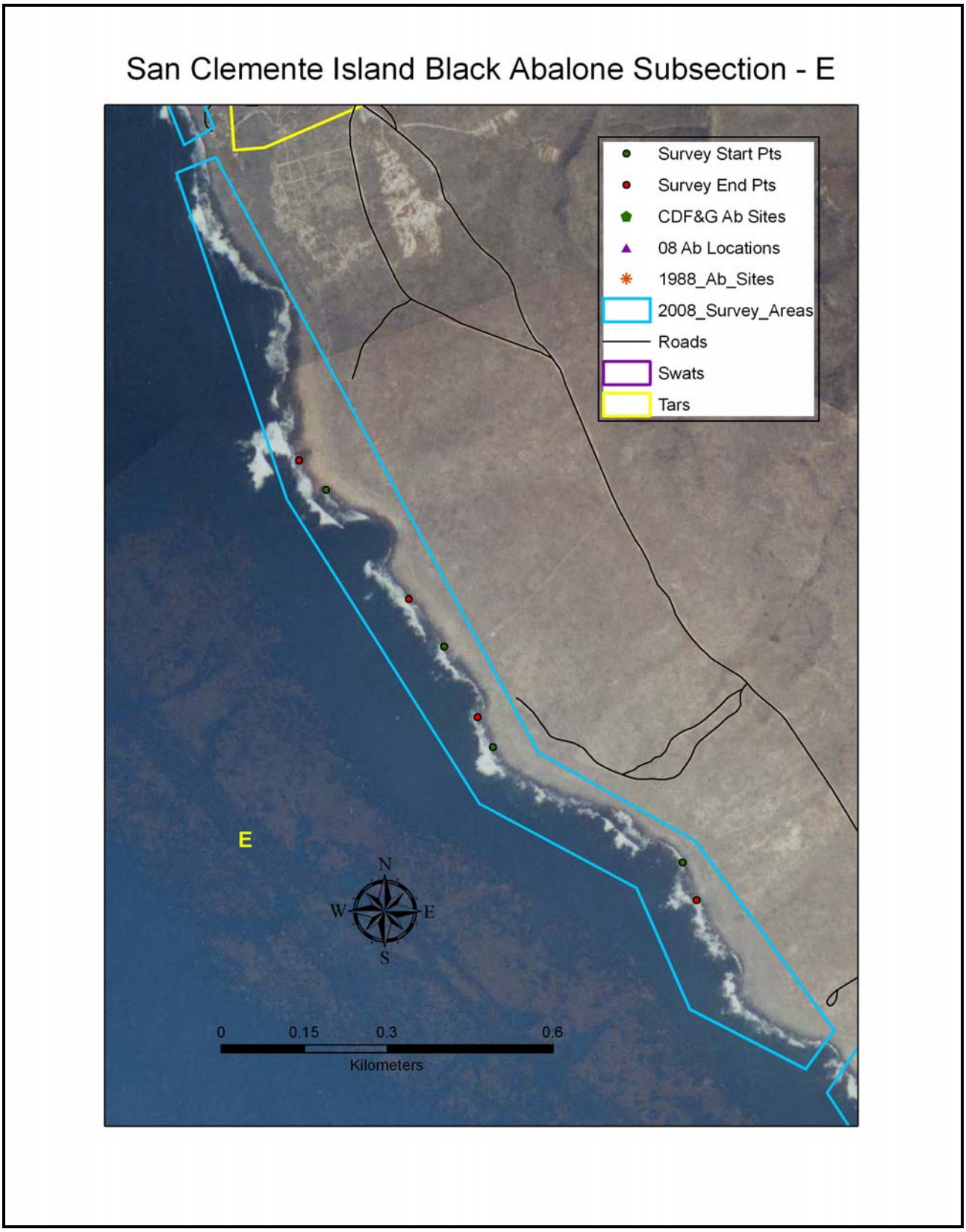



*Figure A-5. Subsection E survey starting and ending points with documented abalone locations.*

## *A.6 Subsection F –Eel Point south to northern edge of SWAT 6*

Subsection F was primarily mid to low relief rocky bench and boulder habitat that was of moderate quality as abalone habitat. Upper intertidal areas were compressed with the mid and low intertidal zones exaggerated from a low sloping angle. Substrate was mostly smooth, less than 2 meters height, but extremely rugose. Algal assemblages were dense in the lower zones with surge channels common perpendicular to shore. Old black abalone shells were common on coastal bluffs and one was found in the intertidal. No live black abalone were observed during any of the surveys.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D. Lerma | F1 | 354232.924158 | 3647557.952640 | 354297.686919 | 3647529.892120 |
| I. Taniguchi | F3 | 354503.659276 | 3646987.309450 | 354518.910466 | 3647070.259260 |
| I. Taniguchi | F4 | 354740.593881 | 3646676.949530 | 354798.869794 | 3646615.094790 |
| I. Taniguchi | F12 | 354870.608916 | 3646508.681960 | 354878.731728 | 3646425.387230 |

*Table A-6. Subsection F Observers and Transect locations in UTM's.*



*Photo A-6. Survey site F3.*

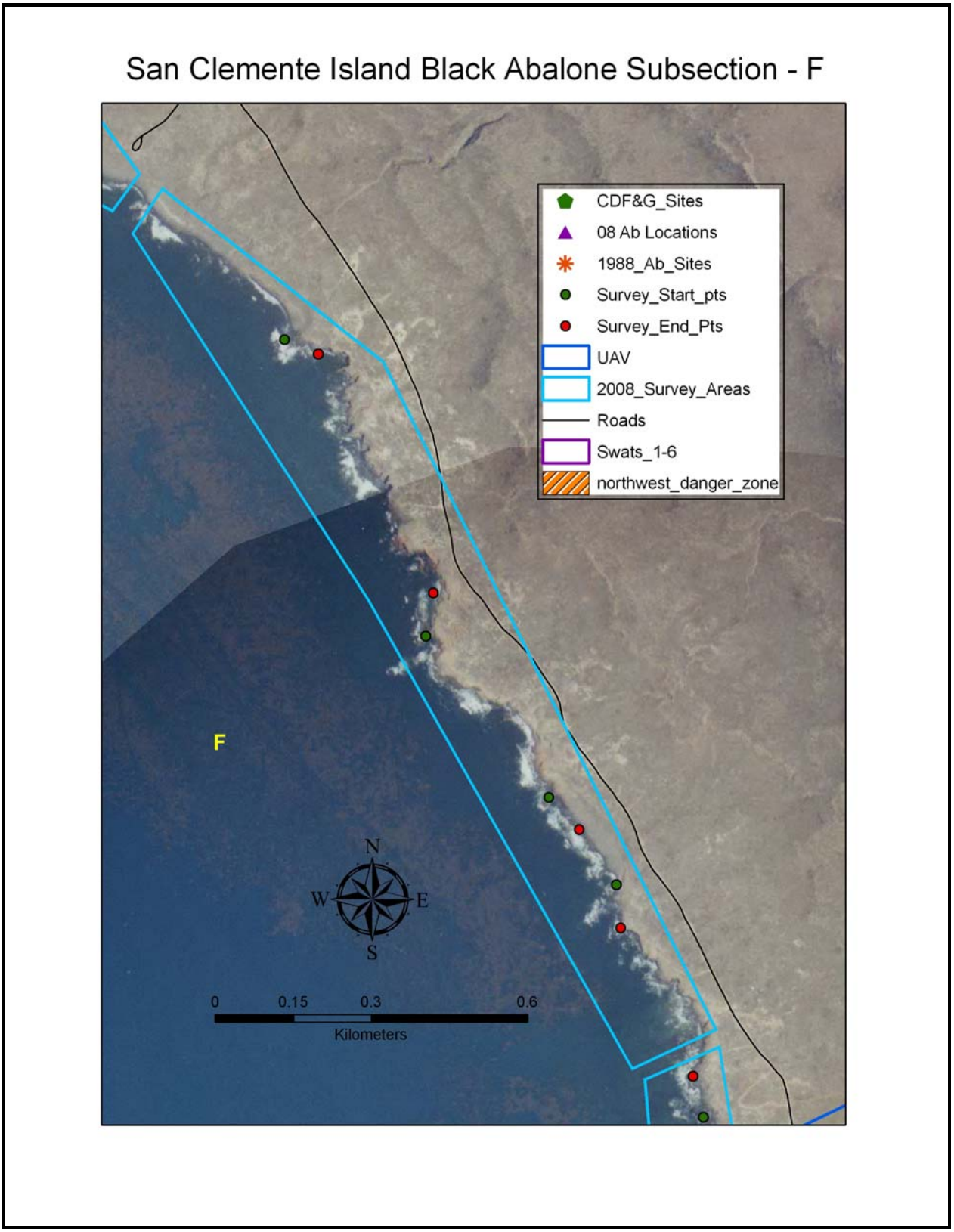



*Figure A-6. Subsection F survey starting and ending points with documented abalone locations.*

## *A.7 Subsection G – Spray point at the terminus of the Eel Point road marks the center of this subsection*

Subsection G contained diverse substrate from high relief rocky headlands in the north to boulder habitat in the south. The quality of abalone habitat varied with substrate and was noticeably poor boulder/cobble in the southern section. Previous CDF& G abalone sites were located in the northern portion of this subsection (Figure A-7). Mussels (*Mytilus californianus*), Gooseneck barnacles (*Pollicipies polymerus*), and Owl limpets (*Lottia gigantia*) were all common. Surf grass (*Phyllospadix spp.)* was abundant and occurred in dense mats within the lower intertidal. Several old black abalone shells were observed in the intertidal. No live black abalone were observed during any of the surveys.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| J. Altstatt | G1 | 355156.417481 | 3645177.335830 | 355183.950265 | 3645111.276970 |
| M. Moss | G10 | 355153.837290 | 3644938.274230 | 355183.391818 | 3644900.244740 |
| M. Moss | G11 | 355255.970370 | 3644843.395550 | 355277.666249 | 3644792.395720 |
| I. Taniguchi | G22 | 355037.784428 | 3646061.273050 | 355017.529440 | 3646140.075990 |

*Table A-7. Subsection G Observers and Transect locations in UTM's.*



*Photo A-7. Survey site G11.*

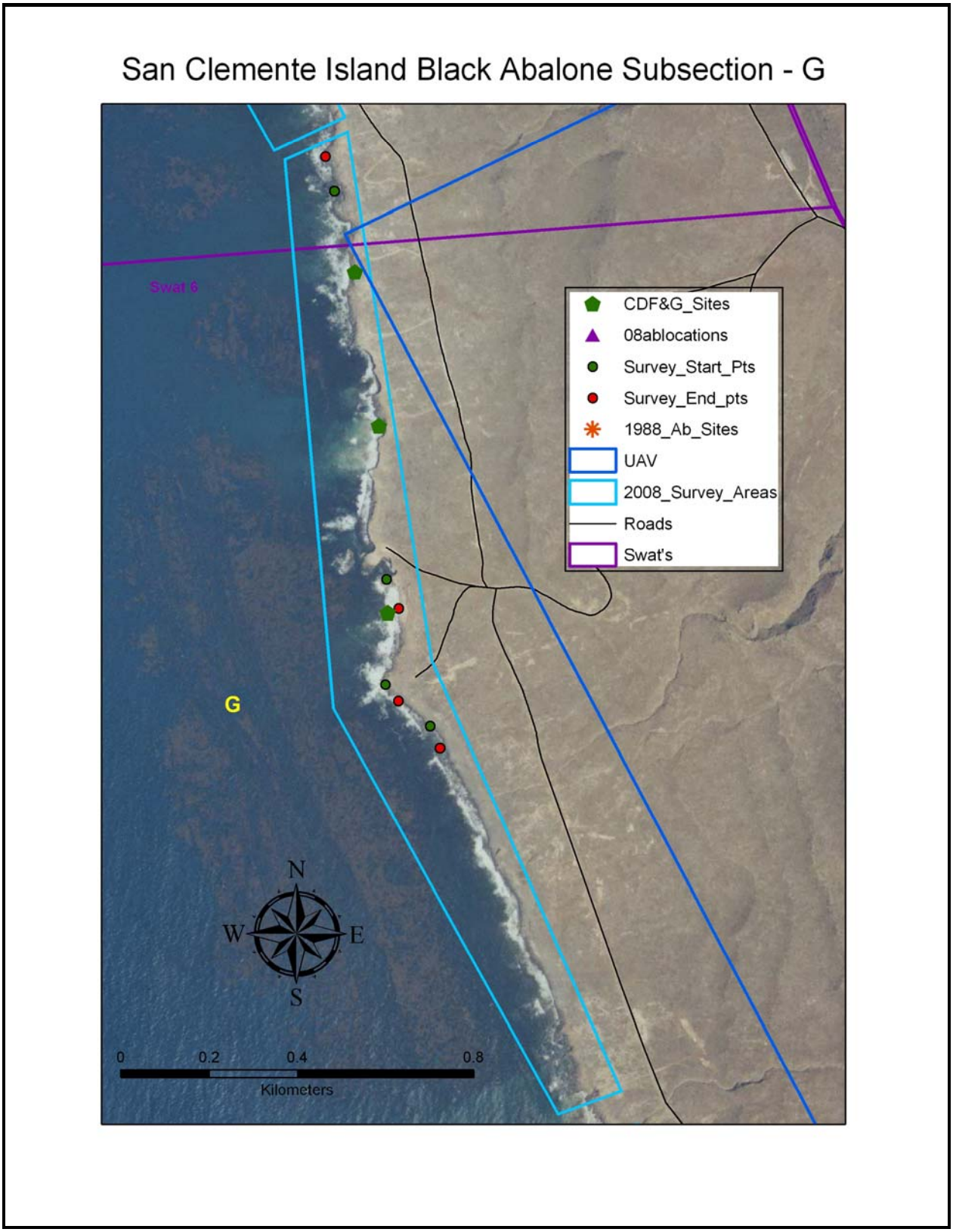



*Figure A-7. Subsection G survey starting and ending points with documented abalone locations.*

## *A.8 Subsection H – North of Eel Point to South of Seal Point, southern areas closed to access or cliff*

Subsection H was primarily high relief rocky headland surrounded by low lying cobble/boulder shoreline. The headland area was excellent abalone habitat with abundant vertical cracks and ledges creating extensive three dimensional habitats. Several headlands were isolated from the shoreline by deep surge channels and could not be surveyed. The upper intertidal (spray zone) contained abundant tidepools. Lower intertidal areas supported dense aggregations of mussels and Ochre Star's (*Pisaster ochraceus*) that were noticeably absent at most survey sites. Mid intertidal algae was sparse but lower intertidal turf reds were dense and diverse. Three live black abalone (100 mm, 105 mm, and 130 mm) were observed in H2, two in a single location within a shallow crack.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| J. Altstatt | H1 | 355633.243990 | 3643273.898270 | 355690.878046 | 3643249.161000 |
| J. Altstatt | H2 | 355401.996649 | 3643232.411670 | 355359.978464 | 3643273.403070 |
| J. Altstatt | H3 | 355554.692272 | 3643530.178030 | 355580.554028 | 3643590.793530 |
| J. Altstatt | H4 | 355585.834695 | 3643802.446960 | 355587.359698 | 3643737.622290 |

*Table A-8. Subsection H Observers and Transect locations in UTM's.*



*Photo A-8. Survey site H2 where abalone were found.*

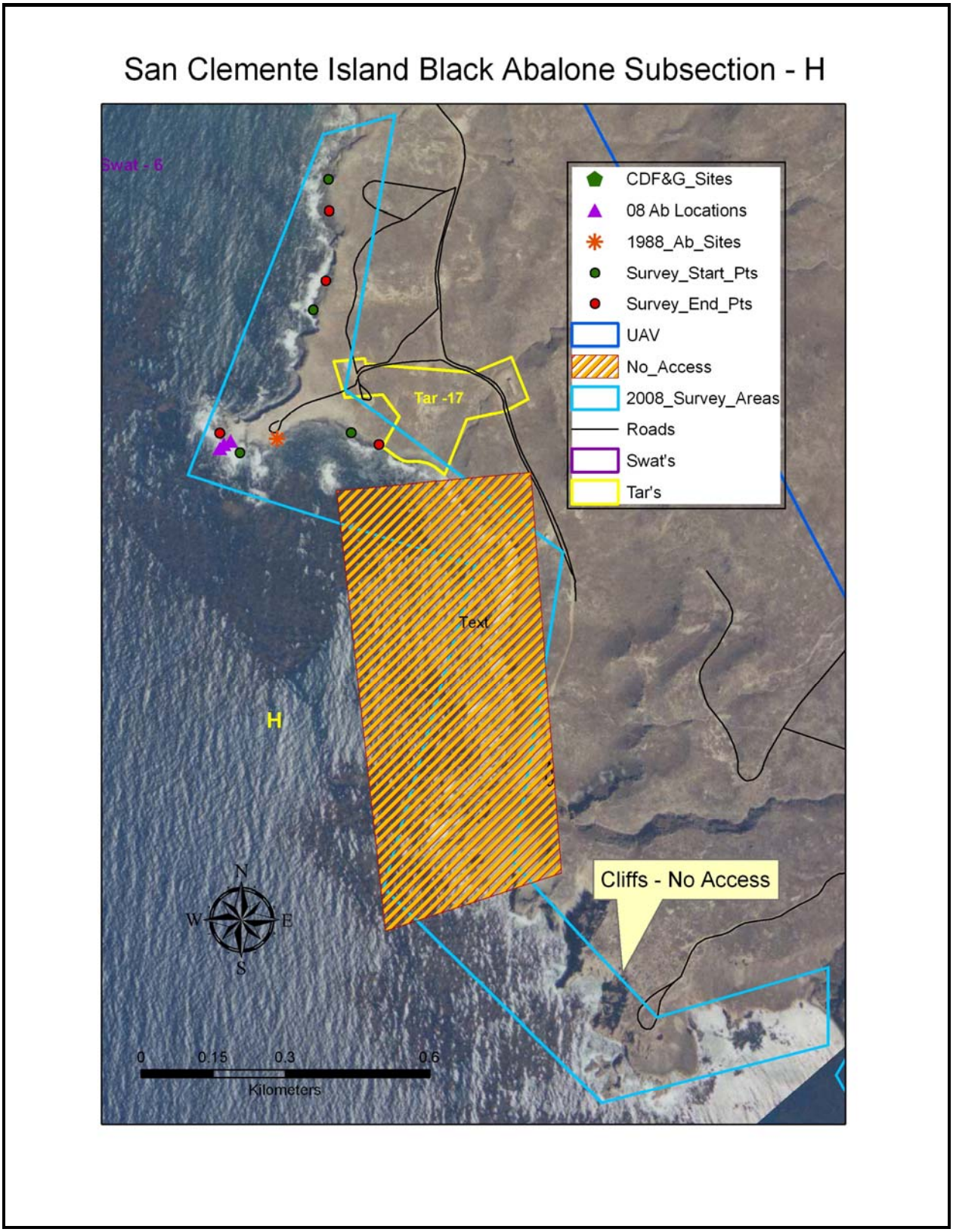



*Figure A-8. Subsection H survey starting and ending points with documented abalone locations.*

## *A.9 Subsection I – South of Seal Point to South of Wallrock Canyon*

Subsection I encompassed steep cliff areas near Seal Point, that contained high densities of California Sea Lions (*Zalophus californianus*), interspersed with rocky headlands and boulder/cobble beaches moving south. Primarily smooth high to mid relief rocky bench and boulder habitat this area was excellent abalone habitat. Upper intertidal areas were mostly bare boulder and cobble with evidence of physical movement. Substrate was mostly smooth, less than 2 meters height, but extremely rugose. Algal assemblages were dense in the lower zones with dense Surfgrass and various brown algae present. Red turf algae and articulated corallines were abundant and dominant in the mid/low tide areas. Middle to upper algal assemblages were patchy but robust. Old black abalone shells were abundant on coastal bluffs and several shells and pieces were found in the intertidal. No live black abalone were observed during any of the surveys.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D Lerma | I1 | 357102.279765 | 3641050.892520 | 357134.503675 | 3641014.938430 |
| D Lerma | I2 | 357420.595904 | 3640399.753000 | 357458.103654 | 3640421.407590 |
| D Lerma | I3 | 357582.086560 | 3640292.881130 | 357613.243185 | 3640218.425910 |

*Table A-9. Subsection I Observers and Transect locations in UTM's.*



*Photo A-9. Survey site I2.*

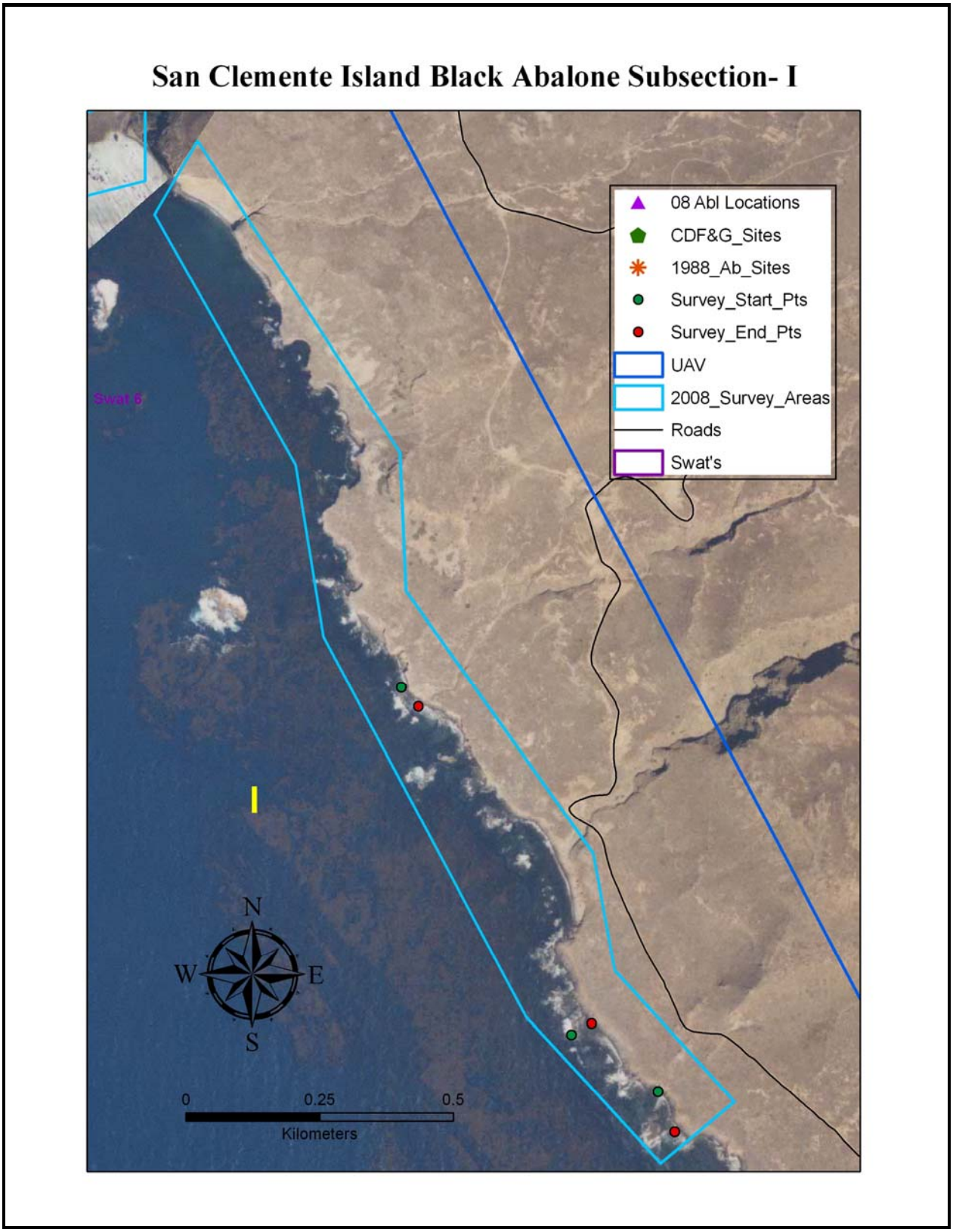



*Figure A-9. Subsection I survey starting and ending points with documented abalone locations.*

## *A.10 Subsection J – Mail Point to just south of Waymuck Canyon*

Subsection J was primarily mid to low relief rocky bench and boulder habitat that was of moderate quality as abalone habitat. Upper intertidal areas had a low sloping angle and were dominated by small boulders (< 1m radius). Substrate was mostly smooth with patchy acorn barnacles (*Balanus/Thamulas spp*.) and *Endocladia muricata* well represented in the high tide zone. Algal assemblages were dense in the middle and lower tides zones including various turf reds and articulated corallines. Old black abalone shells were common on coastal bluffs and several were found in the intertidal. Two live black abalone (120 and 124 mm) were observed at site J1. California Sea Loins were abundant at Mail Point precluding any sampling on the point itself. Areas south of Mail Point were either low relief exposed cobble beach occupied by California Sea Lions or steep cliff areas greatly reducing the potential area sampled within this subsection

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| I. Taniguchi | J1 | 357740.600572 | 3640075.607470 | 357769.515436 | 3640030.874450 |
| I. Taniguchi | J2 | 357970.204639 | 3639907.537330 | 357907.057567 | 3639960.235450 |

*Table A-10. Subsection J Observers and Transect locations in UTM's.*



*Photo A-10. Survey site J1 were two abalone were observed.*

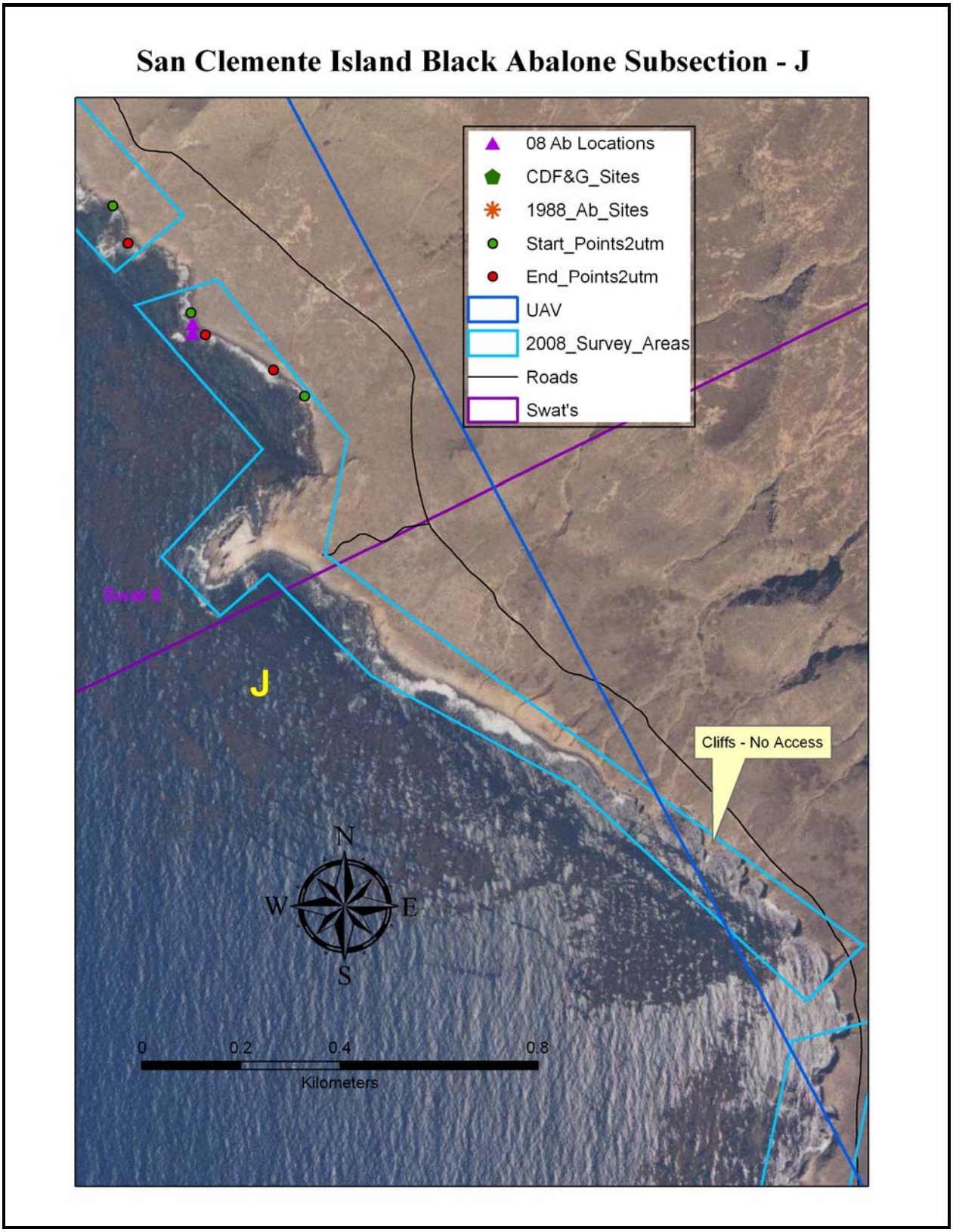



*Figure A-10. Subsection J survey starting and ending points with documented abalone locations.*

## *A.11 Subsection K – Waymuck Canyon to north of Lost Point*

Subsection K was primarily high to mid relief smooth rocky headland habitat that was of excellent quality as abalone habitat. Northern areas were inaccessible cliff and the southern areas dominated by cobble/boulder shoreline. Headlands extended well away from the coastal bluff and provided the upper intertidal protection from wave action. Invertebrate and algal assemblages were diverse and abundant. The mid intertidal zones contained dense sections of rockweed (*Silvetia compressa*) and turf reds. Algal assemblages were dense in the lower zones with deep irregular tide pools common throughout both sites. Old black abalone shells were abundant on coastal bluffs and several were noted in the intertidal. No live black abalone were observed during any of the surveys. An old ship wreck was observed on the headland at site K2. Additional surveys could be performed within this subsection in the future.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| M. Moss | K1 | 358963.553965 | 3638155.985030 | 358931.722419 | 3638115.740810 |
| M. Moss | K2 | 359077.695837 | 3637569.641760 | 359058.792408 | 3637511.426890 |

*Table A-11. Subsection K Observers and Transect locations in UTM's*



*Photo A-11. Survey site K2.*

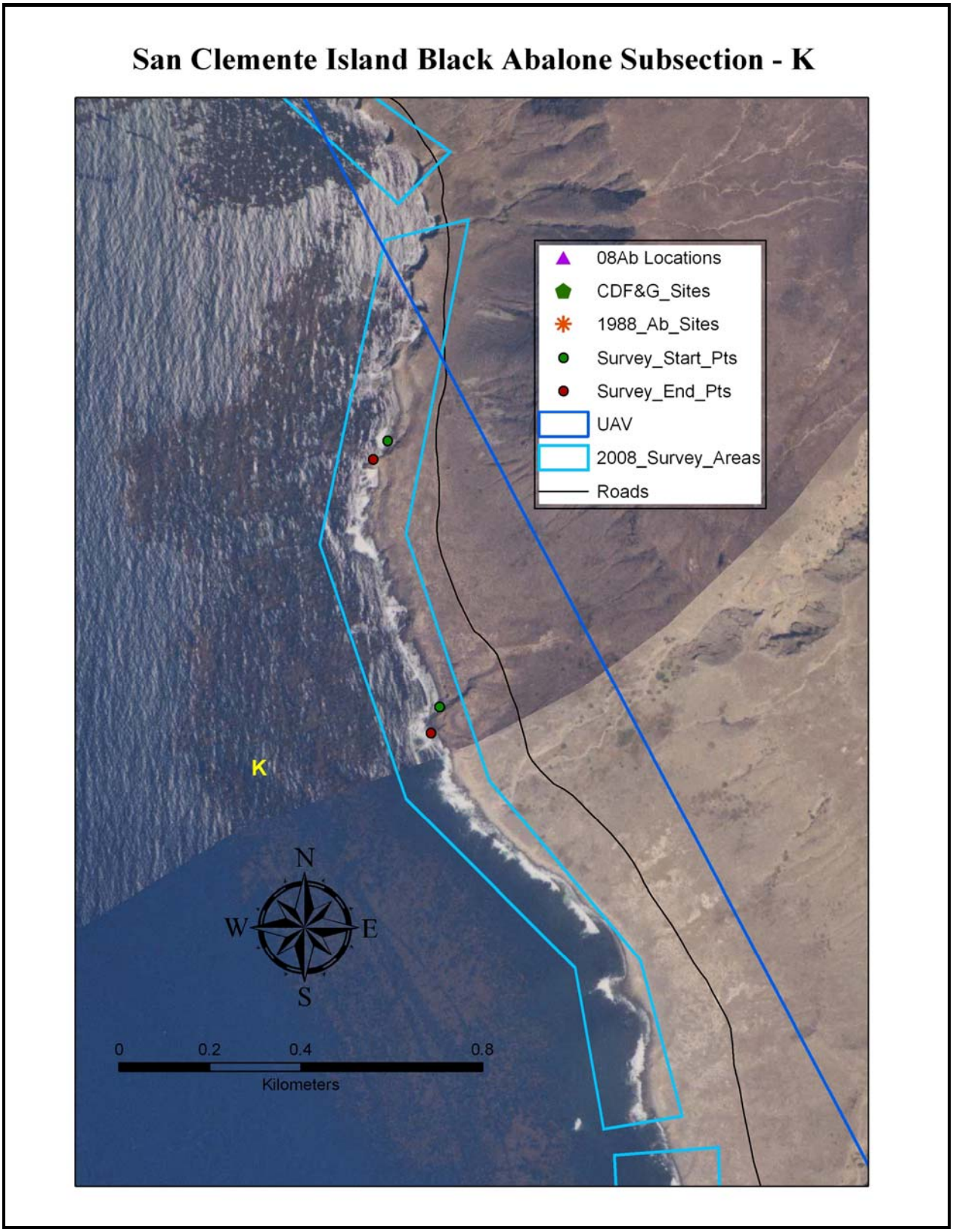



*Figure A-11. Subsection K survey starting and ending points with documented abalone locations.*

## *A.12 Subsection L – Lost Point*

Subsection L was primarily smooth high relief rocky headlands divided by deep surge channels and coved boulders. The quality of abalone habitat was excellent throughout the subsection with abundant vertical cracks and ledges and invertebrate and algal assemblages were diverse and robust. Upper intertidal areas contained patchy distributions of barnacles, limpets, and various snails. Zones were compressed in several areas from the relatively steep slope of the intertidal. Algal assemblages were dense in the lower zones with surge channels common perpendicular to shore. Surfgrass formed dense mats in lower tidal areas and tidepools were notably large and contained moderate densities of lobster and sea urchins. Old black abalone shells were abundant in midden sites adjacent to survey sites. One live black abalone was observed (130 mm) at site L2.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| J. Altstatt | L1 | 359614.351425 | 3636485.166820 | 359625.005373 | 3636425.884030 |
| J. Altstatt | L2 | 359587.131677 | 3635956.188220 | 359595.212678 | 3635903.247270 |
| J. Altstatt | L3 | 359999.066909 | 3635791.498940 | 360054.563984 | 3635793.134760 |
| M. Moss | L10 | 360656.918468 | 3635030.536580 | 360621.385244 | 3635053.216570 |

*Table A-12. Subsection L Observers and Transect locations in UTM's*



*Photo A-12. Survey site L2 were one black abalone was found.*

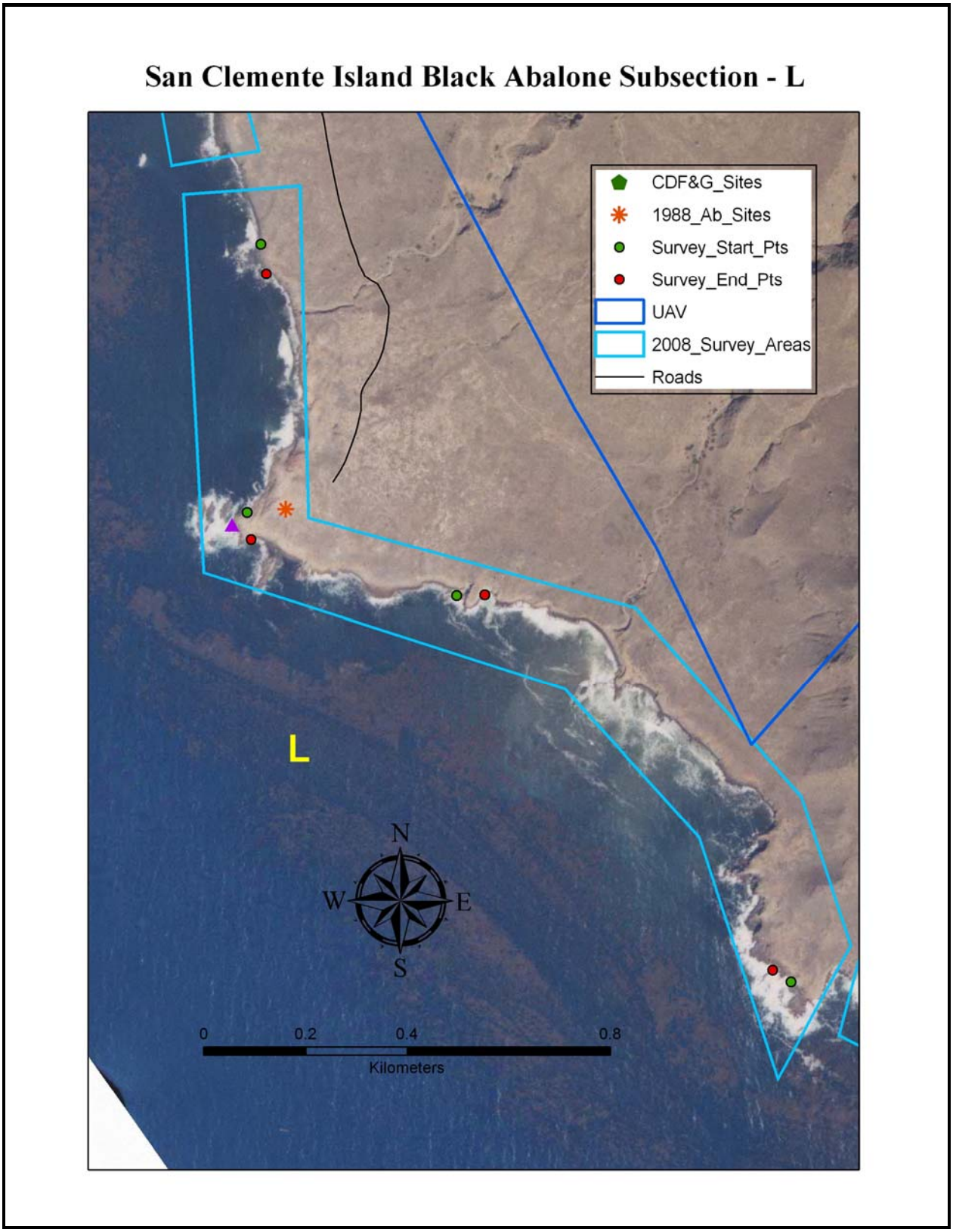



*Figure A-12. Subsection L survey starting and ending points with documented abalone locations.*

## *A.13 Subsection M – SHOBA Boundary south to theHeadland between Chukit Canyon and Cave Canyon*

Subsection L was primarily steeply sloped rough rugose high relief rocky headlands divided by deep surge channels and coved boulders. The quality of abalone habitat was moderate throughout the subsection with zonation compressed and difficult to divide. Upper intertidal areas consisted of primarily spray zone invertebrates such as limpets and barnacles. Algal assemblages were dense in the lower zones with large tide pools common. Brown macro algae including *Cystoseira osmundacea* and *Egregia menziesii* was abundant in the lower intertidal and surfgrass was physically damaged. Mid to low turf red algae were dense and diverse creating nearly continuous coverage over relatively large sections of the intertidal. Old black abalone shells were abundant in midden sites along the coastal bluff and no shells were observed within sites. No live black abalone were observed during any of the surveys.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| I. Taniguchi | M1 | 361206.985542 | 3634871.204280 | 361121.306576 | 3634876.178110 |
| I. Taniguchi | M2 | 361714.667381 | 3634692.202630 | 361793.990892 | 3634674.459150 |
| M. Moss | M10 | 361114.054024 | 3634939.956450 | 361138.278481 | 3634864.850210 |

*Table A-13. Subsection M Observers and Transect locations in UTM's*



*Photo A-13. Survey site M2.*

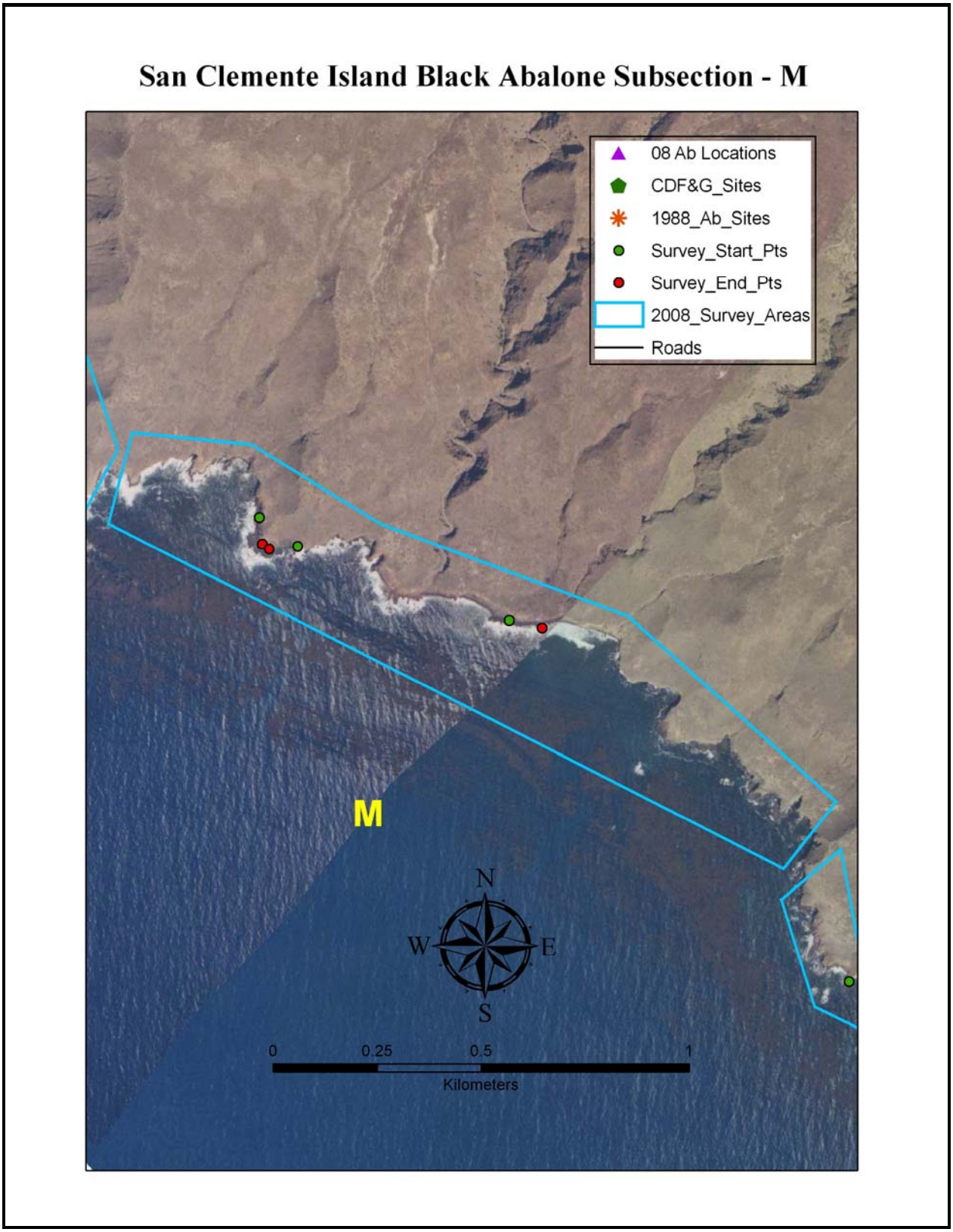



*Figure A-13. Subsection M survey starting and ending points with documented abalone locations.*

## *A.14 Subsection N – North of SHOBA Impact Area 2 to the headland north of Cave Canyon*

Subsection N was mixture of habitat from mid to high relief rough rocky bench to low lying smooth boulder habitat. The majority of the abalone habitat within this subsection was of moderate quality. Upper intertidal areas were mostly barren and varied from high splash zone to smooth movable boulders. The mid intertidal zones were exaggerated from a low sloping angle and most areas were dominated by articulated corallines and turf red algae. Lower intertidal areas consisted of primarily boulders and rocky bench with abundant surfgrass covering the majority of hard substrate. Algal assemblages were dense in the mid to lower zones with surge channels common perpendicular to shore. Old black abalone shells were common on coastal bluffs and two were found in the intertidal. No live black abalone were observed during any of the surveys.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D Lerma | N1 | 362531.627146 | 3633822.484670 | 362587.200365 | 3633820.608670 |
| D Lerma | N2 | 363507.797067 | 3633136.954850 | 363566.593049 | 3633102.875710 |
| J. Altstatt | N11 | 363347.606586 | 3633401.650990 | 363349.520605 | 3633316.569470 |

*Table A-14. Subsection N Observers and Transect locations in UTM's*



*Photo A-14. Survey site N1.*

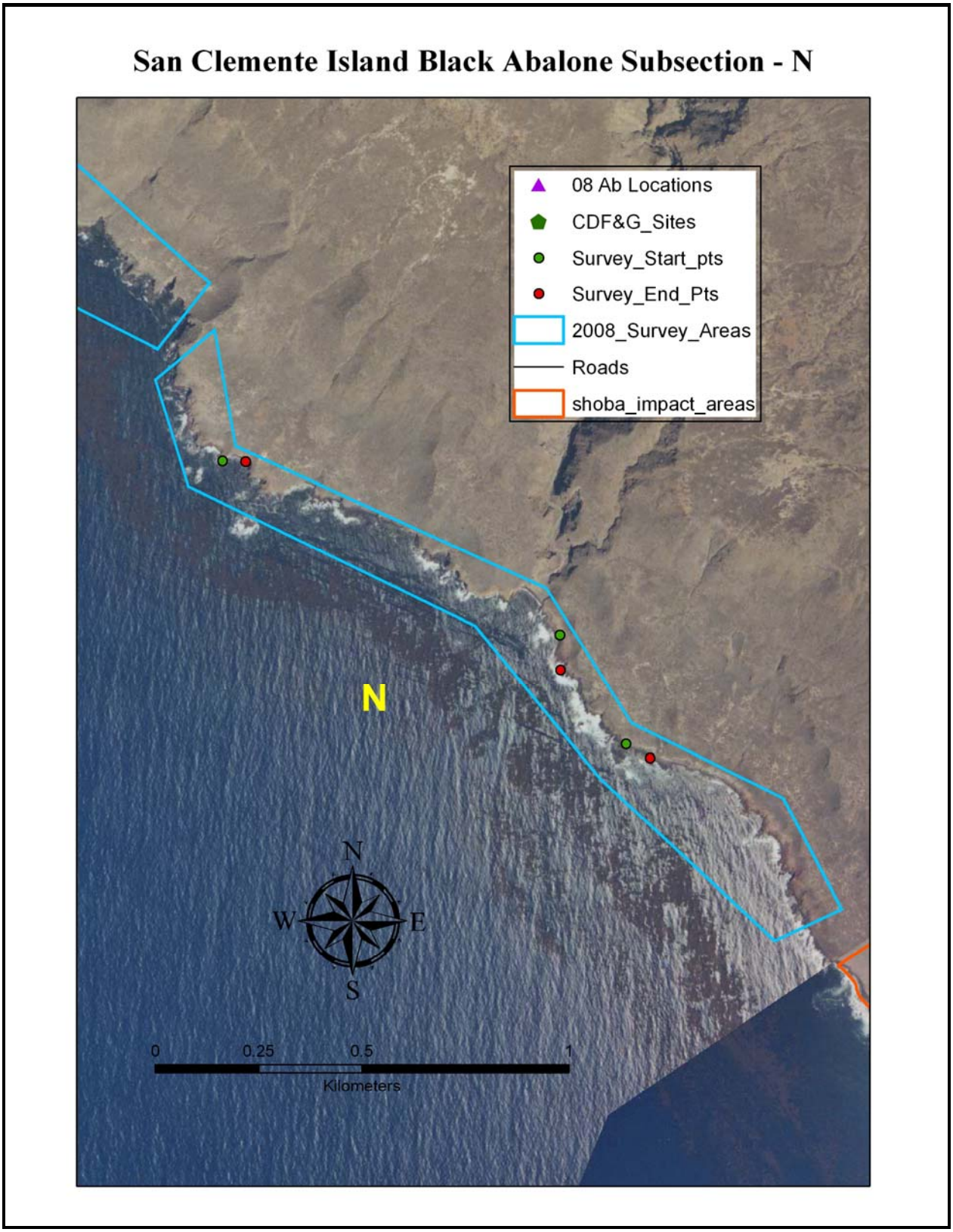



*Figure A-14. Subsection N survey starting and ending points with documented abalone locations.*

## *A.15 Subsection O – South tip of China Point north to boundary of Impact Area 2*

Subsection O was a mixture of high relief rough rocky headland and mid to low relief smooth rocky bench that was of excellent quality as abalone habitat. Upper intertidal areas were mostly barren with low densities of indicator species. Mid intertidal zones were exaggerated from a low sloping angle and supported dense assemblages of articulated corallines, rockweed, and turf red algae. Algal assemblages were dense in the lower zones with surfgrass abundant and healthy, surge channels were abundant perpendicular to shore. Old black abalone shells were common on coastal bluffs and several were found in the intertidal. No live black abalone were observed during any of the surveys but two green abalone (*Haliotis fulgens*) were observed at site O1 under a ledge.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| J. Altstatt | O1 | 366103.438757 | 3630419.785840 | 366159.020618 | 3630485.568980 |
| J. Altstatt | O2 | 366166.052998 | 3630487.118000 | 366246.430336 | 3630488.046990 |
| M. Moss | O10 | 366464.360001 | 3630106.518330 | 366422.637348 | 3630130.816330 |
| M. Moss | O11 | 366483.921060 | 3630219.477250 | 366520.603105 | 3630257.707840 |
| D Lerma | O5 | 366248.084865 | 3630728.325920 | 366238.598081 | 3630670.790660 |

*Table A-15. Subsection O Observers and Transect locations in UTM's*



*Photo A-15. Survey sites O1 and O2 looking east.*

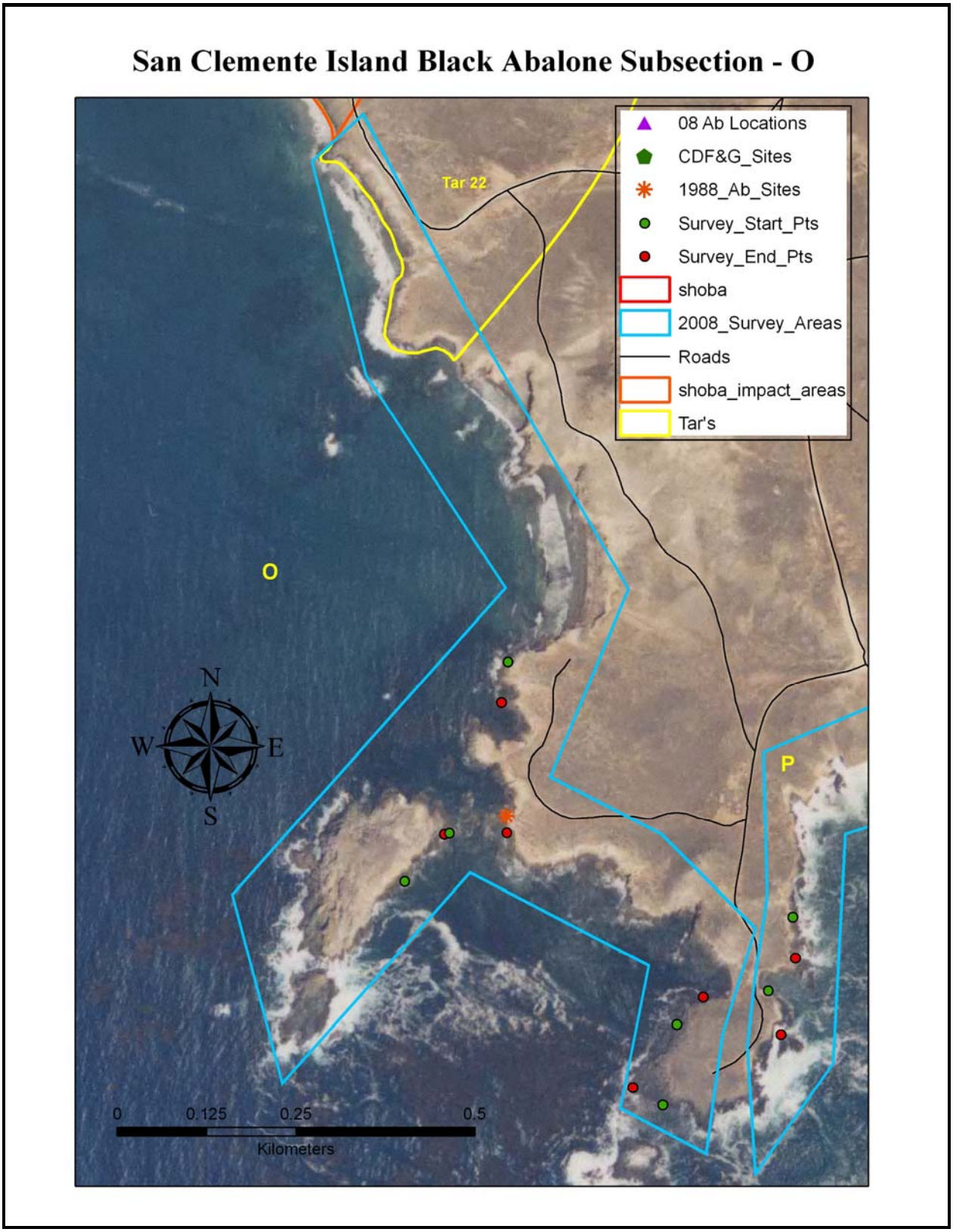



*Figure A-15. Subsection O survey starting and ending points with documented abalone locations.*

## *A.16 Subsection P – China Point east to Horse Beach Cove*

Subsection P was primarily mid to high (1 to 4 m) relief rocky bench and headland habitat that was of good quality as abalone habitat. Steep cliffs lined most of the shore line isolating the quality intertidal areas to headlands protruding out away from shore. Upper intertidal areas contained moderate densities of indicator species but mid tide algae assemblages were abundant and robust. Low tide areas were dominated by dense surfgrass and diverse brown macro algae. Substrate was mostly rough and extremely rugose. Large tide pools were common and lobster were noted frequently Old black abalone shells were common on coastal bluffs and three found in the intertidal. No live black abalone were observed during any of the surveys.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D Lerma | P1 | 367126.498208 | 3630699.862020 | 367151.049999 | 3630763.849140 |
| I. Taniguchi | P10 | 366645.945946 | 3630369.991870 | 366649.855592 | 3630312.608580 |
| I. Taniguchi | P11 | 366611.778580 | 3630266.880000 | 366629.684251 | 3630205.648730 |

*Table A-16. Subsection P Observers and Transect locations in UTM's*

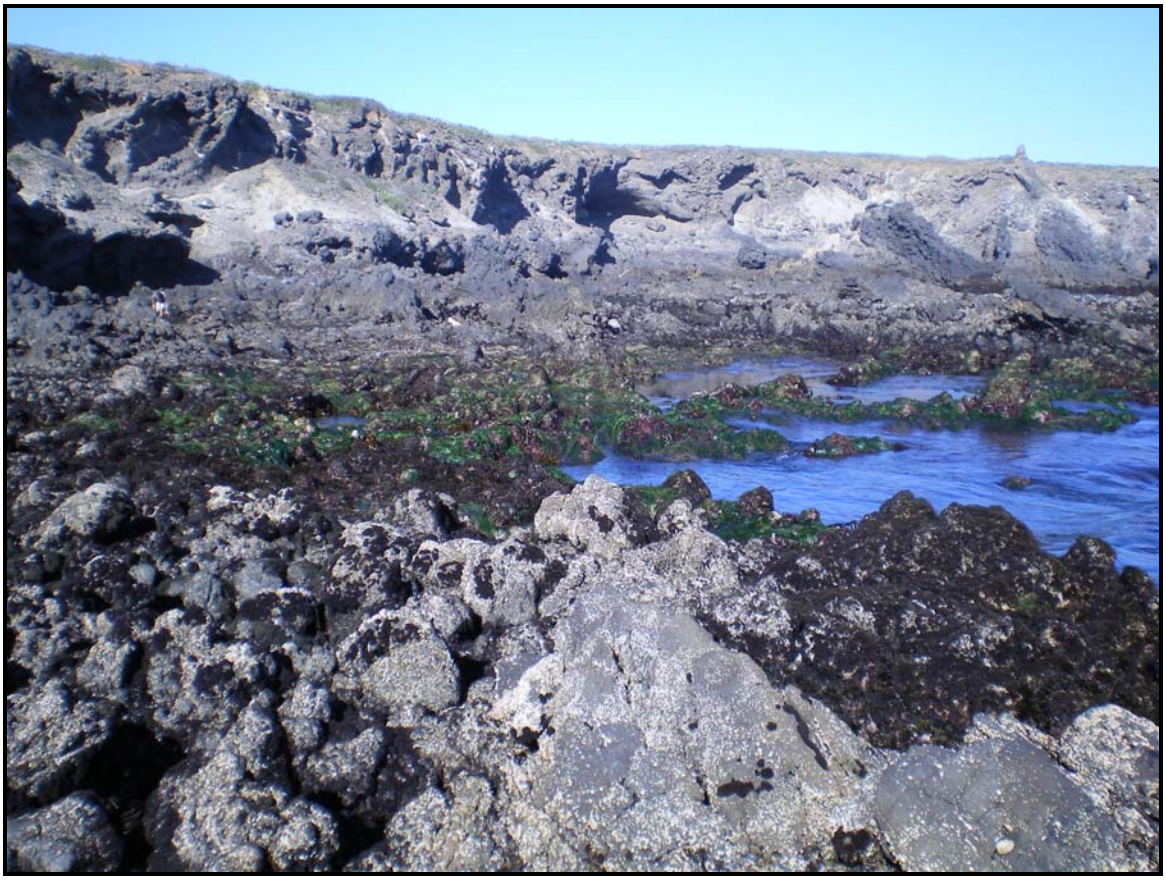


*Photo A-16. Survey site P1 looking east.*

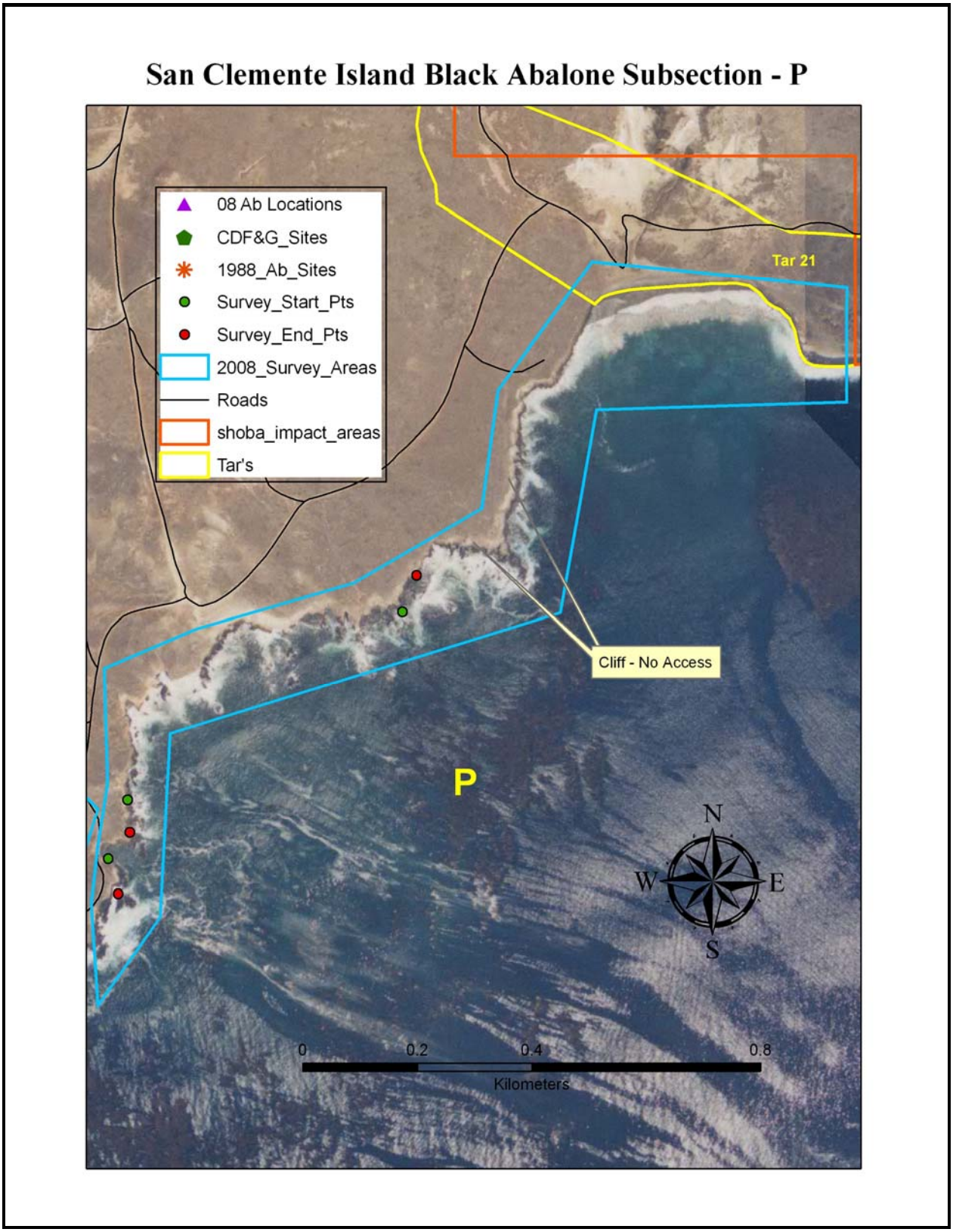



*Figure A-16. Subsection P survey starting and ending points with documented abalone locations.*

## *A.17 Subsection Q – Pyramid Cove*

Subsection Q was primarily mid relief rocky bench bisected perpendicular to shore by deep surge channels. The rock was rough and rugose made up of a mixture of volcanic basalt and conglomerate. This subsection was of moderate quality as abalone habitat. Intertidal zones were broad and zonation of indicator species was inconsistent moving shoreward. The mid and low intertidal zones were exaggerated from a low sloping angle. Substrate was mostly less than 2 meters height, but expansive. Algal assemblages were dense in the lower zones with surge channels common perpendicular to shore. Surfgrass dominated the lower intertidal and very little movable rock was present. Several different species of abalone shells were observed but all the black abalone shells were old and in fragments. No live black abalone were observed during any of the surveys but one green abalone was observed in site Q1.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| J. Altstatt | Q1 | 371551.361326 | 3632217.458950 | 371631.039879 | 3632218.195410 |
| J. Altstatt | Q2 | 371530.965894 | 3632258.032820 | 371508.965918 | 3632334.525200 |
| M. Moss | Q10 | 371957.041307 | 3632188.453080 | 371863.104802 | 3632179.734730 |
| M. Moss | Q11 | 372394.505371 | 3632192.290560 | 372296.030126 | 3632203.466340 |

*Table A-17. Subsection Q Observers and Transect locations in UTM's*



*Photo A-17. Survey site Q1 looking southwest.*

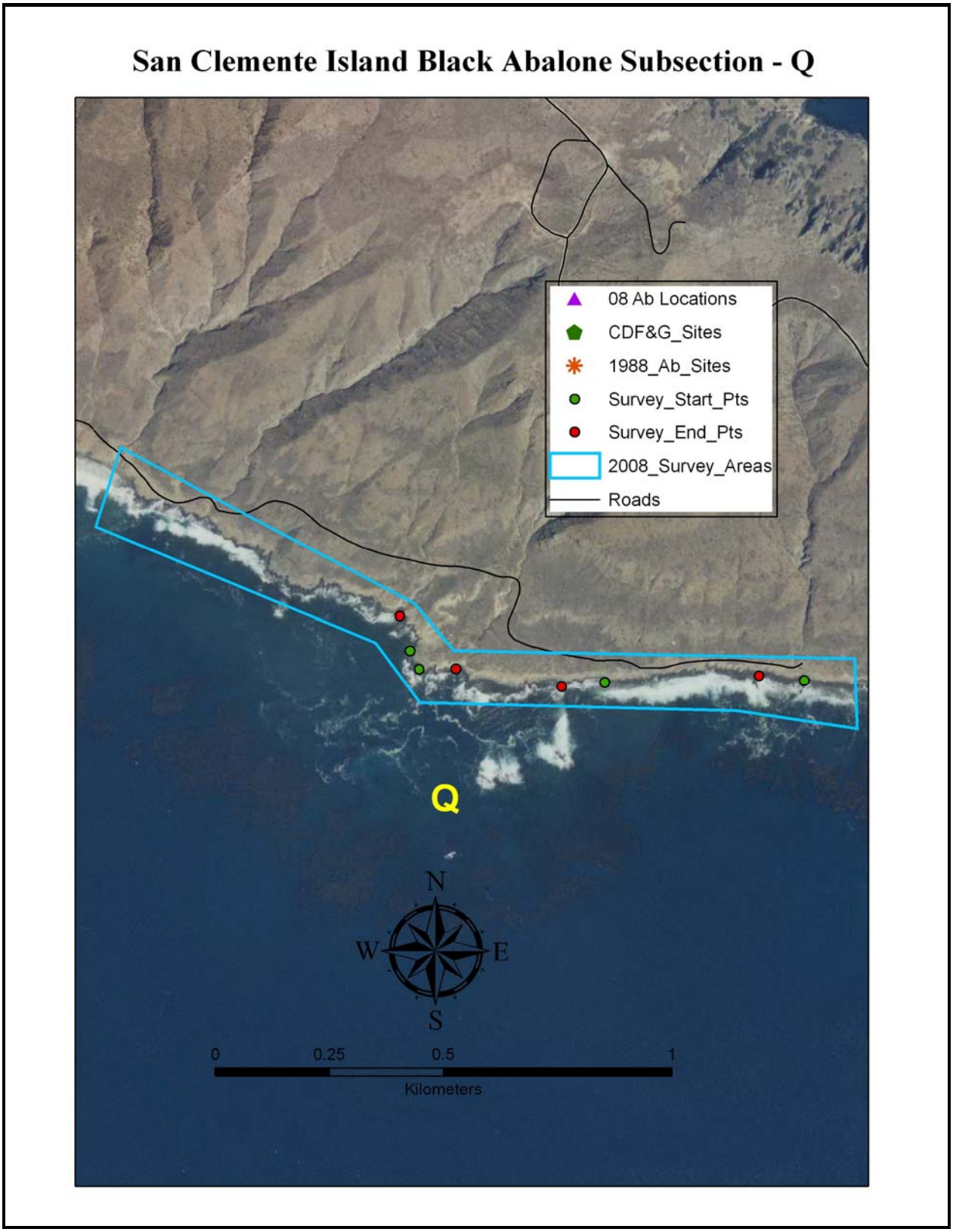



*Figure A-17. Subsection Q survey starting and ending points with documented abalone locations.*

## *A.18 Subsection R – Pyramid Head*

Subsection R was primarily mid to low relief rocky bench habitat that was of moderate quality as abalone habitat. All the survey sites within this subsection contained relief less than 2 m height and abruptly ended at the lower end in deep surge channels parallel to shore. Upper intertidal areas contained low densities of indicator species with mid and lower intertidal zones containing the highest diversity and density of biological assemblages. Substrate was rough and rugose with articulated coralline and red turf algae dominating most of the sites. Lower intertidal zones were lush and expansive containing dense mats of surf grass and various brown macro algae. Purple urchins (*Strongylocentrotus purpuratus*), shore crabs (*Pachygrapsus crassipes*), and several worm species were abundant in tide pools and protected areas. Old black abalone shells were abundant at site access points and a few were found in the intertidal. No live black abalone were observed during any of the surveys. Several green and pink abalone shells of varying age were observed throughout this subsection.

| Biologist | Site | Start Long | Start Lat | End Long | End Lat |
|---|---|---|---|---|---|
| D Lerma | R1 | 373579.756729 | 3632003.323030 | 373556.029783 | 3632051.640640 |
| D Lerma | R2 | 373242.644635 | 3631876.344840 | 373315.404910 | 3631906.128940 |
| I. Taniguchi | R10 | 373095.352946 | 3631832.103460 | 373034.523405 | 3631834.658020 |
| I. Taniguchi | R11 | 372976.923651 | 3631964.803660 | 372919.279717 | 3631974.747570 |

*Table A-18. Subsection R Observers and Transect locations in UTM's*



*Photo A-18. Survey site R2*

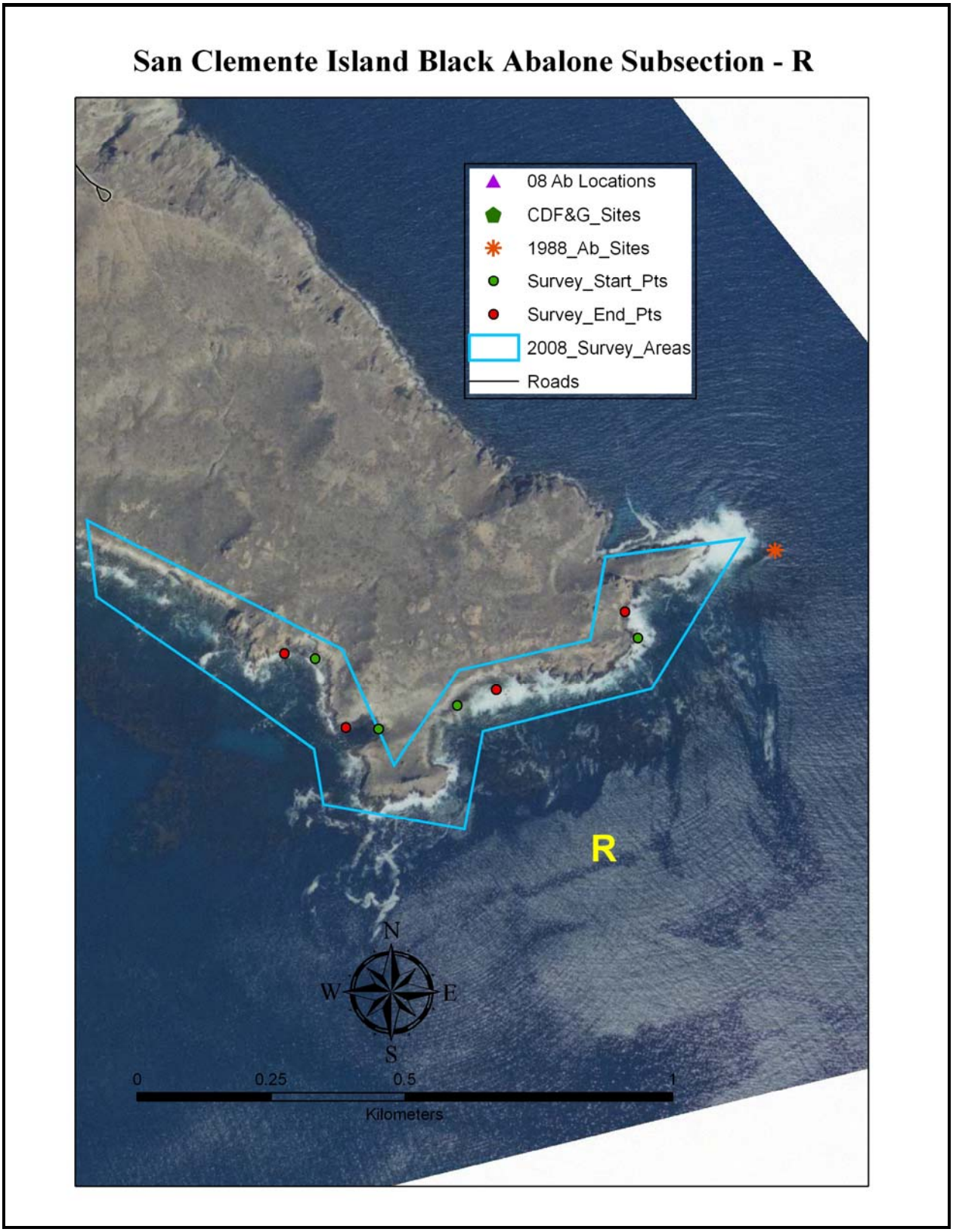



*Figure A-18. Subsection R survey starting and ending points with documented abalone locations.*

## *A.19 Subsection S- Wilson Cove south to restricted access area*

Subsection S was not surveyed during this investigation do to the lack of time and resources and the low probability of black abalone being present. This subsection contains only a narrow band of intertidal made up of large boulders that slope steeply into the subtidal. Zonation indicator species are compressed throughout this area and individual rocks can display the full range of tidal movement. Previous documentation of black abalone by surveys conducted by Los Angeles County in 1988 (Jack Engle, pers. comm.) described this habitat as marginal and documented black abalone as present but in relatively low numbers. Future investigations should attribute some effort to this area to confirm the population status documented throughout other available habitat on San Clemente Island.

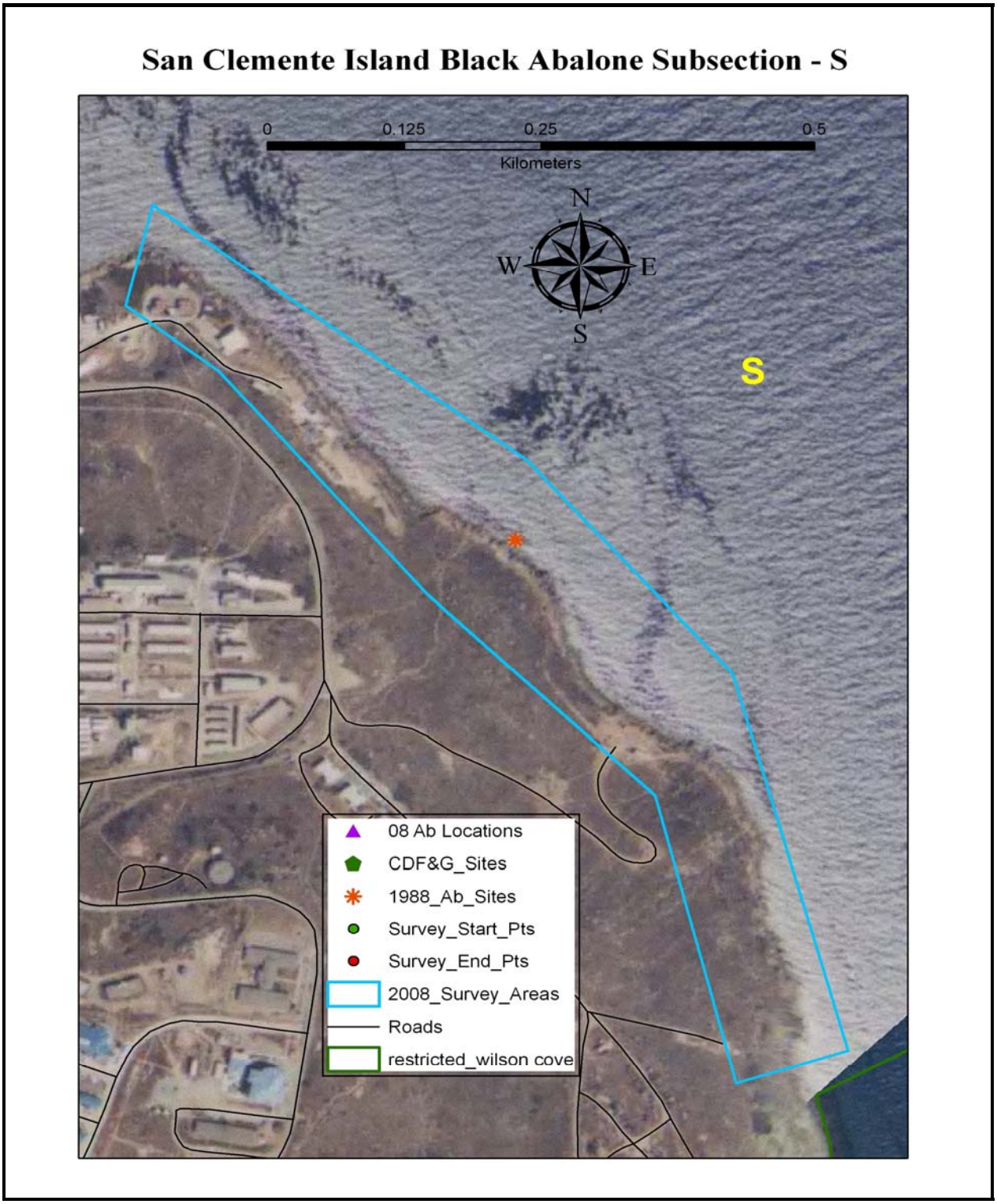



*Figure A-19. Subsection S survey area and associated abalone sites.*