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Translocation Manual as part of an emergency response for the Federally Endangered Black Abalone (*Haliotis cracherodii)*

Oblique aerial photograph of the Mud Creek Landslide taken May 20, 2017 and provided by Jonathan Warrick (U.S. Geological Survey (USGS)).

Black abalone found in critical habitat just north of the Mud Creek Landslide. Photo taken by Christy Bell (UCSC) on July 24, 2017.

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Qualifications and Requirements

In order to work with species listed as endangered under the federal Endangered Species Act (ESA) studies must be permitted by the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service (NMFS). In the case of the federally endangered black abalone, permits from the National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife (CDFW) are required. Federal permits can take up to one year to obtain and CDFW permits can take several months even under emergency situations. Therefore, for emergency situations researchers should already have permits in place to work with the endangered species at risk. Special consultations with the permitting agencies regarding the nature of the work and the emergency are required. In addition, in order to collect, hold and/or transport endangered species, existing permits will need to be amended and Letters of Authorizations (LOA's) will need to be obtained.

Introduction and Background

In May 2017, a massive landslide occurred at Mud Creek in Big Sur, California that buried approximately 1500 meters of designated critical habitat for the black abalone (*Haliotis cracherodii*), which was listed in 2009 as endangered under the Endangered Species Act (ESA). At the time of the landslide, there were no historical data describing the abundance and distribution of black abalone at this location, due to its remoteness and difficult access. Through consultation with Monterey Bay National Marine Sanctuary (MBNMS) and National Marine Fisheries Service (NMFS) staff members, it was determined that surveys should be conducted to identify the locations of black abalone (if present) and the quality of black abalone habitat.

In July 2017, once it was determined to be safe to access the intertidal habitat potentially impacted by the slide, a team of black abalone experts conducted surveys and found a large and healthy population of black abalone as well as some good quality habitat. Unfortunately, it was also determined that a large stretch of coastline directly adjacent to the slide (especially to the south, but also to the north) had already been impacted by sediment, and would likely continue to be impacted by sediment movement. For the next several months, biologists on site captured weekly photographs of the toe of the slide as well as stretches of coastline to the north and south, and shared updates on sediment movement with black abalone experts and resource agency staff.

By October 2017, it became clear that the large and healthy population of black abalone (primarily north of the slide) was in imminent danger of burial by ongoing influx of sediment eroded from the toe of the slide. This document describes, in a general way, the steps taken to rescue some of these black abalone.

Objective

To create a document that could be used for future emergencies - both natural (such as landslides) and anthropogenic (such as oil spills) - that may potentially impact black abalone or their habitat. At the time of the Mud Creek Landslide, no such document existed, and it had been many years since black abalone translocations had occurred. This document is intended as a guide and reference for future emergency responses.

Methods/Steps for responding to an emergency that threatens black abalone or their habitat

1. Gather historical data and aerial images
2. Assess the area impacted or potentially impacted
3. Assess the physical threat to black abalone
4. Weigh the risks of moving vs leaving animals in place
5. Options for moving abalone
6. Moving Black Abalone
7. Mobilizing a team of experts
8. Rescue/Collection of black abalone
9. Transport and holding of black abalone
10. Translocation of black abalone
11. Follow up

Step 1: Gather historical data and aerial images

In the event of an emergency, it is important to determine if any historical data on black abalone presence or the quality of critical habitat exist for the impacted area. It is also useful to locate any aerial images of the impacted area. Images available on Google Earth (https://www.google.com/earth/) and California Coastal Records Project (https://www.californiacoastline.org/) have been used to plan surveys. During the Mud Creek Landslide, recent aerial images taken by USGS were also obtained (Figures 1-2).

Figure 1. Oblique aerial photographs of the Mud Creek Landslide provided by Jonathan Warrick (U.S. Geological Society). Photographs were taken on May 27, 2017 (left) and January 29, 2018 (right).

Figure 2. Oblique aerial photographs (stitched together by UCSC using SpinPanorama) of the Mud Creek Landslide taken June 27, 2017 and provided by Jonathan Warrick (U.S. Geological Survey).

It is helpful to employ Google Earth to mark areas that have been surveyed previously (if they exist) and to map out the impacted area as well as the footprint of the area of potential impact in preparation for on-the-ground surveys. If possible, it is also useful to use an Unmanned Aerial Vehicle (UAV) as soon as possible (permits can and must be obtained to fly a UAV) after the emergency event to collect aerial images of the impacted area (Figure 3), especially if it can be done at or near low tide when abalone habitat is exposed (not all images on Google Earth or California Coastal Records are taken at low tide). In addition, the UAV can quickly and easily capture images of the adjacent areas that have not been impacted, but that have the potential to be impacted by the event, as well as a buffer of where no impact is expected. This will provide additional baseline information and assist the team in planning their assessment surveys, as well as any future surveys. If the threat changes, these UAV surveys can be repeated to inform the appropriate response and serve as a good visual record of any changes. Any aerial imagery is valuable, but UAV can be far superior to plane and satellite imagery during low-

ceiling weather periods and can provide high resolution data; plane and satellite imagery can be compromised by low marine layers and may be too coarse to be of use.

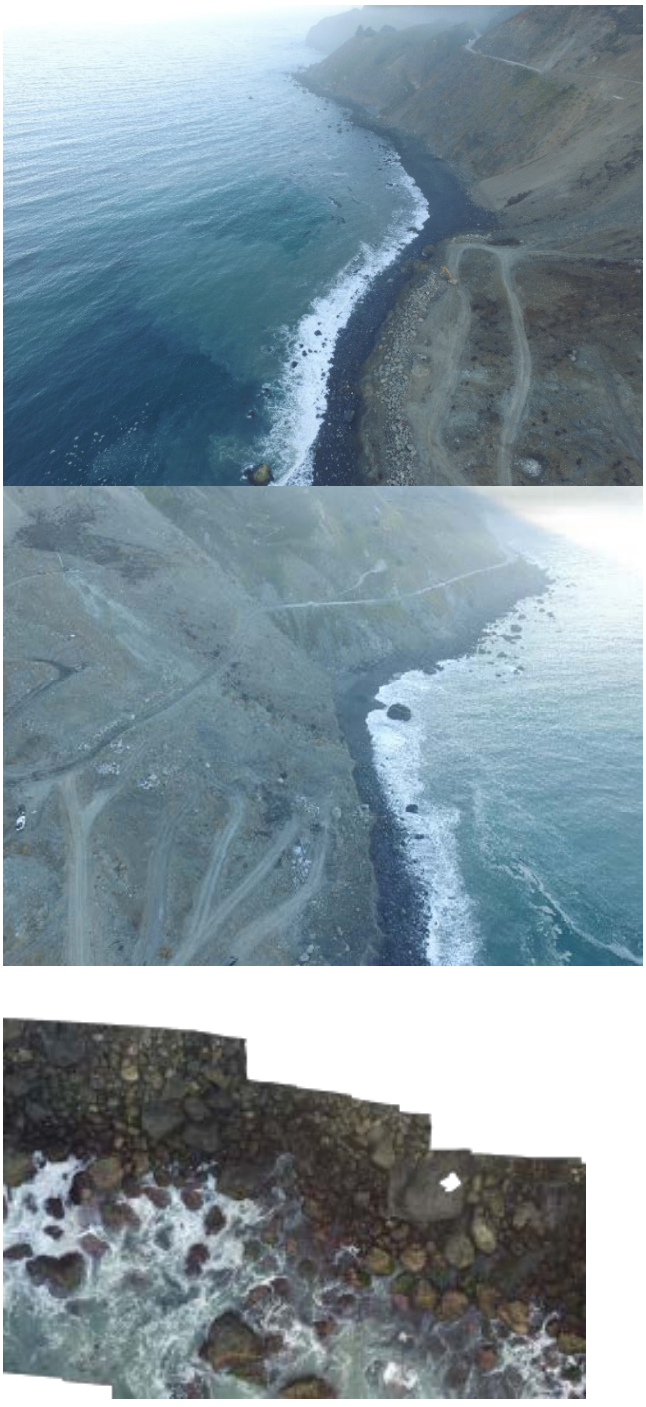

Figure 3. UAV images. Top: north (high altitude image), Middle: south (high altitude image) and Bottom: stitched section from lower altitude images) of the Mud Creek landslide taken on July 11, 2017 by Patrick Robinson (UCSC).

Step 2: Assess the area impacted or potentially impacted

As soon as it is safe to do so, a team of black abalone experts should be mobilized to conduct population surveys to assess the current status of black abalone and characterize the quality of black abalone habitat (Appendix II: 2A, for specific survey methods). These data may be the first data ever recorded for an area, as was the case for the Mud Creek Landslide, or they may be used to compare to previously collected data. If historic data exist, a resurvey of the same areas should be done so direct comparisons can be made. In either case, the surveys should be extensive enough to cover any areas impacted or having the potential to be impacted by the emergency event. Both live and dead black abalone should be recorded.

In addition to on-the-ground surveys, it is recommended that aerial images are taken (permits must be obtained to fly a UAV) both upcoast and downcoast of an impact zone. Experts can use the aerial images to assess the area prior to doing field surveys. Aerial images can also be used to photographically document changes to the area if the impact expands beyond the initial footprint.

If conditions change, black abalone may need to be rescued/moved. During the population surveys, researchers should determine the number of black abalone threatened by the impact and the percentage of those that can be feasibly and safely removed. Many of the black abalone near the Mud Creek Landslide were in deep cracks or under boulders that were impossible to reach. This information will be needed when amending permits and coordinating with potential holding facilities, if the need arises.

Step 3: Assess the physical threat to black abalone

During the assessment surveys, it is important to assess the current threat and the potential threat of the impact to black abalone. Determine the current extent of the threat and its potential to expand. This information is essential for planning ahead and creating a contingency plan.

Begin discussions to amend permits and discuss the authorizations needed to rescue and relocate black abalone, if the footprint of the threat expands. Permit amendments require time to process, even in the case of emergencies. For example, the California Department of Fish and Wildlife (CDFW) permit process can take several weeks, even under an emergency situation. Other permits and authorizations will have different timelines. This could delay a rescue effort if one is called for, and potentially result in the loss of black abalone while permits are amended. In addition, gather the necessary supplies to be prepared for rescue and translocation efforts, if needed.

In the case of the Mud Creek Landslide, biological surveillors photographed the beach upcoast and downcoast of the slide and sent weekly updates to a team of black abalone experts. Photographs were taken from above and at beach level as close to low tide as possible but were often constrained by daylight and sometimes heavy fog. The footprint of intertidal

sediment expanded both upcoast and downcoast from the toe of the slide, largely due to the summer south swell that pushed sediment into critical habitat and began to bury a large and healthy population of black abalone, which had been documented during the initial assessment surveys (Figures 4-5). It became clear that a decision had to be made to reduce further loss of black abalone.

Figure 4. Shows the increase of sediment and burial of black abalone critical habitat. Top photo taken by Christy Bell (UCSC); bottom photo taken by Steve Lonhart (MBNMS).

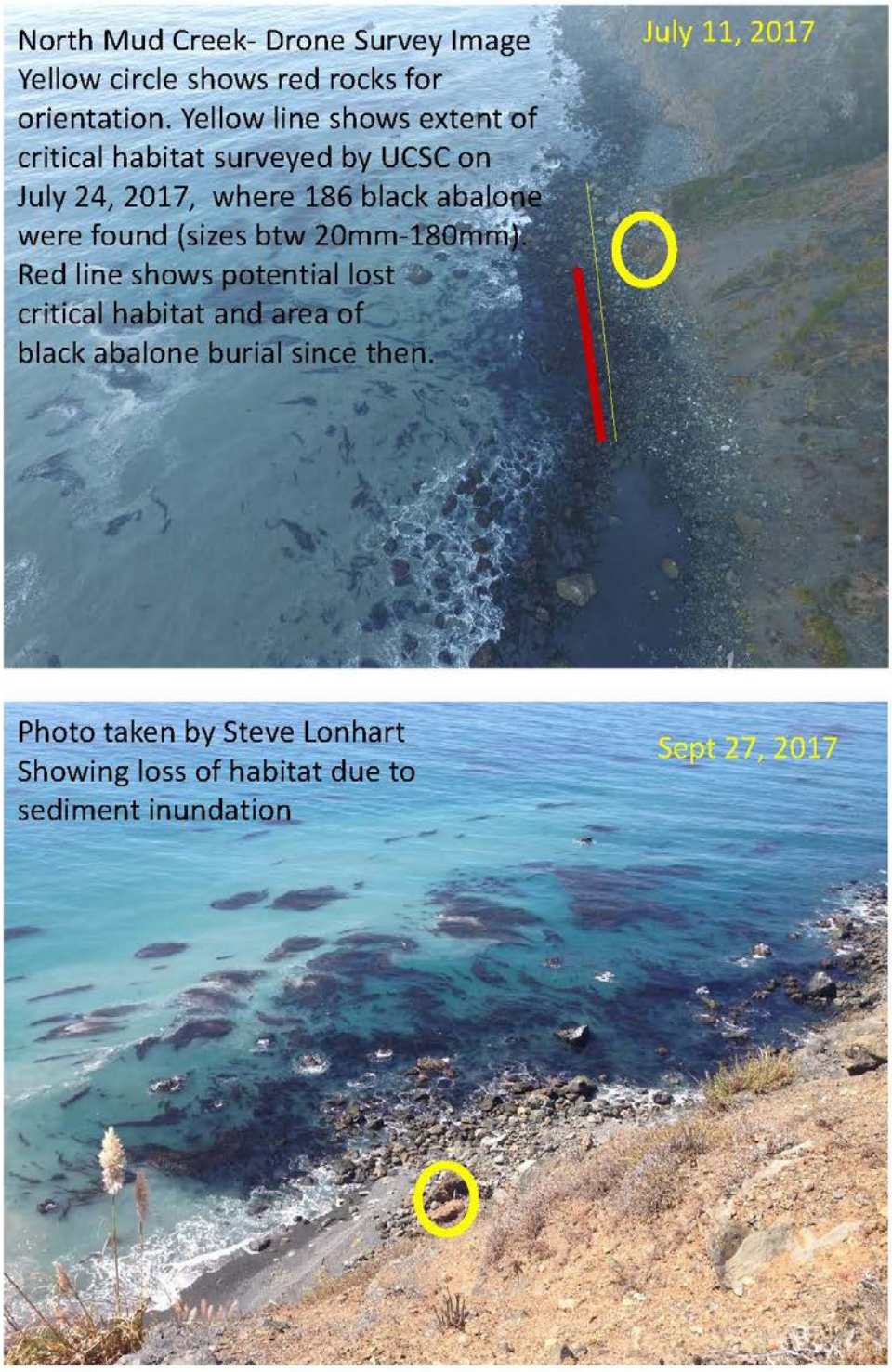

Figure 5. Aerial images showing the increase of sediment and burial of black abalone critical habitat. These images helped inform the rescue response.

Step 4: Weigh the risks of moving vs leaving animals in place

Initially, black abalone may not be in danger. However, the initial impact may expand or change in a way that threatens the abalone. Decisions about how to respond must consider the risk to the animals if they are left in place versus translocated.

An inherent risk to moving black abalone is that some could be accidentally damaged or fatally wounded when pried off rocks. Removing black abalone should only be attempted by individuals with experience, to minimize injuries and accidental death of the abalone. However, if doing nothing will result in the loss of many black abalone, then the risk of losing some may be worth the benefit of rescuing a portion of the population, and preserving some genetic diversity. Most black abalone will be in locations that are difficult or impossible to safely remove them from the rocks, so many will be left in place (Figure 6). It is likely that only a very small portion will be in locations that allow for rescue.

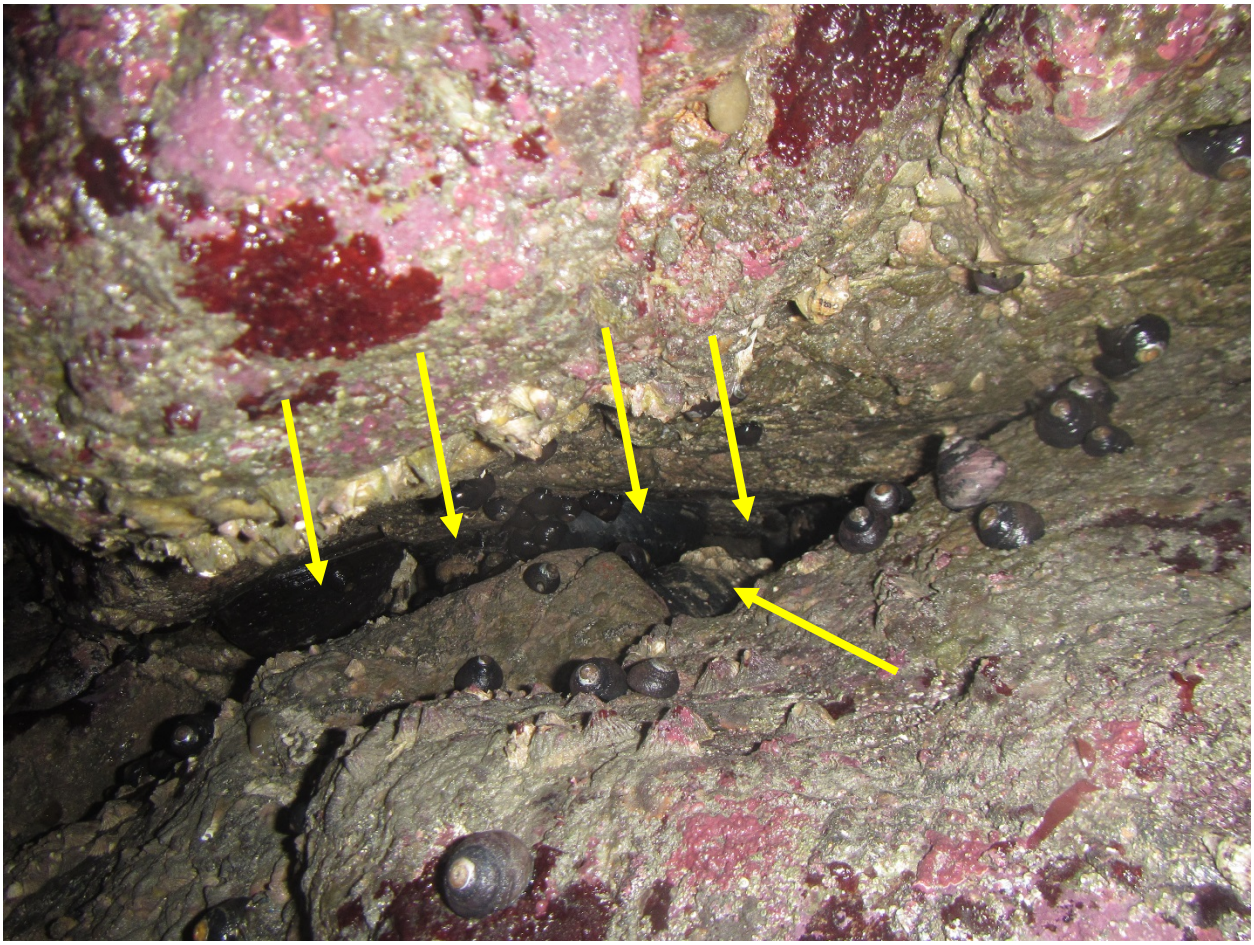

Figure 6. Photo shows black abalone that were found deep under boulders at Mud Creek, which would be impossible to rescue. Photo taken by Christy Bell (UCSC).

Step 5: Options for moving abalone

If the best response includes moving black abalone, there are many things to consider and many logistical steps that will need to be taken. Options for moving black abalone should be considered first, and it might be best to combine several of the following options.

Table 1. Summary of options for translocating black abalone with detailed descriptions of each option following the table.

Considerations for each option	Option 1: Collect and translocate the black abalone directly to another field site.	Option 2: Collect and bring black abalone into captivity (≤ 24 hours) until conditions (tides) allow for translocation to the field site.	Option 3: Collect and bring black abalone into captivity to monitor health and conduct phased translocation to the field site.	Option 4: Collect and translocate a portion of the black abalone directly to the field site and a portion to a captive facility or facilities.
Site Selection	Select nearby site outside of impact area (preferably a MARINe site)	Select nearby site outside of impacted area (preferably a MARINe site)	Select nearby site outside of impacted area (preferably a MARINe site)	Select nearby site outside of impacted area (preferably a MARINe site)
ESA Coverage	Section 7 consultation Section 10 research permit	Section 7 consultation Section 10 research permit Holding included as part of transport and translocation procedures	Section 7 consultation Section 10 research permit Separate authorizations may be needed for collection, holding, and future outplanting.	Section 7 consultation Section 10 research permit Separate authorizations may be needed for collection/ translocation and for holding/ future outplanting.
State Authorization	CDFW Permit CDFW Letter of Authorization	CDFW Permit CDFW Letter of Authorization	CDFW Permit CDFW Letter of Authorization	CDFW Permit CDFW Letter of Authorization
Tagging and Processing	Tag Photograph Measure shell length Note injuries Genetic tissue sample	Tag Photograph Measure shell length Note injuries Genetic tissue sample	Tag Photograph Measure shell length Note injuries Genetic tissue sample	Tag Photograph Measure shell length Note injuries Genetic tissue sample
Funding	Personnel (time, travel, equipment)	Personnel (time, travel, equipment) Captive facilities	Personnel (time, travel, equipment) Captive facilities	Personnel (time, travel, equipment) Captive facilities
Personnel	Field biologists	Field biologists Captive facilities	Field biologists Captive facilities	Field biologists Captive facilities
Constraints/ comments	Difficult to complete all tasks in one low tide.	Short-term holding allows more time for tagging, processing, and tissue collection.	Duration of captive holding with phased translocation plan and additional permits needed.	Criteria for selecting which abalone to translocate to the field site vs bring into captivity.

Option 1: Collect and translocate the black abalone directly to another field site

- Site Selection: choose a nearby site outside of the impacted area and, as feasible, protected from poaching. If possible, choose a long-term Multi-Agency Rocky Intertidal Network (MARINe) site to allow for continued annual monitoring. Contact Steve Lonhart from MBNMS (steve.lonhart@noaa.gov, (831) 420-3661) and/or Susan Wang from NMFS (susan.wang@noaa.gov, (562) 980-4199) for a list of preapproved sites by region.
    - Example: For the Mud Creek Landslide, the black abalone translocation site was a MARINe site about 16 miles south of Mud Creek with restricted access and an onsite manager, which may deter poaching. There were also local qualified volunteers and funds available to support monitoring at the translocation site.
- ESA coverage: ESA authorization is required and can be obtained through an ESA Section 7 consultation or an ESA Section 10 permit. The translocation of black abalone in response to the Mud Creek Landslide was covered by California Department of Transportations (Caltrans') emergency consultation with NMFS.
- State authorizations: CDFW permits and a Letter of Authorization are required. For the Mud Creek Landslide, UCSC (with a supporting letter from NMFS) amended an existing CDFW permit to collect, transport, and translocate the black abalone.
- Tagging and processing: Tag the collected black abalone prior to relocating them, especially if black abalone are already present at the chosen site. This will allow for the distinction between local (pre-existing) vs. translocated black abalone. In addition, measure and record the shell length of each black abalone, photograph the shell and foot, note the severity of any injuries, and collect a non-lethal tissue sample for genetics.
- Funding: Funding is needed for field personnel's time, travel, equipment, and supplies.
- Personnel: The team should consist of biologists who have current permits and extensive experience working with and monitoring black abalone (e.g., University of California, Santa Cruz) assisted by biologists from the Responsible Party (RP) (e.g., Caltrans) and other entities who have experience with abalone monitoring, collection, and transport (e.g., MBNMS, NMFS, and CDFW).
- Constraints: Performing all of the required tasks within a single low tide (black abalone habitat is typically exposed for 3-5 hours) might not be possible unless black abalone can be translocated to a safe area at the same site or a site very

nearby. In particular, tagging and processing black abalone in such a short time would not be possible unless a large team is available.

Option 2: Collect and bring the black abalone into captivity for a short period of time (≤ 24 hours) until conditions (tides) allow for the translocation of black abalone to the chosen field site

- Site Selection: choose a nearby site outside of the impacted area and, as feasible, and protected from poaching. If possible, choose a long-term Multi-Agency Rocky Intertidal Network (MARINe) site to allow for continued annual monitoring. Contact Steve Lonhart from MBNMS (steve.lonhart@noaa.gov, (831) 420-3661) and/or Susan Wang from NMFS (susan.wang@noaa.gov, (562) 980-4199) for a list of preapproved sites by region.
- ESA coverage: ESA authorization is required and can be obtained through an ESA Section 7 consultation or an ESA Section 10 permit. The translocation of black abalone in response to the Mud Creek Landslide was covered by Caltrans' emergency consultation with NMFS. Holding the black abalone for <24 hours in captivity can be considered part of the transport and translocation procedures.
- State authorizations: CDFW permits and a Letter of Authorization are required. For the Mud Creek Landslide, UCSC (with a supporting letter from NMFS) amended an existing CDFW permit to collect, transport, and translocate the black abalone.
- Tagging and processing: If brought into captivity (even for <24 hours), the tagging, processing, and tissue collection procedures will be less rushed and much easier. Photograph and tag the collected black abalone prior to relocating them, especially if black abalone are already present at the chosen site. This will allow for the distinction between local (pre-existing) vs. translocated black abalone. In addition, measure and record the shell length of each black abalone, photograph the shell and foot, note the severity of any injuries, and collect a genetic tissue sample.
- Funding: Funding is needed for field personnel's time, travel, equipment, and supplies. Additional funding for captive facilities may also be needed.
- Personnel:
  - Field: The field team should consist of biologists that have current permits and extensive experience working with and monitoring black abalone (e.g., UCSC), assisted by biologists from the Responsible Party (RP) (e.g., Caltrans) and other entities who have experience with abalone monitoring, collections, and transport (e.g., MBNMS, NMFS, and CDFW).

- Captive facility: A local facility certified by CDFW to be sabellid-free, such as: The Abalone Farm, Granite Canyon, Monterey Bay Aquarium, Bodega Marine Lab, or the Southwest Fisheries Science Center (SWFSC) in La Jolla. The facility must also be approved and permitted to hold black abalone under ESA Section 10(a)(1)(A). It is important to specify that holding conditions meet the permit standards.

Option 3: Collect and bring black abalone into captivity to monitor their health and conduct phased translocation to the field site

- ESA coverage/process: ESA authorization is required and can be obtained through an ESA Section 7 consultation (including an emergency consultation) or an ESA Section 10 permit. Separate authorizations may be needed for collection and translocation of the abalone to the field site, and for holding and future outplanting of the abalone from the captive facility to the field site.
  - Example: For the Mud Creek landslide, the collection and translocation of black abalone was covered by Caltrans' emergency consultation with NMFS. The holding of black abalone at captive facilities (> 24 hours) was covered by an existing ESA section 10(a)(1)(A) permit with SWFSC. Scientists will need to obtain a separate ESA permit to outplant the abalone to the field.
- State authorization: CDFW permits are needed for collection, transport, and translocation of the abalone, including a Letter of Authorization.
- Tagging and processing: Measure and record the shell length of each black abalone, note the severity of any injuries, and collect a genetic tissue sample. Photograph the shell and foot, and tag the collected black abalone. This will aid in tracking the survival and recovery of individuals, as well as allow for the distinction between pre-existing vs. translocated black abalone once they are placed back into the wild.
- Personnel:
  - Field: The field team should consist of biologists who have current permits and extensive experience working with and monitoring black abalone (e.g., UCSC), assisted by biologists from the Responsible Party (RP) (e.g., Caltrans) and other entities who have experience with abalone monitoring, collections, and transport (e.g., MBNMS, NMFS, and CDFW).
  - Captive facility: A local facility certified by CDFW to be sabellid-free, such as: The Abalone Farm, Granite Canyon, Monterey Bay Aquarium, Bodega Marine Lab, and the Southwest Fisheries Science Center (SWFSC) in La

Jolla. The facility must also be approved and permitted to hold black abalone under ESA Section 10(a)(1)(A). It is important to specify that holding conditions meet the permit standards.

- Funding: Funding is needed for field personnel's time, travel, equipment, and supplies. Additional funding for captive facilities may also be needed.
- Considerations for captive holding and phased translocation plan:
  - The severity of injuries and the treatment needed.
  - The time needed to adequately monitor health and recovery from injuries.
  - Comparison of survival in the lab vs. field (e.g., a portion of the animals are translocated and a portion are held in the lab for a longer period).
  - The ESA coverage/process needed. For example, the process for issuing an ESA permit may take up to one year, if a permit does not already exist for translocating black abalone.

Option 4: Collect and translocate a portion of the black abalone directly to the field site and a portion to a captive facility or facilities

- Site Selection: choose a nearby site outside of the impacted area and, as feasible, protected from poaching. If possible, choose a long-term Multi-Agency Rocky Intertidal Network (MARINe) site to allow for continued annual monitoring. Contact Steve Lonhart from MBNMS (steve.lonhart@noaa.gov, (831) 420-3661) and/or Susan Wang from NMFS (susan.wang@noaa.gov, (562) 980-4199) for a list of preapproved sites by region.
- ESA coverage/process: ESA authorization is required and can be obtained through an ESA Section 7 consultation (including an emergency consultation) or an ESA Section 10 permit. Separate authorizations may be needed for collection and translocation of the abalone to the field site, and for holding and future outplanting of the abalone from the captive facility to the field site.
  - Example: For the Mud Creek landslide, the collection and translocation of black abalone was covered by Caltrans' emergency consultation with NMFS. The holding of black abalone at captive facilities (> 24 hours) was covered by an existing ESA section 10(a)(1)(A) permit with SWFSC. Scientists will need to obtain a separate ESA permit to outplant the abalone from the SWFSC facility to a field site.
- State authorization: CDFW permits are needed for collection, transport, and translocation of the abalone including a Letter of Authorization.

- Personnel:
  - Field: The field team should consist of biologists who have current permits and extensive experience working with and monitoring black abalone (e.g., UCSC), assisted by biologists from the Responsible Party (RP) (e.g., Caltrans) and other entities who have experience with abalone monitoring, collections, and transport (e.g., MBNMS, NMFS, and CDFW).
  - Captive facility: A local facility certified by CDFW to be sabellid-free, such as: The Abalone Farm, Granite Canyon, Monterey Bay Aquarium, Bodega Marine Lab, and the Southwest Fisheries Science Center (SWFSC) in La Jolla. The facility must also be approved and permitted to hold black abalone under ESA Section 10(a)(1)(A). It is important to specify that holding conditions meet the permit standards.
- Funding: Funding is needed for field personnel's time, travel, equipment, and supplies. Additional funding for captive facilities may also be needed.
- Identify criteria for fate of abalone (field site or captive facility). For example:
  - Total number rescued – if small, may want to place all at field site
  - Proportion to go to field vs. lab
  - Health, injuries: place healthy abalone in field, injured abalone in lab

Step 6: Moving Black Abalone

If it appears that the benefit of translocating black abalone outweighs the risk of leaving them in place, then the recommendation and options to move the abalone should be discussed (see Step 5) with the following: CDFW, NMFS (Protected Resources Division), other resource agencies with legal obligations (e.g., National Marine Sanctuaries, California Coastal Commission, Department of Defense), field biologists with decades of experience monitoring black abalone, and a representative biologist from the Responsible Party and Federal or State nexus. Once the decision to translocate the black abalone is officially made, then there are many logistical issues that must be addressed prior to collecting and moving any black abalone.

Permits must be amended to allow for the collection and transportation of black abalone (NMFS/CDFW) and Letters of Authorization (LOA's from CDFW) to possess black abalone must be obtained. This is another reason it is helpful to involve field biologists who have extensive experience and are already permitted to monitor black abalone. This process can take a couple of weeks even if it is deemed an emergency. During the Mud Creek Landslide, we were able to work under Caltrans' Emergency Consultation with NMFS.

The initial population surveys will help determine how many black abalone could be impacted and what percentage of those are in accessible locations for removal. This information will be needed for obtaining and/or amending permits and for coordinating with potential

captive/holding facilities. Note: many of the black abalone near the Mud Creek Landslide were in deep cracks or under boulders and were impossible to reach (Figure 6).

The translocation team will need to decide where to hold and process the black abalone that are collected. The holding facility must be certified by CDFW as sabellid-free. Arrangements will need to be made with the facility prior to the transfer of black abalone. It is helpful to provide the facility with an estimate of how many individuals will be rescued, so they can prepare holding tanks ahead of time. An onsite meeting with the facility manager should also be made ahead of the collections, so that all team members know the plan (how to access the facility after hours, where to house the black abalone once they are brought in, where they can be tagged and processed, how long they can stay at the given facility, what equipment the facility can provide, etc.) to insure the smooth transfer and safety of the animals. This will also help ensure that all issues can be resolved ahead of the arrival of the black abalone.

The team will also need to determine:

- the type and number of tags to be used (e.g., Floy®, PIT, or other available options)
- how to apply the tags (e.g., CorAffix for FLOY® tags; super glue, CorAffix, or marine epoxy for PIT tags)
- whether to notch or engrave the shell as another form of tagging and obtain the necessary supplies (a Dremel tool for notching the shell; eye and respiratory safety equipment (PPE) for the processor)
- what tissue samples will be taken and the necessary supplies (e.g., ethanol, vials, scalpels, scissors, secondary containment, coolers, ice)
- a location for photographing the abalone and camera for photographing the dorsal surface for identifying marks or damage (e.g., epibionts, tags, notches) and ventral surface (to document any injury and health of foot) of each black abalone (Note that photographs of abalone should be taken post-tagging and should include a ruler for scale (Figure 7))
- who will provide what equipment, tools, etc. (see List of Equipment Needed in Appendix III below)

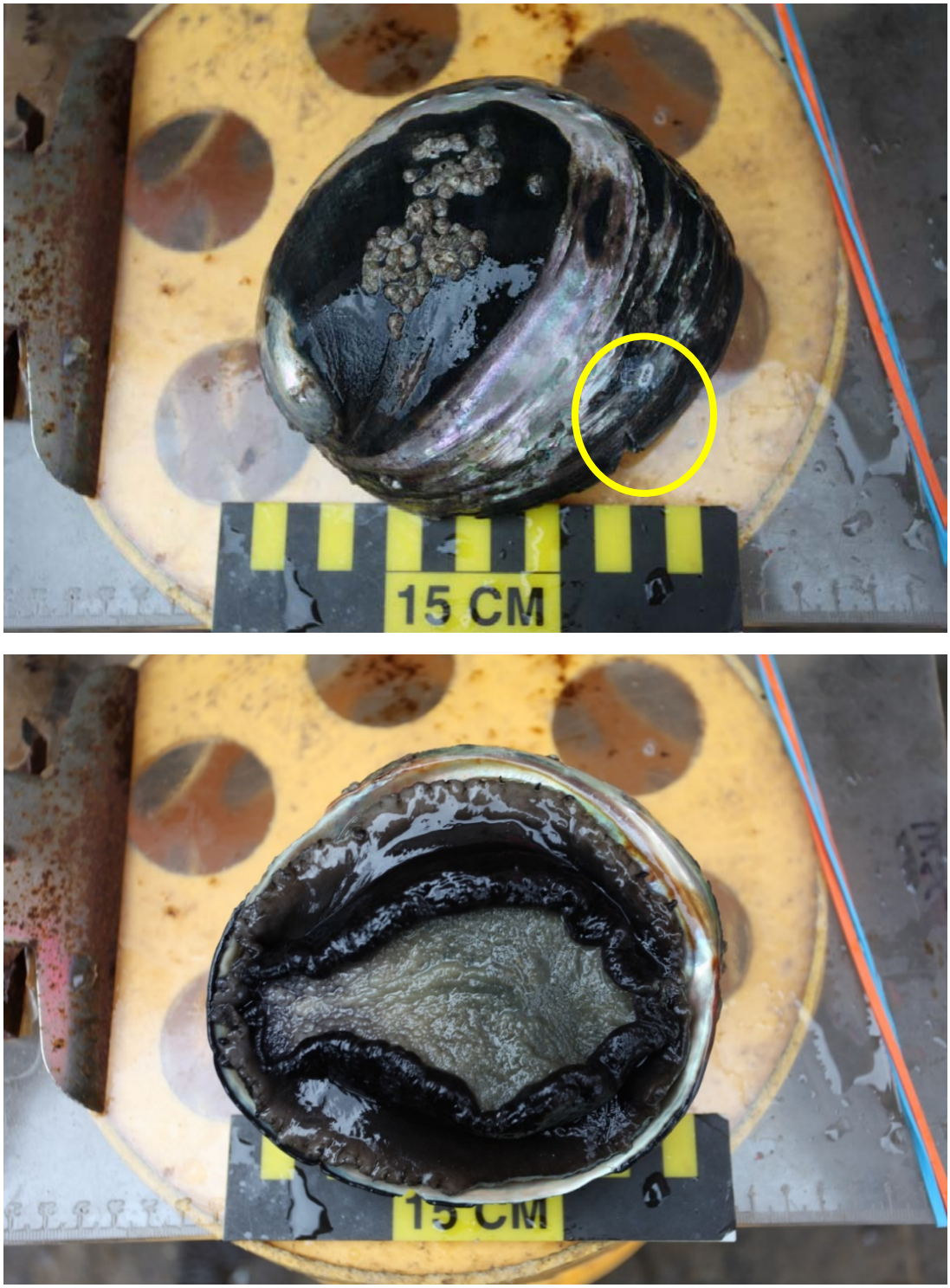

Figure 7. Top example photo of tagged black abalone the Floy tag and shell notch are visible inside the yellow circle. Photographs were also useful for identifying individual abalone due to unique characteristics (e.g. erosion and barnacles on shell). Bottom photo of ventral surface to document health of foot. Photos taken by Steve Lonhart (MBNMS).

The team will also need to determine the best place to translocate the rescued black abalone, once they have been processed and tagged (contact Steve Lonhart from MBNMS (steve.lonhart@noaa.gov, (831) 420-3661) and/or Susan Wang from NMFS (susan.wang@noaa.gov, (562) 980-4199) for a list of preapproved sites by region).

It is important to consider:

- the level of public access at the translocation site
- if there is any onsite protection from poaching
- if there is good quality habitat and an extant population present
- the distance and difficulty in getting from the parking area to the translocation site
- the availability of local volunteers to help with post-translocation monitoring
- the distance between the translocation site and the impacted site
- the distance between the translocation site and the holding/processing facility
- whether the translocation site is an existing long-term black abalone monitoring site

Once the site is selected, a team of experts should identify where black abalone should be translocated within the site. Several cracks with good black abalone habitat qualities should be chosen. The cracks should be at the appropriate tidal height and ideally have some local black abalone present, since this indicates suitable conditions. If possible, it is best to select cracks and crevices that would be accessible during marginal low tides, this will allow more flexibility for future monitoring. If abalone are translocated into very low and/or exposed cracks future monitoring will be greatly constrained by conditions. The cracks should provide good quality habitat that afford black abalone protection from predators.

If available, cracks and crevices in bedrock should be selected over boulder fields, because they are easier to search/monitor. Boulders often contain spaces that are narrow and at angles that are not easily visible or reachable. While cracks in the low intertidal can have water moving in and out, this is especially problematic in boulder fields where water can inundate the base of the boulders and obscure abalone potentially making monitoring more difficult. In addition, in areas exposed to powerful surf, such as the Big Sur Coast, even very large boulders (e.g., Volkswagen Bug size) can be moved by waves and crush abalone.

The following steps must be completed before moving black abalone to the selected site:

- The cracks should be permanently marked with bolts (Figure 9), which will likely require one or more permits. Ideally someone on the response team would already have permission to do this or be able to amend existing permits.
- GPS points should be taken at each bolt.
- If the site is an existing long-term monitoring site, distances and compass bearings from existing bolts should be taken for newly installed bolts to aid in relocation. If the site is new, consider installing a “reference” bolt in an easy to find location (e.g., top of high rock) from which measurements can be taken and later used for finding bolts marking translocation crevices.
- The cracks should be photographed in a way that will be useful for relocating them (e.g., include prominent rock features in foreground/background; see Figure 8 and Appendix I for example photos).
- Maps of the site and each of the cracks should be drawn, including good reference points (see Appendix I for example maps). Even rough hand drawn maps are useful because site features that might not be obvious from photos can be highlighted.
- The local population of black abalone within a translocation site should be counted and measured (see Appendix IV for datasheets).

Figure 8. Top photo of tagged black abalone, awaiting placement in marked cracks (installed bolt marking one end of a plot is shown inside the yellow circle) at the translocation field site. Bottom photo showing an example of a marked plot where some abalone were translocated. Photos taken by Christy Bell (UCSC).

Finally, the team will need to decide whether to transport a portion of the black abalone to a captive facility (or facilities) and what criteria should be used to select these abalone. For example, the team may decide to hold a specific number or proportion of black abalone in captivity to evaluate post-collection survival and health. Another criterion may be the severity of injuries. The team may decide to hold severely injured abalone in captivity for treatment and recovery.

The captive facilities must be certified sabellid-free and must be authorized to hold black abalone under an ESA permit. The team will need to consider how long the black abalone will be kept in captivity, which will depend on the treatment needed and the time required to adequately monitor health and recovery from injuries. The team will also need to develop a plan for reintroducing (or outplanting) the black abalone back to the wild.

Step 7: Mobilizing a team of experts

Once permits and a rescue plan are in place, choose the next best tide (during daytime negative low tides when sea conditions are safe for field work) to do the collections and assemble a team of experts, including:

- those involved in the initial population and habitat assessment (Appendix II: 2A)
- those with experience removing/collecting black abalone
- experts that have experience safely transporting black abalone
- experts that can evaluate black abalone injuries to determine which abalone are safe to translocate, which should be taken to a captive facility for treatment, and which should be sacrificed (e.g., those with lethal injuries or severely shrunken foot indicative of disease)
- a shellfish pathologist to evaluate the health of the abalone and to collect appropriate samples
- a representative from the responsible party (if required)

Step 8: Rescue/Collection of black abalone

The team of experts should first survey the rocky intertidal habitat adjacent to and potentially affected by the impact (Figure 9), to count the number of black abalone, characterize the quality of abalone habitat, and estimate the number of black abalone that are accessible for collection as well as the number that are inaccessible but might be impacted (e.g., buried or dislodged by sediment, smothered by oil, etc.).

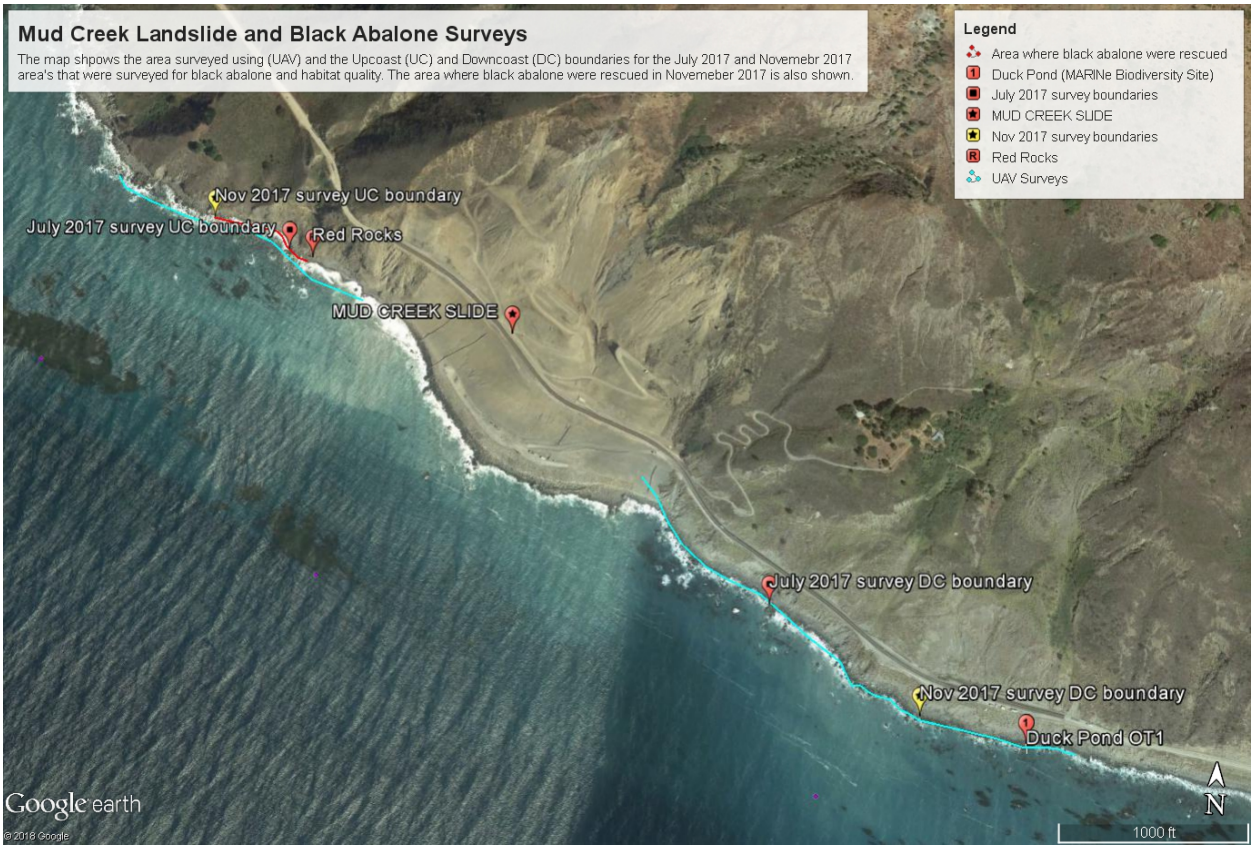

Figure 9. Google Earth image showing locations of the Mud Creek abalone surveys, UAV surveys and black abalone rescue area.

Surveys should be conducted during negative daytime low tides, when sea conditions are safe for field work. If there are enough people, and time and conditions allow, the black abalone should be collected on the same day, or on subsequent days within the same low tide cycle.

Collection should only be attempted and conducted by personnel with experience removing abalone, to minimize injury to the foot muscle. Abalone irons or other removal tools should only be inserted at the rear or sides of the abalone and should never be inserted near the head.

All injuries should be photographed/recorded. If the injuries are severe, such that survival is unlikely, then the black abalone should be sacrificed. Dead/dying abalone encountered in the field should also be saved for necropsy. When the decision is made to sacrifice an abalone, formalin fixation of the gut tissues is preferred if supplies, training, and safety protocols are available. If not, freezing the entire abalone will provide less information, but still allow for determination of the presence and severity of infection with the agent of withering syndrome (WS-RLP, or, more recently CaXc, for *Candidatus Xenohaliotis californiensis*). Sampling should be coordinated with the CDFW Shellfish Health Laboratory (Point of contact: Blythe Marshman, blythe.marshman@wildlife.ca.gov, (707) 875-2066).

The geographic scope of survey and rescue efforts will be determined based on the number of experts available to help, field conditions, the status of black abalone populations and their habitat, and the extent and speed of the impact and its potential for expansion.

Step 9: Transport and holding of black abalone

Rescue and translocation activities can only be safely and effectively conducted during negative daytime low tides (or close to negative low tides) and appropriate sea conditions. Thus, temporary holding at a captive facility may be required for at least one day to several weeks, particularly during times of the year when negative low tides occur close to or before sunrise or after sunset and swell conditions are not safe for field work. Animals can be held in captivity until field conditions allow placement of the animals at the translocation site (e.g., during the same low tide cycle or the next daytime low tide cycle).

Black abalone should be transported according to methods described in the abalone transport protocols (NMFS 2008 and 2015). This involves wrapping the animals in damp cloths and placing them in coolers to keep them within the appropriate temperature range. Animals may be transported by vehicle to the translocation site or to temporary holding facilities.

The holding facilities must be certified sabellid-free and permitted to hold black abalone under an ESA Section 10(a)(1)(A) permit. The holding facility must maintain the black abalone and conduct regular cleaning and health monitoring. Any dead or dying black abalone should be noted and sent to the CDFW Shellfish Health Laboratory for necropsy, if needed. Abalone should be tagged (numbered/colored tag glued to shell) to monitor survival over time during captivity and after placement at the translocation site. Tissue and fecal samples (using non-lethal methods) should be collected to inform genetic and disease risk assessment (Figure 10).

Figure 10. Rescued black abalone being processed (measured, tagged and genetic samples taken) prior to translocation. Photos Courtesy of Steve Lonhart (MBNMS).

Black abalone that have been severely injured and that are unlikely to survive in the wild should be transferred for longer-term holding, monitoring, and rehabilitation at a sabellid-free facility that is permitted to hold black abalone under an ESA permit (such as the SWFSC lab in La Jolla).

Step 10: Translocation of black abalone

Translocation of black abalone to the new field site should occur as soon as possible, during appropriate field and tidal conditions. Black abalone should be transported using the protocols described above, placed in pre-identified crevices (that were chosen by NMFS-approved biologists) at the translocation site, and monitored on at least an annual basis, though initial monitoring may need to be more frequent.

Step 11: Follow up

The translocated black abalone will need to be monitored to determine rates of movement, tag loss, and survivorship. Initially, black abalone should be monitored as soon as possible after the translocation (if possible the next day or several days following), to track movements that are likely to occur immediately. The initial burst of movement by translocated abalone will likely diminish with time, possibly stabilizing or ceasing within a month. Results from these initial surveys will dictate the appropriate frequency for subsequent surveys. Ideally, follow-up monitoring should be done once per tide cycle (~ every 2 weeks) for the first three months, then move to monthly (for approximately 6 months), then semi-annually (for approximately 1 year), and finally annually until translocated abalone can no longer be found (e.g., tag loss, death of animals). The number of abalone translocated, site terrain, access to the site, and number of personnel available may present logistical constraints on the frequency of monitoring.

Lessons learned during the Mud Creek black abalone Translocation:

What is feasible in a single low tide

It took 11 people approximately four hours to survey and collect 45 black abalone. The tide was in the late afternoon and was not low enough (only +0.2'), nor were there enough people to process, tag, and release all of the rescued black abalone in the same tide.

Temporary holding

Some of the abalone gripped tightly to the side of the holding tanks and were tricky to remove for tagging. If black abalone are only being held in captivity for <24hours, it may be worth keeping individual black abalone in their own mesh collecting bags inside the holding tanks to avoid issues of them clinging to the sides of the tanks or to each other (Figure 11). If that is not feasible, it may be necessary to anesthetize them using carbon dioxide. Bubble carbon dioxide into seawater for about 15 minutes to create a saturated carbon dioxide solution. Abalone should loosen their grip after about 4-5 minutes. Do not leave them in the saturated solution for more than 10 minutes (NMFS 2015). Alternatively, John Hyde at the SWFSC has successfully used 2-3% ethanol in seawater as an anesthetic for black abalone. He found that it generally takes 5-10 minutes before for it causes them to fall off but they often loosen up quicker. The Hyde lab has also used 25% ethanol squirted with a syringe near their respiratory pores to irritate them and get them to loosen their grip, making it easier to slide a spatula under their foot to pry them off.

Figure 11. Black abalone temporarily held in mesh collecting bags inside the holding tanks. Photo taken by Steve Lonhart (MBNMS).

Injuries due to collection

Of the 45 rescued black abalone, five were sacrificed: one due to shrunken foot (possibly due to withering syndrome) and four due to severe injuries that were sustained during collection (Figure 12). This highlights the importance of having a team with experienced collectors.

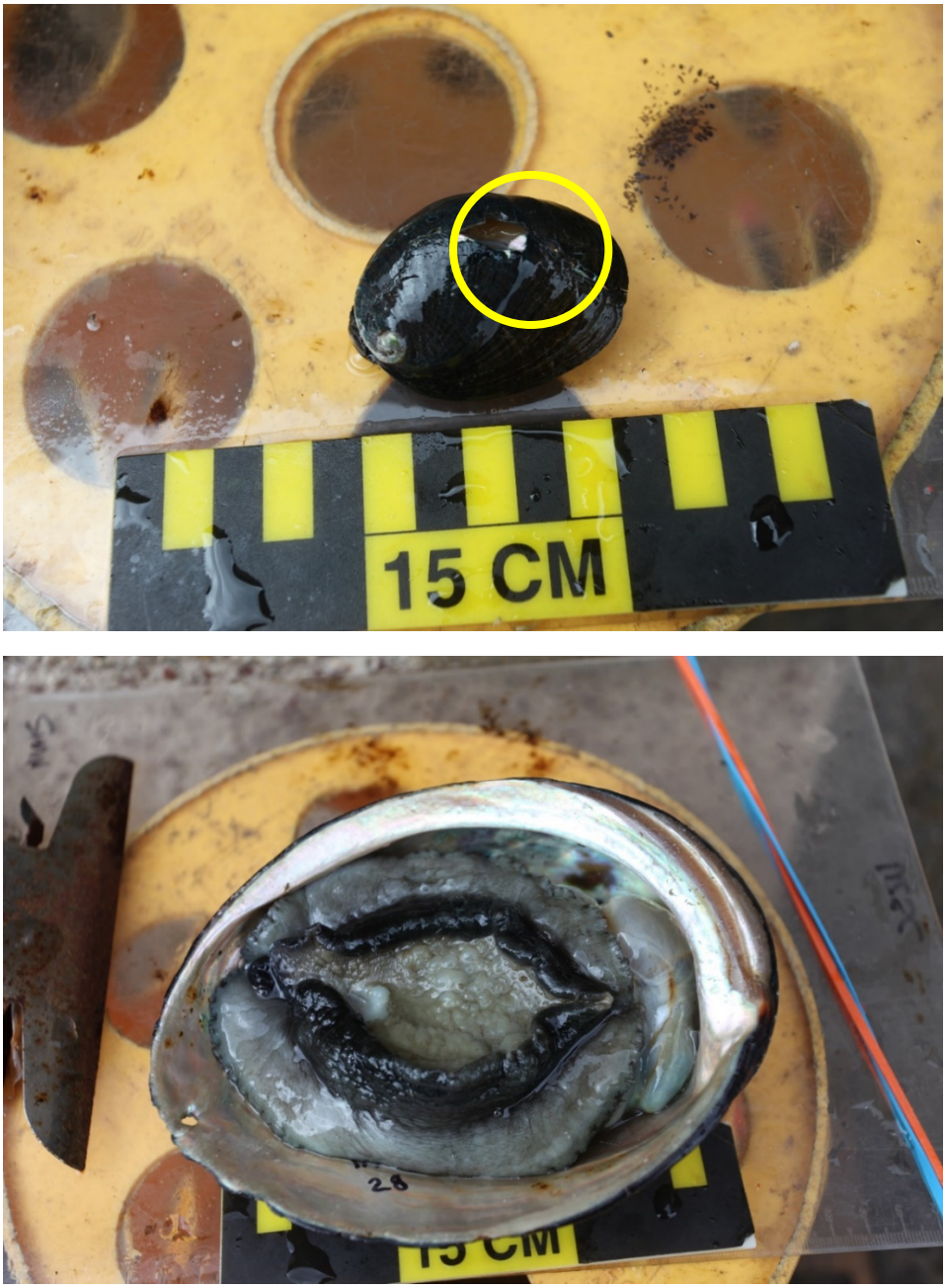

Figure 12. Black abalone that were sacrificed due to fatal injuries (e.g. cracked shell shown inside yellow circle) that were sustained during collection (top) and due to shrunken foot (bottom). Photos taken by Steve Lonhart (MBNMS).

Translocation site selection

Be prepared to change locations if needed. Even if a crack looks good, black abalone may find it unsuitable. At the Mud Creek translocation site, one crack had been prepared for rescued black abalone but was not used because two black abalone would not adhere to the surface of the crevice, seemingly "rejecting" the location. Local abalone were not in this particular section of the crevice, but they did occur to either side in the same rock formation. A new location in a different crack was selected and the same two black abalone that had rejected the initial location attached right away, adhered strongly, and did not release.

Movement of translocated black abalone

Some of the translocated black abalone were documented to be 10 meters or more away from where they were initially placed (Figure 13). Many of them began moving within the first few days after translocation. It is unclear why they moved. Large black abalone tend to establish a home base, so perhaps the tagged black abalone were searching for their old homes. Or, they may have moved because the rocky reef habitat at the translocation site was different from the boulder field at Mud Creek. Some of the tagged black abalone continued to move and have not been observed again, due either to tag loss, many available cracks (too many to search effectively), or perhaps mortality.

Figure 13. Translocated black abalone #951 found the wall of a surge channel 20 m offshore of the crack where it was originally placed, the Floy tag and shell notch are visible inside the yellow circle. Photo courtesy of Steve Lonhart (MBNMS).

Movement of local black abalone

We also observed movement of local black abalone that were already at the translocation site. Some left the cracks that the translocated black abalone were introduced to. This was not expected. Perhaps the local black abalone detected the injuries of the translocated black abalone and were trying to avoid predation (note that some of the local black abalone eventually returned to these cracks). We also checked our long-term abalone plots to see if the numbers were declining but found that they were stable. In fact, some of the tagged, translocated black abalone had moved into our long-term monitoring plots that were more than 20 m away (Figure 14).

Figure 14. Top photo of tagged (#982/#93) and notched black abalone that was translocated to the field site. Bottom photo is a close-up photo of the same black abalone. This abalone was found >20 m away from where it was originally translocated and had moved into one of the long-term MARINe monitoring plots. Floy tag is visible inside red circle. Photo taken using a plumber's scope on February 1, 2018 by Dan Richards (retired NPS).

Tagging

Even with two Floy® shellfish tags attached on different sides of the shell, the tags were sometimes difficult to read due to the location and/or orientation of the abalone within a crack (Figure 15). Sometimes, the shell notch was not visible due to the orientation of the black abalone, but the notch could still be felt. In order to avoid touching them, it may be better to notch or engrave symbols (such as triangles or a unique combination of symbols) into the shell at various locations, so that there are be multiple ways of identifying a translocated black abalone. The adhesive CorAffix was used to attach tags to the shell. If the adhesive does not completely dry, or is smudged, a hazy and uneven surface results, partially obscuring the numbers. Sometimes tags were accidentally smudged while notching the shells. Therefore, it would be best to notch and/or engrave the shells prior to collecting genetic samples, and then tag and photograph the abalone. This would also allow plenty of time for the adhesive to dry, and both the notch (and/or engraved symbols) and the tag would be visible in the photographs. It would also be better to use tags with larger numbers, which would make them easier to read in a deep crack. It may also be helpful to use tags with different colors to make them easier to spot. Prior to the next emergency response, it would be informative to try different adhesives on shells, document curing times, experiment with various sizes of tags and notching/engraving patterns, and test subsequent visibility. This could be done on black abalone shells in a facility with running sea water system to mimic conditions that live abalone would experience when undergoing the tagging process. Developing enhanced methods for the application of tags to black abalone shells is highly recommended.

Over time, tags eventually fall off and black abalone repair the notches that were cut into their shells (Figure 16). However, even after being repaired, the notches are often visible as scars in the shell and can be used for identification if the abalone is oriented such that the scars are visible to samplers. Scientists can also examine recovered empty black abalone shells for notches (or scars) to help identify translocated abalone that died. Therefore, it is highly recommended that notches and/or engraved symbols on the shells (or combination of both) be done as a secondary method of marking translocated abalone.

In other studies, PIT tags were attached to the outside of the shell using marine epoxy. Researchers found that these tags could get knocked off from rubbing on the rocks inside narrow crevices. PIT tags might still be useful, however, if they can be attached to the inside of the shell (with CorAffix or super glue or another adhesive) where they will not be knocked off. The PIT tags eventually become encased in the shell as the abalone build nacre over the tag. If the crack is wide enough, a PIT tag reader can be inserted into the crack and used to identify abalone without touching them. PIT tags may be a more effective and less invasive way to identify translocated black abalone that have moved far away from their original location. However, it should be noted that in previous field studies using PIT tags to tag black abalone, that the tags failed after a year. In some cases, the PIT tag readers were too large to fit into

narrow cracks, but newer, smaller, stick-like models are now available. Additional, new technological advances in tagging with remote sensing capabilities should also be explored.

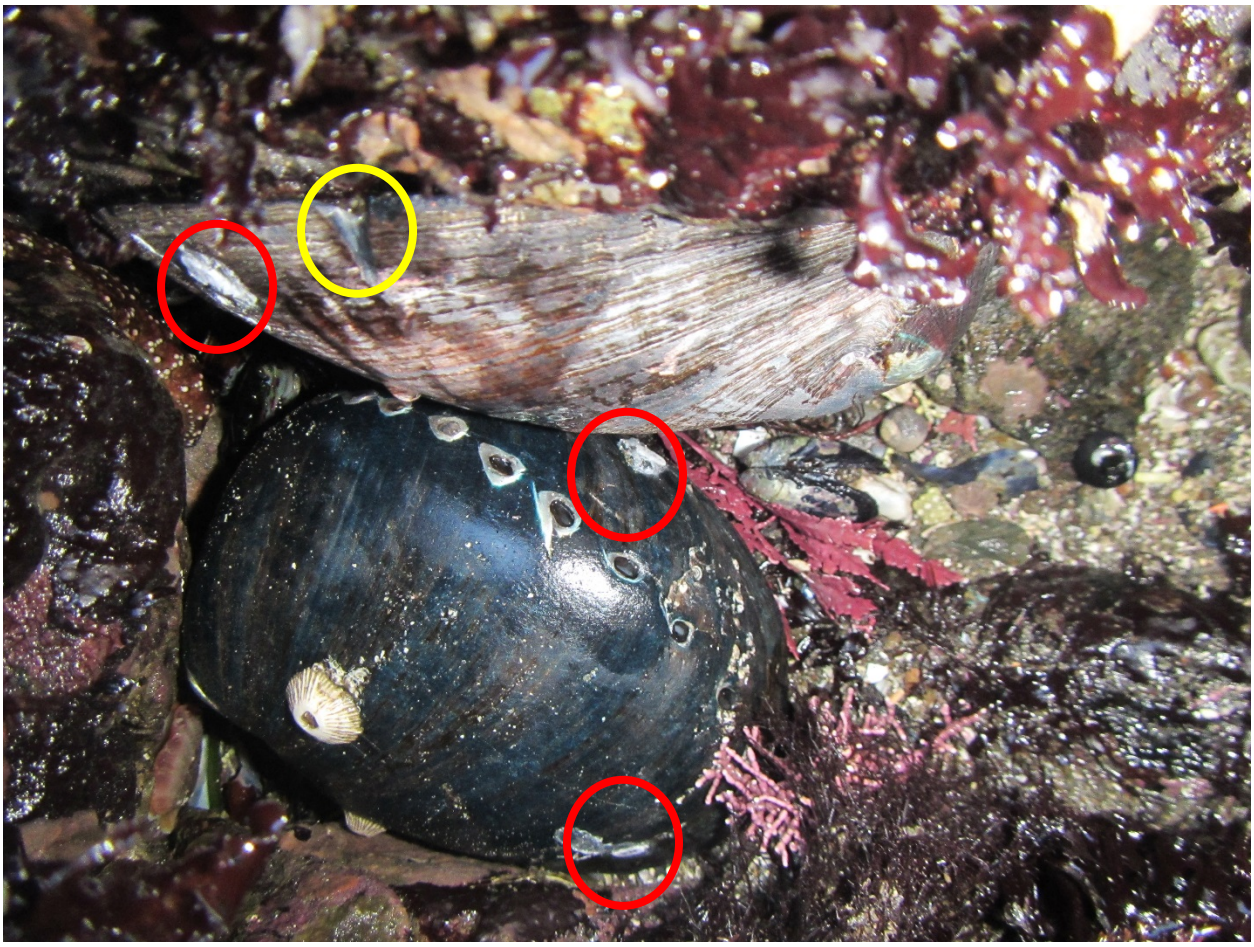

Figure 15. Photo of tagged and notched black abalone that were translocated to the field site. Yellow circle shows shell notch and red circles shows Floy tags. Note that it is not always easy to read tags depending on the orientation of the black abalone. Photo taken by Christy Bell (UCSC).

Figure 16. Top photo shows black abalone (tag #'s 989 & 438), before it was translocated on November 4, 2017. Bottom photo is of the same abalone on March 14, 2018 after the tags had apparently fallen off, but due to the distinct slit through the respiratory pores on the shell, it was still identified using photos. Both photos were taken by Steve Lonhart (MBNMS).

Survivorship

The survivorship of black abalone that were injured during collection was fairly high for those that were transferred to the SWFSC La Jolla lab. There were three fatalities out of nine black abalone that went to this lab. Two died 11 days after they were collected; both had deep wounds. The third fatality on December 13, 2017 (41 d after collection) was a black abalone that had suffered severe damage to the shell and foot. If the injuries had been noticed sooner, the abalone likely would have been sacrificed (Figure 17).

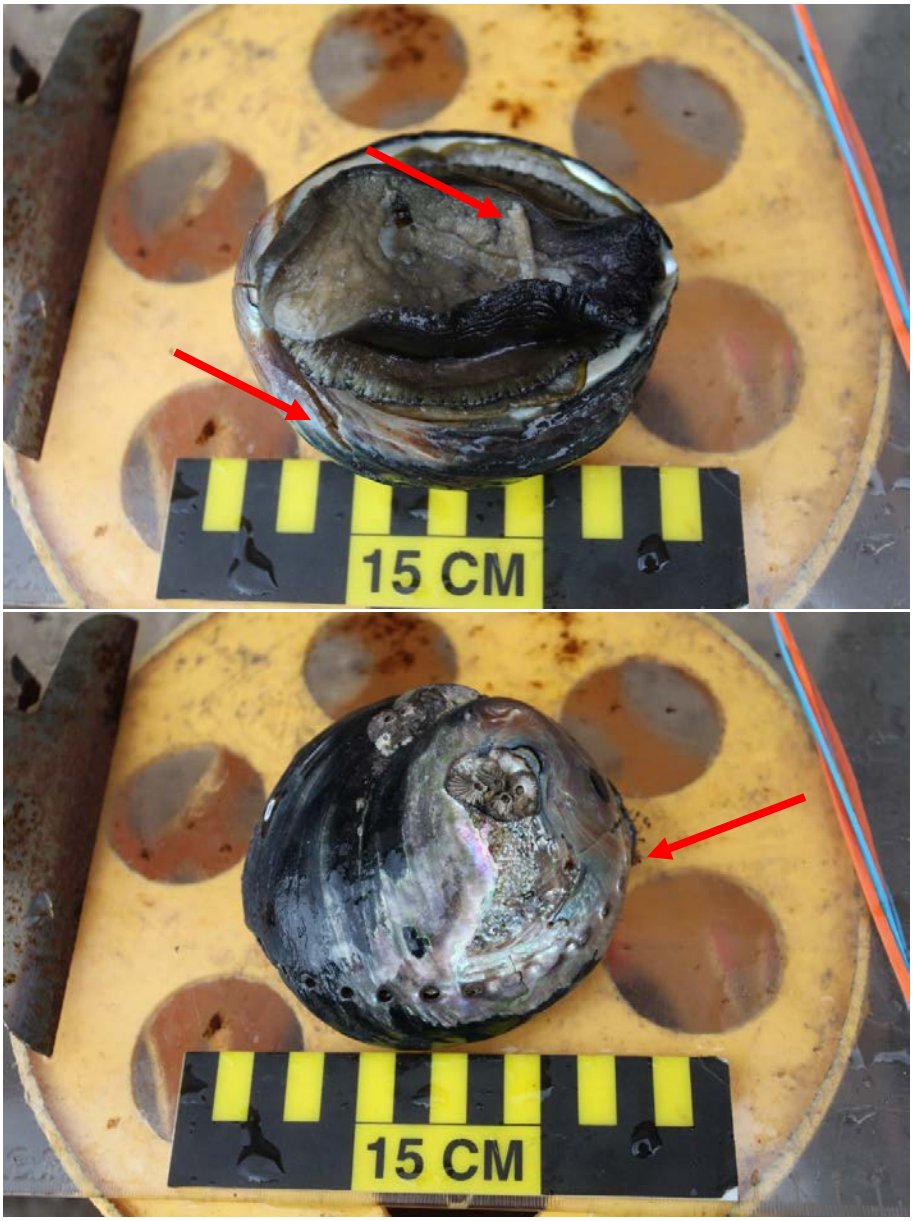

Figure 17. Example black abalone that suffered severe damage to the shell and foot during collection and died 41 days after collection in the SWFSC lab in La Jolla, CA. Red arrows show cracked shell and injury to foot. Photo taken by Steve Lonhart (MBNMS).

Of the 31 black abalone that were translocated to the field site, there have been five confirmed mortalities as of the last monitoring survey in November 2019. One was found intact in its shell shortly after it died and was collected and sent to Jim Moore (CDFW) for necropsy. This black abalone had sustained significant injuries and was supposed to go to the SWFSC lab but was accidentally translocated to the field site. That abalone died four days after it was collected from Mud Creek and two days after it was accidentally translocated. The other four black abalone mortalities were confirmed when empty tagged shells were found. One was found two weeks after the translocation, two were recovered three months later and one was recovered 9 months after translocation. However, exactly how soon they died after the translocation is not known. Most of these shells were recovered in a surge channel located between plots 5 and 7. Over the past year, that channel has filled in with a deep layer of empty mussel shells, making it more difficult to find additional empty black abalone shells.

Recommendations for Future Emergencies

If abalone are in imminent danger of dying (e.g., burial, oiling), then a rescue effort must be considered. In the case of the Mud Creek rescue effort, most of the rescued black abalone were translocated to a field site (n=31) and only those with significant injuries (n=9) were transferred to the SWFSC lab in La Jolla. Despite their injuries there was relatively high survivorship for the captive black abalone (n=6). In addition, these captive black abalone have since been used in experiments and may eventually be used in a captive breeding program. By contrast, the rate of survival for the translocated black abalone is not known. The translocated black abalone began moving almost immediately and most were not relocated. The 31 translocated black abalone ranged in size from 40-155 mm, with the majority being >110 mm (only 3 were <65 mm), but all size classes moved. Therefore, in future emergencies it may be worth considering (if the facilities are available) the transfer of more rescued black abalone into captivity, where they can be used for non-lethal experiments and/or captive breeding. In addition, improved tagging methods and tracking technology may be developed or available during future rescue efforts, and more could be learned about the survivorship of translocated black abalone. Data on the survivorship of translocated black abalone will help inform future translocation efforts and aid in the general recovery of black abalone.

Acknowledgements

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Thanks to Google Earth (https://www.google.com/earth/) and California Coastal Records Project (https://www.californiacoastline.org/), which were both used for planning the initial surveys.

We thank the following; Jonathan Warrick (USGS) for sharing the oblique aerial photographs; Patrick Robinson for the Unmanned Aerial Vehicle (UAV) surveys and images; Mitch Dallas from Caltrans for assisting with the surveys, coordinating site access, assuring safety at the site, for notching the shells of rescued black abalone with a Dremel, and for providing weekly updates from the biological monitors (from Tenera Environmental) regarding the movement of sediment from the slide; Susan Wang and Melissa Neuman (NMFS) for their support, guidance, technical advice, and assistance with permitting issues; Susan Wang (NMFS) for setting up planning calls and sending out detailed call summaries to the group; Katherine Swiney and John Hyde (SWFSC) for providing guidance and laboratory space for nine of the rescued black abalone; Ian Taniguchi, Jim Moore, and Derek Stein (CDFW) for their advice and expertise in collecting black abalone; Ian Taniguchi and Jim Moore (CDFW) for collecting tissue samples for genetics and pathology and for their guidance in determining which abalone should be sacrificed, translocated, or taken to John Hyde's lab in La Jolla; Ian Taniguchi (CDFW) and Amanda Bird (NMFS) for transporting the injured black abalone to John Hyde's SWFSC lab in La Jolla; Gery Cox and Andrew Harmer (Tenera Environmental) for their assistance with the surveys and collections; Steve Lonhart (MBNMS) for his help with logistics, funding and monitoring surveys, and for taking and sharing his photographs; Ray Fields (The Abalone farm, Cayucos) for all of his generosity and assistance, use of equipment, holding tanks, and for providing space to process and tag the rescued black abalone; Ryan Cooper, Jodie Nelson, and Mike Holley (BLM) for their permission, assistance with monitoring the translocated black abalone, and for providing protection to the translocated black abalone; and Steve Lonhart (MBNMS), Dan Richards, and Sarah Chaney for their continued help with monitoring the translocated black abalone. Thanks also to those who were enthusiastically on call in case more help was needed during the rescue including: Susan Wang and Amanda Bird (NMFS) and Malina Loeher and Blythe Marshman (CDFW/BML). Thanks to Susan Wang (NMFS), Steve Lonhart (MBNMS) and Melissa Miner (UCSC) for thoughtfully reviewing and improving this document. Finally, thanks to the other members of the Raimondi intertidal team at UCSC who assisted with these surveys: Karah Ammann, Nate Fletcher, Kate Melanson, and Niko Kaplanis.

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Protocols for Transporting and Holding Black Abalone (Appendix II, 2B):

Black Abalone Working Group. 2013. Draft Black Abalone Oil Spill Contingency Plan for California. Prepared by the California Department of Fish and Game (CDFG), CDFG Office of Spill Prevention and Response, and the National Marine Fisheries Service. Draft dated May 2013. 16 pages.

NMFS. 2015. Draft Abalone Risk Management Guidance Document. Prepared by the National Marine Fisheries Service, the California Department of Fish and Wildlife, and the Abalone Recovery Committee. Draft dated August 2015. 41 pages.

Appendix I: Maps

Note: Due to the ESA status of black abalone, NMFS requested that all site identifying information be withheld from this document. However, detailed maps can be made available to resource managers upon written request.

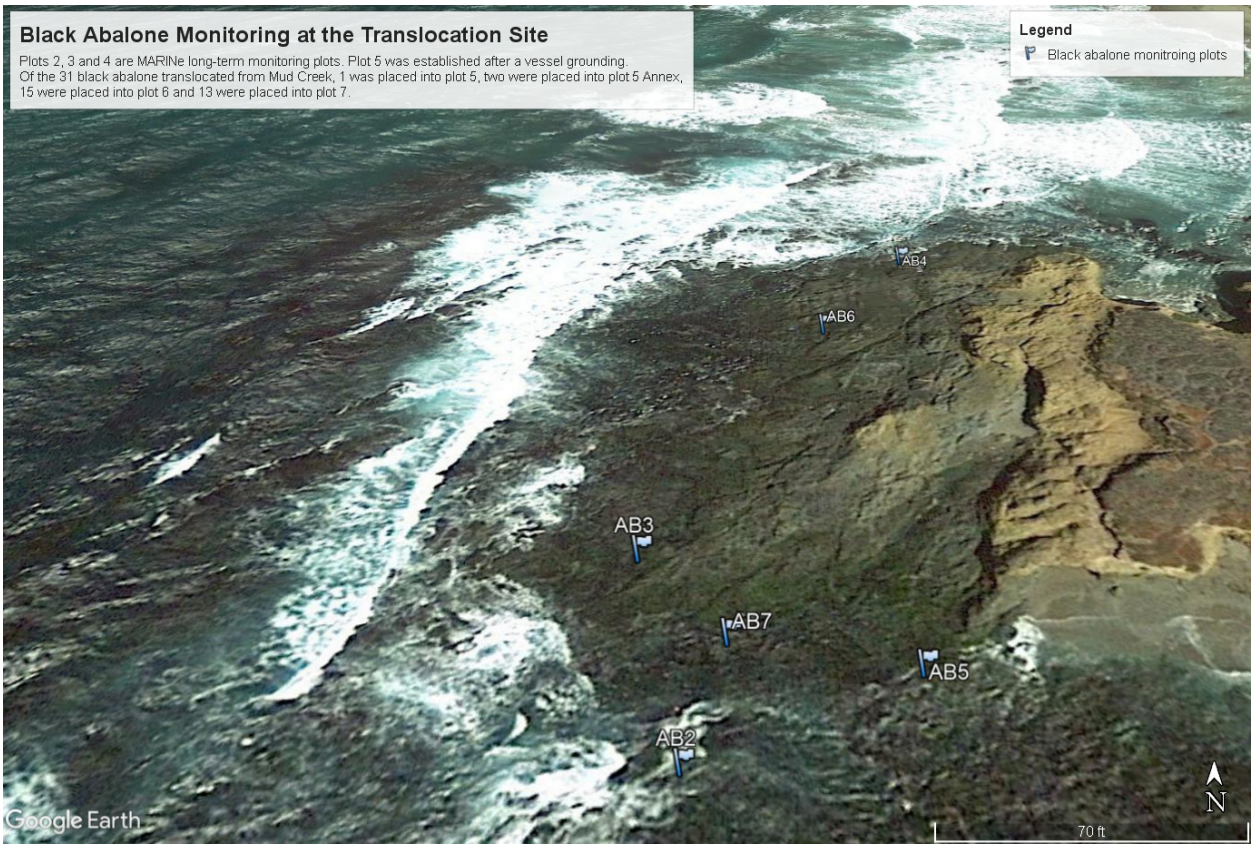

Figure 18. Showing Google image with locations of black abalone monitoring plots at the translocation site. Plots 2, 3 and 4 are long-term black abalone monitoring plots that have been surveyed by UCSC since 1997. Plot 5 was established after a vessel grounding damaged critical black abalone habitat. The black abalone rescued from Mud Creek were translocated into newly established plots 5A, 6, and 7.

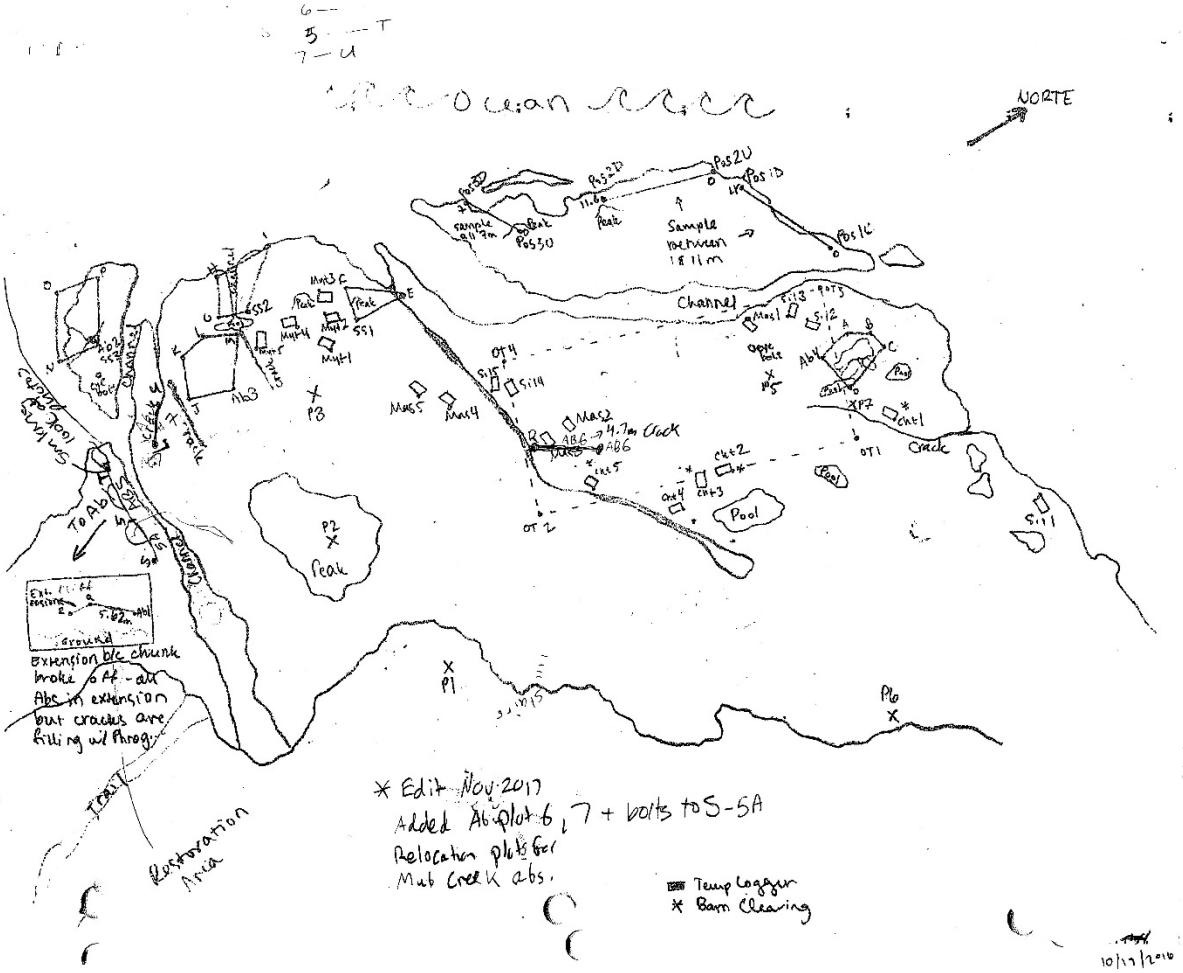

Figure 19. Hand drawn site map with locations of black abalone monitoring plots at the field translocation site. Plots 2, 3 and 4 are long-term black abalone monitoring plots that have been surveyed by UCSC since 1997. Plot 5 was established after a vessel grounding impacted black abalone critical habitat. The black abalone rescued from Mud Creek were translocated into newly established plots 5A, 6, and 7.

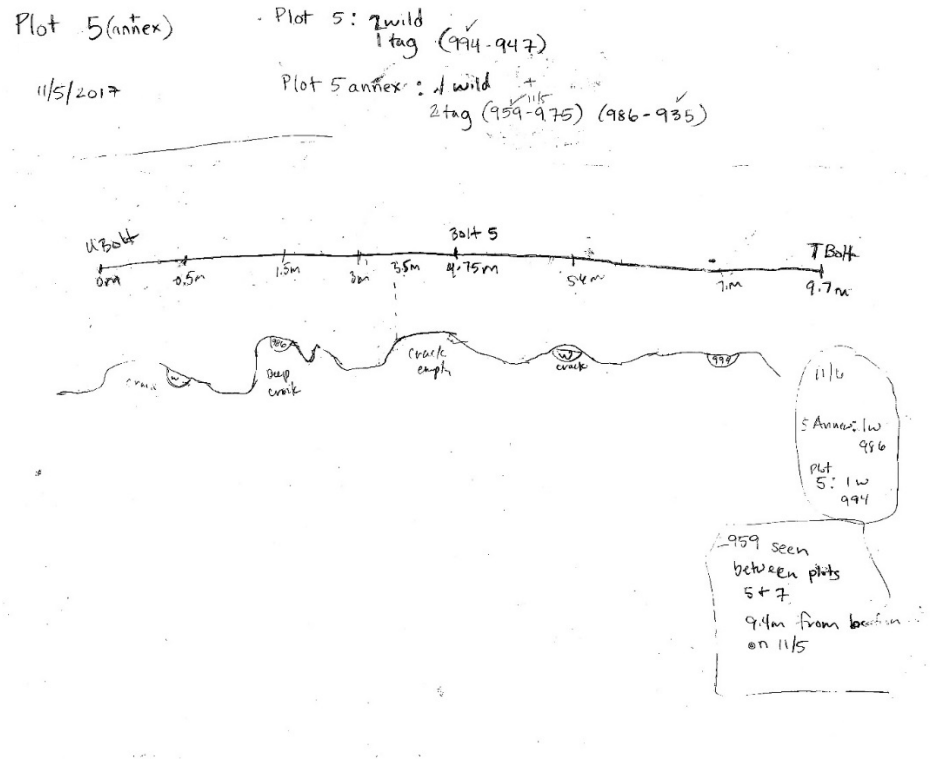

Figure 20. Hand drawn map with locations of black abalone within Plot 5 and 5A at the field translocation site. Plot 5 was established after a vessel grounding that impacted black abalone critical habitat. Plot 5 was extended (Plot 5 A) to add additional black abalone rescued from Mud Creek.

Figure 21. Overview panorama photo of Plot 5 and 5A at the field translocation site, taken by Christy Bell (UCSC) on November 5, 2017.

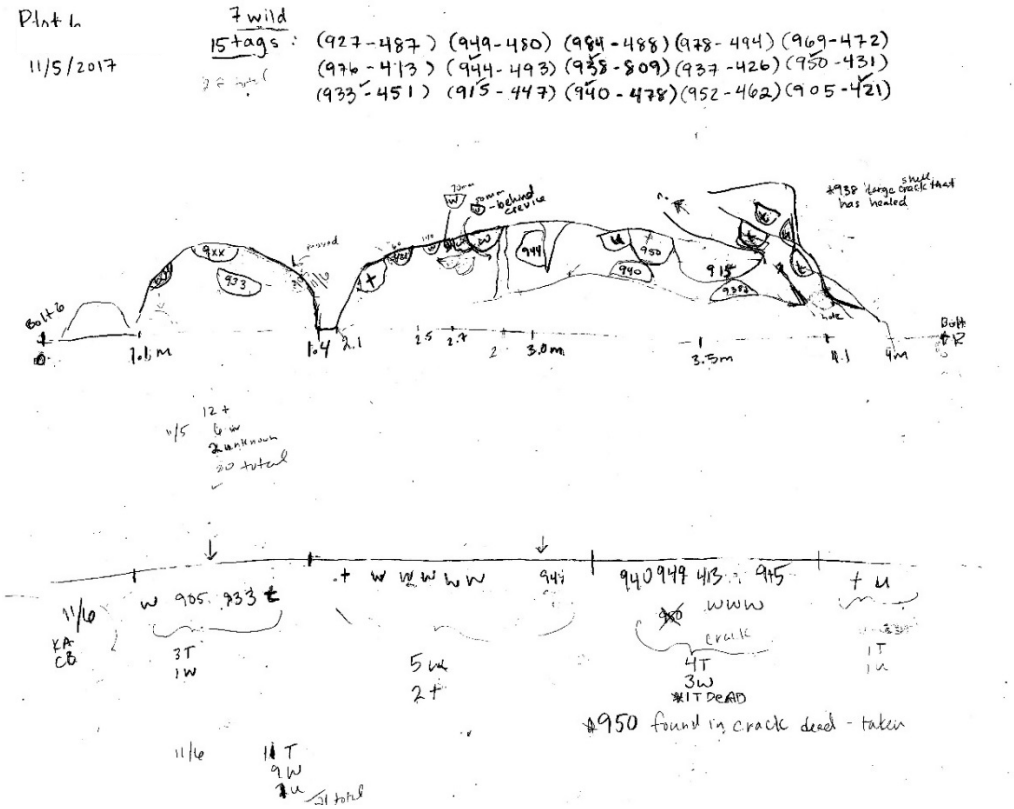

Figure 22. Hand drawn map of Plot 6, showing approximate locations of wild and tagged abalone at time of outplant with lower sketch drawn one day later.

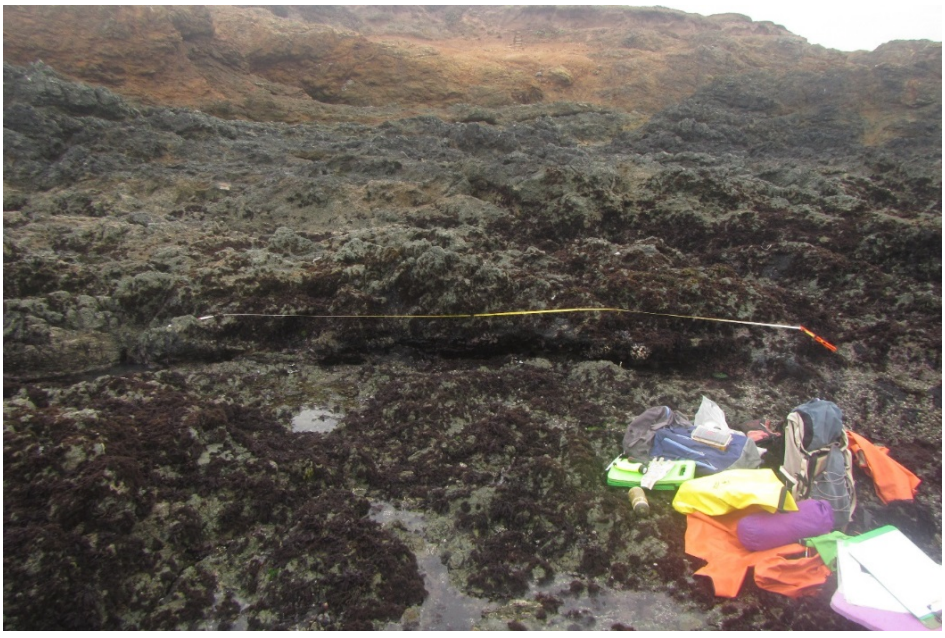

Figure 23. Overview photo of Plot 6 at field translocation site taken by Christy Bell (UCSC).

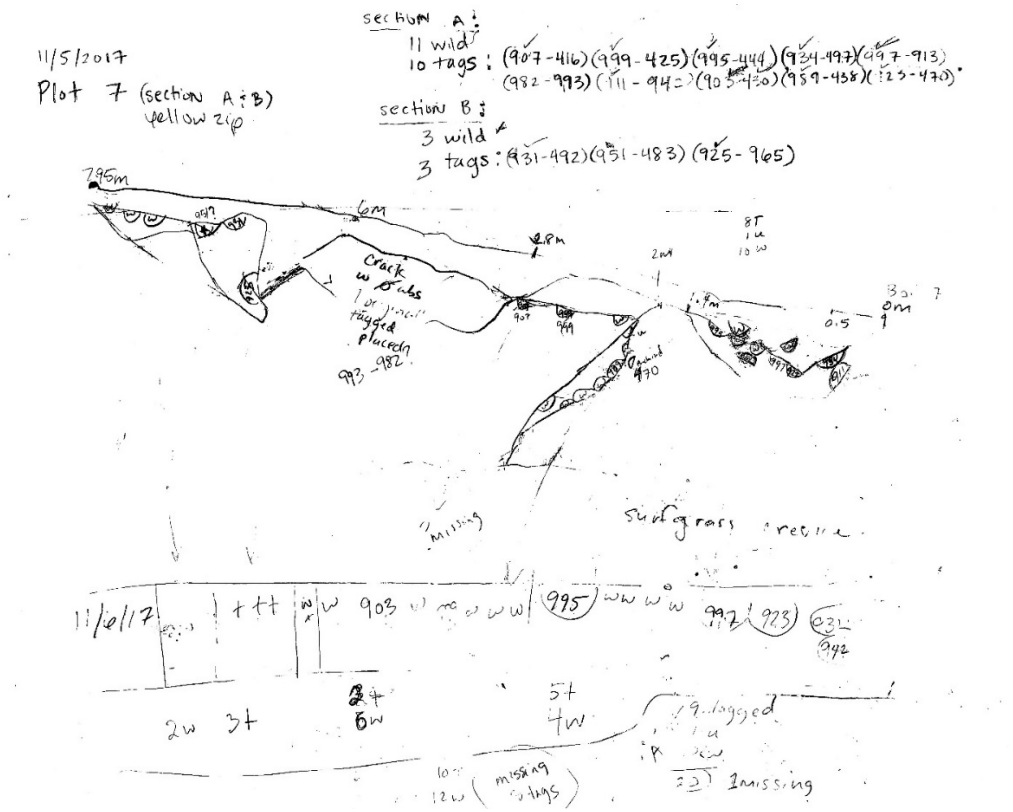

Figure 24. Hand drawn map of Plot 7, showing approximate locations of wild and tagged abalone at time of translocation with lower sketch drawn one day later.

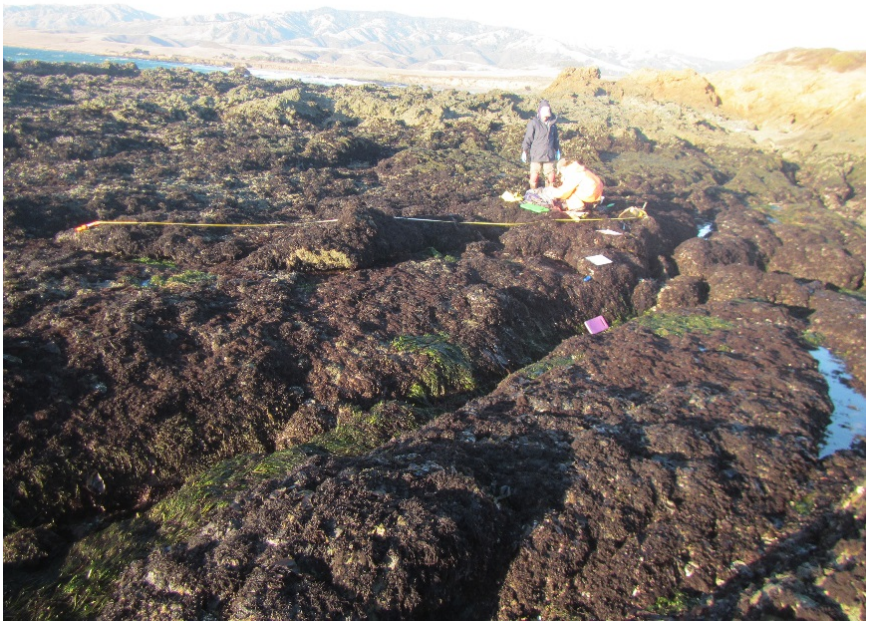

Figure 25. Overview photo of Plot 7 at the field translocation site taken by Christy Bell (UCSC) on November 5, 2017.

Appendix II: Protocols

2A: Black Abalone Population and Habitat Assessment Protocol (Raimondi et al. 2011, 2012, 2015, 2016, 2017, 2018 and 2019).

The purpose of this survey is to assess the abundance of black abalone as well as the abundance and spatial distribution of black abalone habitat. Compared to previous black abalone habitat surveys (central coast, north central coast), this method provides more extensive spatial coverage and is most appropriate for areas where black abalone are uncommon.

1. Abalone and habitat quality are surveyed within segments of rocky intertidal habitat. These are demarcated by natural obstacles (e.g. channels, cliffs), changes in the physical characteristics of the survey area (e.g. change of exposure, rock type), or areas of habitat not suitable for black abalone (e.g. sandy beaches). Note that segments will vary in length and may range from tens to hundreds of meters alongshore.

2. Photograph the start and end of each segment and mark each with a high and low GPS Waypoint (high start, low start, high end, low end. Segment waypoints will allow for an estimate of total linear distance sampled along the coastline and will be used to map polygons of the survey segment and calculate the total area sampled. Also have a GPS track running during the survey, this will help when mapping large survey segments.

3. Search for and record the number of black abalone found within each segment. Record the size of each abalone (to the nearest cm) and the habitat quality of its immediate location (good, moderate, poor). Nearest neighbor distance information should also be recorded for each abalone (A = touching, B = <10cm, C = <1m, D = <5m, E = >5m). If black abalone are rare it may be appropriate to photograph and mark the location of each abalone with GPS. Other species of abalone that are found in each segment should also be noted and if time allows the above information can also be recorded for other abalone species.

4. Subsampling abalone: if abalone are abundant, a subsample of the segment may be done by surveying a 10-meter swath of the segment for abalone.
    a. Upon initial inspection of the survey segment, determine if there are likely to be >50 abalone/10m of shoreline surveyed.
    b. If >50abs/10m of shoreline are present, use a random number generator (e.g. stopwatch, random number sheet) to select a distance from the segment start location to conduct the swath survey. Conduct one subsample for every 100m of survey segment.

c. Conduct additional subsamples if there are drastic changes in habitat characteristics within the segment. Continue to survey the remainder of the segment for habitat quality.
d. If a segment is not subsampled but 200+ abalone are counted, end the segment. Start a new adjacent segment or move onto the next natural segment.

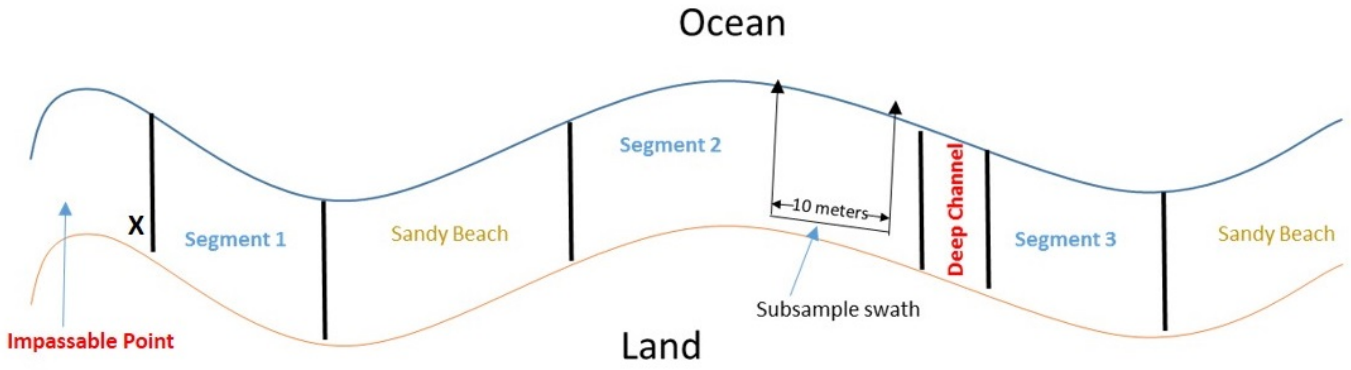

Figure 1. Survey setup example. X = predetermined starting point. Segments 1 & 3 had < 50 abs/10m of shoreline. Segment 2 had > 50 abs/10m of shoreline and was thus subsampled for abalone, but entire segment surveyed for habitat quality

5. At the completion of each segment, estimate the percent of the total area surveyed that is of good, moderate and poor habitat quality. The criteria used to distinguish these categories are:

   Good habitat –very suitable for abalone occupation/high refuge value. Any location where an abalone can live and receive protection from unsuitable environmental conditions and predation. These include cracks/crevices that are at least one hand length in depth (> 10-15cm) and are not too wide as to offer good protection to abalone. Note that such conditions may be found on the underside of boulders.

   Moderate habitat – moderately suitable for abalone occupation/moderate refuge value. Any location where an abalone can live and only receive moderate protection from unsuitable environmental conditions or predation. This includes cracks/crevices that are either not one hand length in depth or are too wide to offer the abalone good protection. May also include smaller pits or depressions in the rock (if big enough to

support an abalone), and the undersides or sides of boulders.

Poor habitat – minimally suitable for abalone occupation/low refuge value. Includes any location that offer little or no protection from unsuitable environmental conditions or predation (e.g. flat or bare surfaces), or areas outside the habitable zone for black abalone.

6. Also note and record additional segment characteristics:
    a. Substrate type (e.g. bedrock reef, boulders, mixed bedrock/boulders)
    b. Relief (high, moderate, low)
    c. Rock type
    d. Exposure (high, moderate, low)
    e. Sediment Influence (high, moderate, low)

2B: Black Abalone Collection, Holding and Tagging Protocol (NMFS et al. 2013 and 2015)

Introduction

The purpose of this protocol is to establish the collection and holding procedures that must be followed in order to minimize associated risks of mortality. The basis of this collection and holding protocol comes from an appendix to the white abalone recovery plan (2008) that provides information on the collection, shipment, and holding of white abalone as part of recovery efforts. This document is not meant to serve as a how-to manual. Instead, the intent is to manage the risks involved with collection, shipment, and holding in order to minimize stress and maximize survival of abalone during this process. This protocol has been adapted to apply to black abalone and other abalone species that inhabit the rocky intertidal area of the California coast.

Collection of abalone from the wild must be covered under a state broodstock collecting permit (issued only to registered aquaculturists in California; see California Fish and Game Code Section 5521.6) or a state scientific collecting permit, both issued by the California Department of Fish and Wildlife (CDFW). A federal permit is also required for species listed under the federal Endangered Species Act (i.e., white abalone and black abalone). These permits include specific stipulations such as where abalone may be collected, how many, and how they may be collected.

Collection of Abalone

Great care must be taken to avoid cutting the soft parts of this marine gastropod during removal from the substrate. Although abalone can move, they typically adhere to rocky substrate with their large muscular foot. When disturbed the abalone will use its foot to pull the shell down tightly against the rock substrate for protection. Once in this defensive position it is very difficult to remove the abalone without injuring it.

Traditionally abalone taken for commercial, sport, aquaculture, and research activities have been removed from the substrate with an abalone iron. This iron consists of a thin metal blade 1 – 2" across and 1/8 – ¼" thick that is inserted between the substrate and the foot of the abalone. A swift upward motion of the iron's handle is used to remove the animal from the substrate. In the hands of an experienced abalone collector, the abalone iron is a quick and efficient tool for obtaining abalone without injury. One disadvantage of this method is that the rocky substrate on which the abalone is perched may be uneven and the abalone iron may nick or cut the foot. Burge et al. (1975) found that commercial fisherman cut 12.6% of the pink abalone that they collected. Sports divers deeply cut 38% of the abalone in their bag limits.

Abalone often suffer mortality from wounds incurred during removal from the substrate. Abalone blood has no clotting ability (Cox, 1962) and relatively minor cuts can cause loss of

hemolymph, resulting in mortality. Burge et al. (1975) showed that mortality in sub-legal red abalone from half-inch cuts was 60% in the laboratory.

Unlike other California abalone species, black abalone live in the intertidal zone, typically in habitat with exposure to surf. Collection of submerged black abalone during high tide is unlikely to be a viable approach in most situations, and thus collection at low tide using an abalone iron or similar tool will likely be necessary. To minimize stress and trauma to the animals during collection and transport, the following methods are suggested.

Abalone iron or similar tool: This is the traditional way to remove abalone from the rock substrate. However, the risk of injury to abalone is high, both from nicks or cuts to the foot muscle tissue and chipping of the shell. Additionally, abalone exposed to air at low tide tend to adhere much more closely to the substrate than when underwater. The use of an alternate tool (e.g., a plastic kitchen spatula, blunted butter knife, or other tool with a wide blade and thin profile) instead of a traditional abalone iron may help to minimize cuts and trauma, and use of a tool with a thinner profile will be necessary to collect smaller individuals. It should be noted, however, that alternate tools may cause as much or more injury to abalone as traditional abalone irons and require care and experience in use to minimize injuries. The use of alternate tools should be discussed with agencies during the collection permitting process. With any tool that is used, the collector should take great care and adhere to the following guidelines to minimize injuries to abalone:

Approach: Abalone are sensitive to motion and changes in light. Approach an abalone slowly and do not cast a shadow so that the abalone does not go into a defensive posture (tighter adherence to substrate).

Point of insertion for the abalone iron or tool: Injury to the head and anterior portion of the foot should be avoided. The abalone iron or other tool should be inserted along the sides or back of the shell. Look for an area of rock that is smooth and free of depressions so that the tool does not cut into the foot where it has been inserted.

Handling of the abalone iron or tool: When the collector is in position, hold the iron or tool with the concave side down. Press the tip of the iron or tool against the rock substrate and slide quickly forward between the foot and the substrate. Still pressing downward, slide the iron or tool 2-4” under the shell. Quickly pull upward on the handle end of the iron or tool to pop the abalone off the substrate. This entire motion should be done quickly. The element of surprise is essential. If the iron or tool is inserted too slowly the abalone will clamp down and, in the resulting struggle, the abalone will invariably sustain damage to the foot.

Procedures Following Removal

Use of an Artificial Substrate: Once the abalone has been removed from the rock it will be placed in a container or ice chest for transport to the holding facility and then transferred again to a tank in the holding facility. The number of times that an abalone is removed from a surface can be minimized if an artificial substrate is provided. A thin piece of plastic or blade of kelp can act as a portable substrate for the abalone. Once the abalone is removed from the rock it can be placed directly on the plastic. The abalone can stay on the plastic in the ice chest.

Seawater Temperature: The seawater and/or ambient temperature where the abalone are collected should be noted (in advance if possible) so that the temperature in the ice chest can be matched to this temperature, plus or minus 2°C.

Holding abalone during transport: There are several options for holding and maintaining abalone during transport to a holding facility. Temperature control is essential and should be kept within two degrees of the temperature at the collection site. The temperature of black abalone held out of water for more than a few hours should be cold, e.g. 8-12C.

> **Ice chest with gel packs:** for holding times of up to 24 hours. This is the simplest and least expensive holding and transport system. Both juvenile and adult abalone from hatcheries are routinely transported in this manner. The primary objective is to keep the animals cool and moist. Frozen gel packs are used for cooling but should never come into direct contact with the abalone. Individual gel packs should be wrapped with newspaper in order to avoid extremely low temperatures followed by thawing of the gel. To wrap each gel pack, start with 6 – 8 sheets of newspaper. Fold the newspaper lengthwise so that it is one inch longer than the gel pack. Wrap the newspaper around the gel pack so that the two ends are open. Fasten the newspaper in place with packing tape. To ensure that only the ends of the gel pack provide cooling keep the newspaper dry. Used in this manner the gel pack will last 24 to 30 hours. The ratio of abalone weight to gel pack weight should be 2.5:1, that is, 2.5 pounds of abalone for every one pound of frozen gel pack (wrapped in newspaper). Gel packs should be placed on the bottom of the ice chest standing on edge against the walls of the ice chest. A large plastic bag (13 gallons or more) should be placed in the ice chest. Slightly moistened absorbent material, such as foam rubber or moistened towels or rags (preferred; to ensure the towels/rags are clean and free of detergent, soak them in bleach and rinse with fresh water prior to reusing), should be placed in the bottom of the plastic bag to absorb excess water from the abalone. If available, a layer of kelp on top of the absorbent material will give the abalone something to adhere to and provide moisture. For short transport times (8 – 12 hours) leave the bag open at the top to allow air into the bag. For transport times in excess of 12 hours the bags should be filled with oxygen and sealed. Components required are: Ice chest, gel-ice packs, plastic bags, and foam

rubber or moistened towels/rags. It may also be necessary to purchase or rent an oxygen tank and regulator.

Self-Cooling Ice Chest: For short holding times a self-cooling portable ice chest may be suitable to transport abalone. This system eliminates the need for frozen gel packs. Caution should be taken to determine the chilling capacity of the ice chest in advance of any collection activities. Packing of the abalone is similar to that outlined in 1), above. System components should include: Self-cooling Ice Chest. Components required are: self-cooling Ice chest, 12 VDC power source, plastic bags, and foam rubber or moistened towels/rags.

Tagging and Data Acquisition

Tags: It is essential to tag abalone following collection. If a more permanent tag cannot be applied immediately (see below), temporary multi-colored zip ties may be used and may be preferable because they are easy to attach and less likely to fall off (pers. comm. with Aaron Hovis and Chris Plante, Aquarium of the Pacific (AoP), on 22 November 2010). A base color (e.g., white) zip tie is passed through the top-most respiratory pores. Then, zip ties of different colors may be attached to the base color zip tie to create color-coded tags. More permanent tags may be placed on abalone once they are brought into the holding facility. The best example of a long-lasting tag is a Floy tag that can be fixed to the abalone shell with super glue gel. Retention may not be 100% but is very good and animals can be double tagged as a way to mitigate for tag loss (pers. comm. with Jim Moore, Bodega Marine Laboratory, on March 15, 2011). Another example of a long- lasting tag is made of a stainless-steel washer (approximately 5/8" in diameter) that has been stamped with an identifying number (Haaker et al., 1986). The tag is held in place with stainless steel wire by passing the wire through the top-most respiratory pores and through the tag. The wires are then twisted together so that the wire is tight against the shell and does not move. Trim the excess wire and bend the end against the shell so there is no sharp projection. There are multiple disadvantages to stainless steel washer tags in that the wires can wear down and fall off if the abalone move around a lot (pers. comm. with Aaron Hovis and Chris Plante, AoP, on 22 November 2010) and the wire can cause irritation to the animals.

Data Acquisition: The following data should be recorded for each collection: the GPS location of the site, ambient temperature, bottom type, the person who collected the abalone, tag ID, and any other relevant details. Data on the abalone (i.e., shell length, total weight, sex, and tissue samples) should be collected in the laboratory, which provides a more stable and cleaner environment for sampling.

Land-based Transportation of Abalone

Recommended transport times: When properly packed, abalone can be shipped without water for 24 hours with 100% survival. Shipping times for wild caught abalone should be kept to only a few hours to minimize stress.

Packaging: Careful attention should be given to packing the animals for transport. Packing procedure – Prior to handling the animal, prepare the shipping bag. Immerse three pieces of foam rubber sheet or three moistened, clean towels or rags (18" X 18", or appropriate size to fit the plastic bag) into the cold seawater of the holding tank. Squeeze the excess water from two pieces of foam or from two of the towels/rags and then place them in a plastic bag (2' X 2'6", 13 gallons or larger). Remove abalone from the temporary holding tank and drain excess water for 30 seconds. Place the abalone foot down on the two layers of foam or towels/rags. Several abalone can be placed side by side on the foam or towels/rags. Place the third piece of damp foam or towels/rags over the abalone. For trips shorter than 12 hours, no supplemental oxygen is required. Loosely close the plastic bag with a rubber band so that a small amount of gas exchange can occur. Oxygen may be added for trips greater than 8 hours. To fill the bag with oxygen, gather the open end and insert the tube from the oxygen regulator into the bag while holding the bag shut around the tube. Fill the bag with oxygen then press all the oxygen out of the bag, and fill again. Seal the bag by twisting it, making a small loop and securing the loop with a strong rubber band to prevent the escape of any gas. Once the abalone are sealed into the plastic bags, they should be placed in a Styrofoam box or ice chest. Place the abalone in a single layer in the container. Cooling is provided by frozen gel packs. The quantity and handling of gel packs is the same as that described above (i.e., an ice chest with gel packs).

Holding Facilities

Upon arrival at the holding facility, all newly acquired abalone should be quarantined in order to conduct a health and gonad examination, collect data and a tissue sample. These procedures are necessary to ensure newly acquired abalone are healthy and to protect those abalone that are already in the facility from exposure to disease and parasites. The following provides methods for quarantine, health and gonad examination, and tissue sample collection, as well as methods for removing boring organisms from abalone shells and proper holding conditions to minimize stress to abalone.

Quarantine: All newly acquired abalone should be held separately from those already in the facility for a period of three months. This will provide enough time for the new abalone to be assessed for the presence of potential disease agents. During the quarantine period, all equipment should be washed with 100 ppm chlorine and rinsed with seawater after use in the new abalone tanks. Note: Technicians should observe good husbandry practices and wash hands in freshwater before and after working in each tank, as well as use separate tools for each tank system.

Health and Gonad Examination and Tissue Sampling: Upon arrival of the abalone at the holding facility the health and spawning condition of the abalone should be assessed, a tissue sample collected for genetic analysis, and data on shell length, total weight, and sex recorded. The soft tissues of the foot and epipodia should be examined for any nicks, cuts, or abrasions resulting from collection. Any findings should be noted on a data sheet that contains the abalone tag ID and the date and location of collection. The total weight and shell length should be determined along with information about the appearance of the shell. For example, if the growing edge of the shell is sharp, this indicates that the animal has recently grown. If the edge is rounded, it indicates that some time has passed since the shell grew. The extent of fouling of the shell by boring sponge, boring clams and boring polychaetes should be noted.

The gonad index (GI) of each abalone should be noted. Several methods have been developed to measure gonad ripeness. Uki and Kikuchi (1982) developed a convenient scale as follows:

Gonad Ranking	Description of Gonad and Spawning Activity
0	No gonad observed. Not possible to determine sex. Abalone will not spawn.
1	Small volume of gonad observed. Possible to determine sex of abalone by gonad color. Males have a light tan or creamy colored gonad; females have a darker gonad from brown to green in color. Abalone will not spawn.
2	Larger volume of gonad. Easy to distinguish sexes. Gonad bulk visible. Abalone may spawn.
3	Volume of gonad quite large, may extend below the lower plane of the shell. Abalone will probably spawn.

In some cases, the abalone will very effectively resist moving the body mass in order to observe the status of the gonad. In those cases, record “gonad could not be observed”.

A tissue sample should be collected from each newly acquired abalone. Tissue samples will provide valuable genetic information about the population structure of the abalone. A non-lethal tissue sampling methodology has been developed that uses one of the abalone’s many epipodal tentacles. While this sampling method poses minimal risk to the abalone, it should only be carried out by someone skilled in handling abalone. The method is as follows: With a pair of tweezers, grasp the end of one of the epipodial tentacles on the sides or posterior of the animal. While gently pulling the tentacle taut, use a nail clipper to cut the tentacle 1 – 2 mm from its base. Place the tentacle in a microfuge tube with 1-2 ml of a high salt buffer 5XNET, pH 8 solution. This buffer will

preserve the DNA in the sample indefinitely. When specifically instructed to do so, 95-100% non-denatured ethanol can be used instead. Seal the top of the tube and record the animal tag ID, location, and date on the tube label. Refrigerate the tube. Materials needed: 4 plastic containers (50 ml each) with tops; 10 plastic droppers; 50 microfuge tubes; and 100 ml buffered 5XNET, pH 8 solution, composed of 2.5 Molar NaCl, 0.25 Molar EDTA, and 0.25 Molar Tris pH 8.

Detection of the Agent of Withering Syndrome

The agent of withering syndrome (WS-RLP, or, more recently CaXc, for *Candidatus Xenohaliotis californiensis*) is thought to be present in all abalone populations from Mexico to north-central California. The CaXc infection status of captive populations can be efficiently assessed by PCR analysis of feces collected from holding units. Contact Blythe Marshman at the CDFW Shellfish Health Laboratory (blythe.marshman@wildlife.ca.gov, 707 875-2066) for a current protocol and to arrange shipping the samples to a testing laboratory.

Holding Conditions: Conditions under which abalone are held should mimic day to day and seasonal variations in the natural habitat. Consideration should be given to control temperature, dissolved oxygen, feeding, waste removal, bacteria, lighting conditions, and handling methods.

Temperature: In general, the desired range for holding abalone is 14°C - 17°C. The effect of temperature on the occurrence of withering syndrome must be considered. In red abalone, withering syndrome is exacerbated or even induced in RLP infected animals when held at water temperatures greater than 16 °C.

Dissolved Oxygen: Dissolved oxygen should be at or within 10% of saturation. Aeration can be used to both provide oxygen and water movement within the holding tank.

Feeding: The types of feed used, the frequency of feeding, amount of feed consumed, and treatment of the food should be considered as follows:

Feed Types: The dietary preferences of black abalone are not clearly understood. *Laminaria* sp., *Egregia* sp. and *Macrocystis* sp. probably make up a large portion of the diet but, in general, abalone consume many different kinds of macroalgae, including a variety of red, green and brown algal species. Abalone of many species grow very well on a diet of dulse (*Palmaria mollis*), which is more nutritious than kelps (Burton et al. 2008).

Frequency of feeding: The frequency of feeding should be once or twice a week depending upon the rate of consumption and stability of the food.

Quantity of Feed: Black abalone are not aggressive feeders and should be fed ad libitum. Most feeding may take place at night. It is important to measure the quantity of feed consumed to get a feeling for the health of the abalone. One of the first signs of withering syndrome is loss of appetite.

Water Flow and Aeration: Flowing water provides aeration while removing solid and dissolved waste products. Water flows should be sufficient to provide and maintain good water quality conditions (temperature, oxygen, ammonia, suspended solids). In most tank systems aeration should also be provided to provide additional oxygenation and emergency oxygenation in case of water flow failure. In some farm systems aeration is provided on a period basis, e.g. on five minutes every half of an hour.

Waste Removal: A byproduct of protein metabolism, the ammonium ion (NH3-N), is extremely toxic to abalone. Solid waste should be prevented from accumulating on the tank bottom since this can quickly turn anaerobic and produce toxic ammonia compounds. This can be achieved by using a small pump to recirculate water within the tank. If the holding tank is not self-cleaning (i.e. waste is not being filtered automatically), then waste should be removed with a siphon daily.

Handling Methods: Abalone must be handled with great care since their tenacious hold on the substrate and tender flesh make a combination that may result in nicks or cuts in the hands of an unpracticed worker. To reduce the possibility of wounding an abalone, only people skilled in the handling of abalone should move the abalone. If abalone are held in plastic or fiberglass tanks a thin metal or plastic kitchen spatula can be an effective tool to quickly remove abalone from a tank. If a spatula is used it should be inserted from the rear or sides of the animal. Never insert a spatula under the head.

Processing of Dead and Moribund Animals: All animals that are found dead or moribund (unresponsive, unable to attach to tank walls) must be processed as instructed by CDFW in order to maximize the amount of genetic and health information obtainable, dependent upon the resources available. If possible formalin fixation of the gut tissues is preferred if supplies, training, and safety protocols are available. If not, freezing the entire abalone (at -20C or cooler for subsequent processing by CDFW) will provide less information, but allow for determination of the presence and severity of infection with the agent of withering syndrome, CaXc. Sampling should be coordinated with the CDFW Shellfish Health Laboratory (Point of contact: Blythe Marshman, blythe.marshman@wildlife.ca.gov, 707 875-2066).

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2C: Abalone Shell Notching Protocol

Materials: Dremel tool, tapered bit, safety goggles, dust mask

Time: It takes approximately one to two minutes per abalone

Considerations: It is best to notch them prior to tagging to avoid smudging the glue. In addition, it may be better engrave shells with triangles or other symbols (or a combination of unique symbols) on multiple locations of the shell to make it easier to identify translocated individuals in crevices. It is recommended that notches are made along various edges of the shell margin (but avoid notching near the head or close to the respiratory pores) to make identification easier. It is also recommended to notch them far enough away from the mantle to avoid having them filled in or covered over by new shell.

1. Remove an abalone from the tank
2. Dust mask and safety goggles should be worn by processor
3. Processor should hold abalone firmly in one hand and oriented so that the edge of the shell and the foot can be seen to avoid possible injuries (note: once the Dremel touches the shell the abalone tend to retract)
4. The size of the abalone will dictate how big the notch can be. If possible, try to make a distinctive notch that is approximately 2-5 mm wide or possibly two separate 2 mm slits spaced at least 5 mm apart (abalone will eventually repair the notch, but the visible scar can still be used for identification purposes)
5. Using the Dremel tool make a notch on the edge of the shell margin away from the head and respiratory pores (taking care not to injure the foot)
6. It is difficult to notch the shell uniformly and the final notch shape for each abalone should be photographed and noted on the datasheet (and during the tagging process be sure to include the corresponding tag numbers for each individual)
7. The abalone is now ready to have tags applied

After tagging take several photographs of each abalone to show the notches and tags.

2D: Abalone Tagging: Floy® Tag Protocol (Courtesy of Ian Taniguchi (CDFW)).

Materials: Floy® shellfish tags, CorAffix glue, paper towels, calipers, gloves, tweezers, small tubs

Considerations: Other materials may work better and new technologies may be available, so it is recommended that other options (mentioned in the lessons learned section) are explored.

1. Remove an abalone from the tank and measure maximum shell length with calipers (in mm). Record. The working surface may need mesh or cloth to prevent the abalone from adhering to the surface and requiring force to move and remove, when done.
2. Select tags and record numbers and/or colors on datasheet
3. Thoroughly dry off the flattest area of the shell nearest to the shell rim. Use of a Dremel tool to make a small depression in the shell is recommended, both to ensure adhesion of the glue and to reduce the profile of the tag and increase its durability.
4. Place a dab (roughly the size of the tags) of CorAffix onto the dried off area of the shell.
5. Using tweezers, place the tag onto the CorAffix and press down with the tips of the tweezers.
6. Place the abalone in a dry tub, on a damp towel or other surface that makes it easy to remove the abalone without damaging the foot, until the CorAffix is dried to prevent smudging. Monitor the abalone so they don't escape.
7. Once the adhesive is dried, photograph the abalone to show the notch and tags.
8. Place the tagged abalone back into the water into its assigned module.

Appendix III: List of Equipment Needed

3A: Personal Gear

1. Warm Layers
2. Sun Hat and/or Wool Hat
3. Sunscreen
4. Drinking Water
5. Foul weather gear (may be needed)
6. Boots
7. Safety Vest
8. Tyvek® (may be required for oil spills)
9. Personal Flotation Device or PFD (may be required by site safety officer)
10. Hardhats (may be required by site safety officer for landslides or oil spills)
11. Duct Tape (especially if Tyvek® is required)
12. Watch (for generating random #s, keeping track of tide, to record length of time to survey a given segment, etc.)

3B: Abalone Assessment Surveys

1. Digital waterproof Cameras (2 or more)
2. GPS Unit (1-2)
3. Flashlights (1/person)
4. Headlamps (1/person)
5. Rulers or Calipers (1/person)
6. Chalk or Yellow Lumber Crayons – for marking rocks, to avoid double counting
7. Data Binder for permits, tide tables, overview photos of permanent plots (if they exist), datasheets printed on waterproof paper (field log, photo log, abalone search, abalone habitat characterization, abalone plots, blank waterproof paper, previous data if it exists)
8. Meter tapes (four 50 m tapes and two 30 m tapes)
9. Kneeling pads (1/person)
10. Pencils
11. Clipboards
12. Extra batteries for all electronics (cameras, GPS units, lights, headlamps, etc.)
13. Backpacks
14. Hard hats and reflective vests (may be required for Landslides and Oil Spills)
15. Watch (with stop-watch feature is helpful – for generating random numbers if subsampling is needed)
16. Laptop for downloading images and communicating via email while in the field

3C: Abalone Rescue/Transport

1. Ice chests, for transporting abalone (can be left in vehicles)
2. Back packs, mesh bags, or soft sided coolers with straps- to carry rescued abalone (wrapped in wet towels) to the ice chests in the vehicles.
3. Gel Ice packs with enough newspaper to wrap them in (to keep ice chests and abalone cool).
4. Clean Towels or rags to wrap abalone (bring what you can)
5. Abalone irons, cake spatulas, plastic kitchen spatulas, plastic putty knives, dulled butter knives or other flat and blunt edged tools for removing abalone (experts' choice)
6. 1ml cryovials pre-filled with 1ml absolute, non-denatured ethanol is recommended for non-lethal genetic tissue samples (it is not necessary to pre-label the vials unless the number of samples to be taken is known in advance)
7. Datasheets printed on waterproof paper and blank waterproof paper to keep track of rescued animals (ex. Attached; date, abalone condition, abalone shell length, segment collected from, samples taken (genetic, fecal, etc.), photos taken, transported to, etc.).

3D: Tagging

1. Floy® Shellfish tags FT-LF-97 (small numbered, laminated vinyl, flexible, oval tags) available in various sizes, colors, numbers, etc. from http://www.floytag.com/)
2. Pit tags and Pit tag reader
3. CorAffix glue or DEVCON® 5 minute (clear drying, high strength, all purpose) epoxy (can purchase on Amazon) for attaching Floy® tags
4. Zspar Splash Zone Marine epoxy to attach PIT tags (if used)
5. Dremel tool for notching shells (battery operated Dremel is better if available) and **protective goggles** and **dust masks**!
6. Tweezers/Forceps for tagging and collecting tissue samples
7. Scissors/Scalpels for taking samples and something to sterilize them in between animals
8. A box of nitrile gloves to wear while tagging and taking samples
9. Paper towels and/or clean rags (for drying abalone before tagging, and for placing abalone while glue dries, etc.)
10. Buckets or small tubs for abalone to be held in during tagging
11. Small colored zip ties for back up temporary tagging method
12. Digital camera for photographing dorsal and ventral sides of black abalone
13. Ruler for scale in photographs
14. Additional rulers or calipers for measuring each of the rescued black abalone
15. Datasheet to keep track of tagged individuals.

3E: Translocating/Crack Preparation/Marking Plots

1. Portable electric drill (24v or 36v)
2. Drill bits 3/8”
3. Stainless Steel Hex Bolts (recommend, 4”-6” long and 3/8” diameter)
4. Hammer
5. Squirt bottle
6. Marine epoxy
7. Nitrile gloves
8. Meter tapes
9. Scrapers
10. Wire brushes
11. Protective goggles

Appendix IV: Datasheets

MARINE Rocky Intertidal Field Log

(Fill in all blanks: ----=No Data; **0**=None: **L**=Low; **M**=Med; **H**=High; or Actual Value)

Site: _____ Date:_____ Time:_____ to _____ Low Tide:_____(ft) at _____(hr)
Participants (Recorder 1st):_____

Weather and Sea Conditions (affecting quality of sampling) (use codes listed above)
Swell/Surge: _____ Wind:_____ Rain:_____ Recent Rain:_____ Water Temp (°C):_____
Substratum Changes (sediment=sand, gravel, cobble) (magnitude at site)
Sediment Level: _____ Scour:_____ Rock Movement:_____
Debris and Pollutants (magnitude at site):
Plant Wrack:_____ Driftwood:_____ Shells:_____ Dead Animals:_____ Trash:_____ Oil/Tar:_____
Notes on Physical Conditions: _____

Birds and Mammals (maximum # seen at any one time during the sampling) (see bird/mammal list for other species)

Pelican	Great Egret	Blue Heron	Lg Shorebird	Sea Otter
Cormorant	Snowy Egret	Oystercatcher	Sm Shorebird	Harbor seal
Gull	Tern	Other Birds	Dog	Sea lion
				Elephant seal

Marine Mammal Observations and Disturbances

species	time	age/sex	0	1	2	3	notes
harbor seal							
sea lion							
elephant seal							

Bird/Mammal Notes: _____
Sea Stars (if plots not done) Diseased species: _____
Healthy species: _____
Humans (maximum # seen at any one time during the sampling; note behavior) Reef: _____ Sand:_____

Collections

species	number collected	collector	notes

Non-Native Species Presence	yes	no		yes	no
Sargassum hornerii			*Caulacanthus okamurae*		
Sargassum muticum			*Didemnum vexillum*		
Undaria pinnatifida			*Lomentaria hakodatensis*		
Watersipora spp					

Plot Marker Loss/Repair Notes: _____

Other Notes: _____

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Survey Checklist

Photoplot photos		Owl Limpets		Site Pans	
Photoplot scoring		Abalone plots/time search		Plot overviews	
Barnacle close-ups		Sea star plots/time search		Repairs	
Transects		Mobile inverts		Temp Logger	

MARINE Rocky Intertidal Field Log Definitions

Codes

No Data (----): Draw a horizontal line through any blank area to indicate that this category was not evaluated or does not apply.
None (0): None were found within the defined site boundaries.
Low (L): Relatively few or low levels were found within the defined site boundaries.
Med (M): Medium numbers or moderate levels were found within the defined site boundaries.
High (H): High numbers or high levels were found within the defined site boundaries.

Weather and Sea Conditions (emphasis on those affecting quality of sampling)

Swell/Surge: L/M/H relative levels of water movement over seaward portion of site.
Wind: L = ≤10 knots M = 11-20 knots H => 20 knots
Rain: L/M/H relative amounts of precipitation at the site during the survey.
Recent Rain: Evidence or knowledge of L/M/H amounts of rain at the site within the past few days.
Water Temp: Actual seawater temperature (°C) or L = ≤14°C (57°F) M = 15-18°C H = >18°C (64°F).

Substratum Changes

Sediment Level: L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.
Scour: L/M/H relative extent of scoured reef surfaces within the defined site boundaries.
Rock Movement: L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: L/M/H levels of unattached algae or other drift plants within the site.
Driftwood: L/M/H levels of sticks, branches, and logs within the site.
Shells: L/M/H levels of dead shells, especially mussel shells.
Dead Animals: L/M/H levels of dead invertebrates, fish, birds, or mammals.
Trash: L/M/H levels of human debris including cans, bottles, plastics, and metal items.
Oil/Tar: L/M/H relative extent of fresh or weathered oil/tar within the site.

Birds and Mammals

Core categories are listed and must be scored. Record maximum number seen at any one time during the sampling, preferably upon arrival at site. Other more specific categories or species may be added, but must define linkage to core taxa. Only score species within the defined site, either onshore or within 50 m of shore. Note relevant behaviors.

Marine Mammal Observations and Distrubances

For each species, record total # of individuals observed/disturbed by category. Record time of the event, sex/age of the individuals when possible, and any notes (location relative to site, injuries, etc.). Categories are:

0 = observation by researchers, no reaction by pinniped
1 = pinniped reacted to presence of researchers with movement <1 meter
2 = pinniped reacted to presence of researchers with short movement of 1-3 meters
3 = pinniped flushed to the water or moved >3 meters in retreat

Collections

For any collections made, record species, number collected, collector's name, and any notes (project, purpose, etc.)

Humans

Record maximum number of people seen at any one time during the sampling. Especially check at low tide. Separate counts for people on rock and on sand. Note relevant behaviors. Note also if people present upcoast or downcoast of the site.

Plot Marker Loss/Repair, Other Notes, and Survey Checklist

These are optional categories. Information may or may not be added to the database as text entries.

Non-Native Species

For each species listed, note whether they are present (yes) or not observed (no)

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Overview Photo Log

Site: _____

Date: _____

Overview #	# of photos taken	Notes (mistakes, orientation (portrait/landscape), etc.)

Overview # will be sequential; it can be an overview for relocating a plot, a panorama, a close up of abalone or other photo or set of photos to document anything of importance at a site. This photo log will help when labeling and organizing photos at a later time.

Location:__________ Samplers__________
Date:__________

seg. #	start WP	start time	end WP	end time	# abalone	Habitat Characterization % good	mod.	poor	substrate	relief	rock type	exposure	sediment	notes

Abalone Search

Location:_____ **Date:** _____

Samplers:_____ **Recorder:**_____

Section_____ **# Searchers:** _____

Start WP_____ **End WP**_____ **Search Time:**_____

Subsample Area:____m x_____m = _____
Abalone Found (record size, nearest neighbor)

Total_____
Comments/Notes:

Section_____ **# Searchers:** _____

Start WP_____ **End WP**_____ **Search Time:**_____

Subsample Area:_____m x_____m = _____
Abalone Found (record size, nearest neighbor)

Total_____
Comments/Notes:

Record size in mm to nearest 5mm for abalone <40mm and to nearest 10mm for abalone >=40mm,
Nearest neighbor: A=touching, B=< or = 10cm, C= >10cm but <1m, D=>1m but <5m, E=>5m and
Habitat Quality: G=Good, M=Moderate, P=Poor

Mud Creek Rescue

Site:__________ Date:__________ Samplers:__________

Segment ID	species	Ab ID number	Ab condition	AB- size (mm)	sample taken (fecal, genetic, other)	collected by	group affiliation	transported to	comments

Black Abalone Tagging

Date Tagged:___________________ Recorder:__________________________ Samplers(name-affiliation): ____

Collected From:___________________Collected on:___________________ Transported to and Held at: ____________________________

Ab ID #	AB - size (mm)	Floy tag #1	Floy tag #2	Shell Notched (y/n)	Dorsal and Ventral (photo numbers)	Photographer	Ab Condition (withered, fatally damaged, damaged, ok)	Sacrificed Date	Sample Taken (fecal, genetic, other, none)	Tagged By	Group Affiliation	Transported To (lab or field site)	Date Transported	Comments

Translocated Black Abalone Monitoring

Date:_____ Sampler:_____ Recorder:_____

Plot 5: (994-947) + 1-2 wild
Plot 5 Annex (5A): (986-935) + 1wild
Plot 6: (927-487), (949-480), (984-488), (978-494), (969-472), (976-413), (944-493), (938-809), (937-426), (950-431), (933-451), (915-447), (940-478), (952-462), (905-421) + 9 wild
Plot 7A: *(907-416), *(999-425), (995-444), (934-497), (997-913), *(982-993), (911-942), (903-430), (989-438), (923-470) + 10-11 wild
Plot 7B: (931-492), (951-483), (925-965) + 3 wild
Outside plots: (959-975) found 9.4 meters away from plot 5A (on the side of rock in drained surge channel between plots 5 and 7)
***missing, Died**

Plot # or GPS if tagged outside plot	Tagged found outside plot distance (m) from closest plot	Ab w=(wild), o=(outplant), unk=(unknown)	Floy tag visible (y/n) (record #)	Shell Notch visible (y/n)	Photo(s) taken (photo #s)	collected (y/n)? if yes, by who (name, affliation)

Notes or comments: