

**Papahānaumokuākea Marine National Monument**  
RESEARCH Permit Application

**NOTE: *This Permit Application (and associated Instructions) are to propose activities to be conducted in the Papahānaumokuākea Marine National Monument. The Co-Trustees are required to determine that issuing the requested permit is compatible with the findings of Presidential Proclamation 8031. Within this Application, provide all information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Papahānaumokuākea Marine National Monument (Monument).***

**ADDITIONAL IMPORTANT INFORMATION:**

- Any or all of the information within this application may be posted to the Monument website informing the public on projects proposed to occur in the Monument.
- In addition to the permit application, the Applicant must either download the Monument Compliance Information Sheet from the Monument website OR request a hard copy from the Monument Permit Coordinator (contact information below). The Monument Compliance Information Sheet must be submitted to the Monument Permit Coordinator after initial application consultation.
- Issuance of a Monument permit is dependent upon the completion and review of the application and Compliance Information Sheet.

**INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED**

Send Permit Applications to:

Papahānaumokuākea Marine National Monument Permit Coordinator  
6600 Kalaniana'ole Hwy. # 300  
Honolulu, HI 96825  
nwhipermit@noaa.gov  
PHONE: (808) 397-2660      FAX: (808) 397-2662

**SUBMITTAL VIA ELECTRONIC MAIL IS PREFERRED BUT NOT REQUIRED. FOR ADDITIONAL SUBMITTAL INSTRUCTIONS, SEE THE LAST PAGE.**

## **Papahānaumokuākea Marine National Monument Permit Application Cover Sheet**

This Permit Application Cover Sheet is intended to provide summary information and status to the public on permit applications for activities proposed to be conducted in the Papahānaumokuākea Marine National Monument. While a permit application has been received, it has not been fully reviewed nor approved by the Monument Management Board to date. The Monument permit process also ensures that all environmental reviews are conducted prior to the issuance of a Monument permit.

### **Summary Information**

**Applicant Name:** Donald Potts

**Affiliation:** Institute of Marine Sciences, University of California, Santa Cruz

**Permit Category:** Research

**Proposed Activity Dates:** 1 June 2009 - 31 December 2010

**Proposed Method of Entry (Vessel/Plane):** USFWS charter flights to/from Honolulu

**Proposed Locations:** Two patch adobereef sites in the Midway Atoll lagoon (shown in Fig. 1):

1. Patch reefs north and west of Rusty Bucket and West Beach.
2. Patch reefs at northwestern end of deep lagoon.

**Estimated number of individuals (including Applicant) to be covered under this permit:**

Variable: 2 primary people plus assistance from 6-8 people on Midway under existing permit PMNM-2008-056.

**Estimated number of days in the Monument:** Up to 120 days

**Description of proposed activities:** (complete these sentences):

a.) The proposed activity would...

... investigate and seek to explain the pattern of high recruitment but very low adult abundance of the black-lipped pearl oyster (*Pinctada margaritifera*) at Midway Atoll, using field experiments to: a) identify major predators and measure their rates of predation on juvenile oysters, and b) measure rates of natural survival, growth and mortality under several predation regimes. The immediate goal is to determine whether reducing or eliminating predation can increase survival and growth rates of juveniles.

b.) To accomplish this activity we would ....

... measure survival and growth rates of newly-settled, juvenile pearl oysters under three predation regimes (Uncaged; Caged with Large Mesh; Caged with Small Mesh) that expose the oysters to different size classes of pelagic (e.g. fish) and benthic (e.g. snails, crustaceans, starfish) predators. We will use juvenile pearl oysters that settle on existing spat collectors (under permit PMNM-2008-056) and transplant them to ceramic tiles placed on the reef. We will record survival and growth of each individual at 2-4 week intervals.

c.) This activity would help the Monument by ...  
... providing the first quantitative data on rates of juvenile survival, growth and mortality due to predation for the black-lipped pearl oyster on any PMNM reef, and by providing baseline data for evaluating potential methods for, and the likelihood of success for, future efforts to restore a species that is identified in the Monument Management Plan as over-exploited, and which is not recovering on its own (Keenan et al. 2006). Because large bivalve mollusks provide an important ecosystem service by removing particulates, contaminants, and plankton while filtering large volumes of water each day, successful restoration and monitoring of *Pinctada margaritifera* would also provide a viable bio-indicator of ecosystem health.

**Other information or background:**

This activity directly addresses the goals of Activity HMC-1 of the Monument Management Plan, namely “restoring the health and biological diversity of the shallow reefs and shoals where anthropogenic disturbances are known to have changed the ecosystem ...“

This activity is a direct outgrowth from our existing data on recruitment and distribution of pearl oysters at Midway that we collected in 2007 (permit PMNM-2007-013) and 2008 (permit PMNM-2008-056). Our previous results show that *Pinctada margaritifera* larvae are recruiting from the plankton onto many parts of the Midway reef, but that subsequent juvenile survival is very poor, and live adults are both rare and restricted to limited parts of the reef (So far, we have seen only six live and three long-dead adults). We have identified two areas with high juvenile recruitment rates, both in habitats that appear suitable for both juveniles and adults, although we have found live adults in only one of these areas.

We hypothesize that the most likely factor reducing survival of newly-settled pearl oysters and leading to low adult abundance is predation on small juveniles. We also propose that understanding the nature and magnitude of predation, and how its effects may be reduced, is a necessary precursor for any future effort to restore pearl oysters on Midway Atoll or other PMNM reefs.

## **Section A - Applicant Information**

### **1. Applicant**

Name (last, first, middle initial): Donald C. Potts

Title: Professor of Biology

#### **1a. Intended field Principal Investigator (See instructions for more information):**

Kristin M. McCully (Ph.D. student)

### **2. Mailing address (street/P.O. box, city, state, country, zip):**

[REDACTED]

Phone: [REDACTED] [REDACTED]

Fax: [REDACTED]

Email: [REDACTED]

For students, major professor's name, telephone and email address:

Donald Potts; [REDACTED] [REDACTED]

### **3. Affiliation (institution/agency/organization directly related to the proposed project):**

Institute of Marine Sciences  
and Department of Ecology and Evolutionary Biology  
University of California at Santa Cruz

### **4. Additional persons to be covered by permit. List all personnel roles and names (if known at time of application) here (e.g. John Doe, Research Diver; Jane Doe, Field Technician):**

\* Wendy Cover Field Assistant; AAUS Research Diver; DOI boat operator  
UCSC Ph.D. Student [REDACTED]

\* Kate Schoenrock    Field Assistant; AAUS Research Diver; DOI boat operator  
UCSC [REDACTED]

\* Helen O'Brien      Field Assistant; AAUS Research Diver  
UCSC Ph.D. Student [REDACTED]

Rachel Fabian      Field Assistant; AAUS Research Diver  
UCSC Ph.D. Student [REDACTED]

\* Anne Warner      Field Assistant  
Oberlin College [REDACTED]

\* Up to 5 volunteer field assistants (from Mitsubishi International Corporation) - to be named

\* = already permitted to work at Midway Atoll under Permit PMNM-2008-056

**Section B: Project Information**

**5a. Project location(s):**

<input type="checkbox"/> Nihoa Island	<input type="checkbox"/> Land-based	<b><u>Ocean Based</u></b>	
<input type="checkbox"/> Necker Island (Mokumanamana)	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> French Frigate Shoals	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> Gardner Pinnacles	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> Maro Reef			
<input type="checkbox"/> Laysan Island	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> Lisianski Island, Neva Shoal	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> Pearl and Hermes Atoll	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input checked="" type="checkbox"/> Midway Atoll	<input checked="" type="checkbox"/> Land-based	<input checked="" type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> Kure Atoll	<input type="checkbox"/> Land-based	<input type="checkbox"/> Shallow water	<input type="checkbox"/> Deep water
<input type="checkbox"/> Other			

NOTE: There is a fee schedule for people visiting Midway Atoll National Wildlife Refuge via vessel and aircraft.

Location Description:

We have chosen two areas for experimental sites (Fig. 1):

- 1) on patch reefs north of West Beach (WB in Fig. 1);
- and 2) on patch reefs in the northwestern end of the deep lagoon (PP in Fig. 1).

Both areas had high oyster recruitment in 2008, and both are similar to the habitats with the highest densities of pearl oysters on Pearl and Hermes Atoll, where pearl oysters are more common than at Midway (Keenan et al. 2006). We have found live adult pearl oysters only on reefs in the deep lagoon.

The first site, West Beach (WB), will be >300 m from the beach but within 1 km of 28°12'37.56"N, 177°23'32.21"W. The second site will be within 1 km of a reef we call "Pinctada Patch" (PP) at 28°14'45.82"N, 177°22'41.25"W, where four (of six) known live adults are living. We are unable to give more exact locations for experimental sites at this time because we need to locate specific sites with the following properties:

- 1). a protected, horizontal, hard substrate and low coral cover, where cages and tiles can be deployed without affecting corals or other organisms;
- 2). 3-7 m depth to minimize the possibility that waves, storms or other turbulence could disturb or damage them;
- 3). an adjacent sandy bottom for anchoring our boat at the experimental site during deployment and recovery of tiles and cages.

By conducting this experiment at two sites, we can begin to assess inter- and intra-habitat variation in juvenile growth and mortality on the reef and gain insights into the best sites for future studies and ultimate restoration.

**5b. Check all applicable regulated activities proposed to be conducted in the Monument:**

- Removing, moving, taking, harvesting, possessing, injuring, disturbing, or damaging any living or nonliving Monument resource
- Drilling into, dredging, or otherwise altering the submerged lands other than by anchoring a vessel; or constructing, placing, or abandoning any structure, material, or other matter on the submerged lands
- Anchoring a vessel
- Deserting a vessel aground, at anchor, or adrift
- Discharging or depositing any material or matter into the Monument
- Touching coral, living or dead
- Possessing fishing gear except when stowed and not available for immediate use during passage without interruption through the Monument
- Attracting any living Monument resource
- Sustenance fishing (Federal waters only, outside of Special Preservation Areas, Ecological Reserves and Special Management Areas)
- Subsistence fishing (State waters only)
- Swimming, snorkeling, or closed or open circuit SCUBA diving within any Special Preservation Area or Midway Atoll Special Management Area

## **6 Purpose/Need/Scope *State purpose of proposed activities:***

In the Monument Management Plan, Strategy HMC-1 is to "...develop and implement a strategy for restoring the health and biological diversity of the shallow reefs and shoals where anthropogenic disturbances are known to have changed the ecosystem." Activity HMC-1.1 specifically identifies *Pinctada margaritifera* as a species which has been negatively impacted by humans and may be in need of restoration. Surveys by Keenan et al. (2006) concluded that this species has not recovered since intensive harvesting in the late 1920s on Pearl and Hermes Atoll, the only reef in the Monument that was surveyed for *P. margaritifera* before 1990 (Galtsoff 1933).

*P. margaritifera* is a valuable and important part of the coral reef ecosystems of the Monument because large bivalve mollusks filter large volumes of water each day and sequester remove particulates, contaminants and plankton. For this reason, mollusks are often used as indicators of ecosystem health (e.g., NOAA's Mussel Watch Program), and Sarver et al. (2003) concluded that *P. margaritifera* appears to be a suitable organism for heavy metal pollution monitoring.

To design or conduct a successful restoration program, the Monument will require detailed prior knowledge of: a) the biology of this species, including timing and rates of reproduction, recruitment, survival, growth, and juvenile and adult habitats; b) its community interactions with other species (e.g. predators, competitors, pathogens); and c) its responses to potential transplantation and restoration methods.

While some of this biological information is known from the south and western Pacific, where *P. margaritifera* is commonly used for pearl culture, no analogous information is available specifically for the Hawaiian Archipelago, where conditions may be very different. The only studies of Hawaiian *P. margaritifera* are surveys of adult distribution on Pearl and Hermes Atoll (Galtsoff 1933, Keenan et al. 2006) and other reefs in the Monument (Keenan 2008); similar surveys in Kane'ohē Bay, O'ahu (Rodgers et al. 2000); and one study of the value of *P. margaritifera* for monitoring heavy metal pollution (Sarver et al. 2003).

Another reason why data from other parts of the Pacific may not be applicable is that several taxonomists have proposed that black-lipped pearl oysters in the NWHI are an endemic species or subspecies. *P. galtsoffi* was described as a distinct species by Bartsch (1931), and this usage is retained in several biodiversity databases (e.g. OBIS, ITIS). However, recent usage in Hawaii tends to treat it as a subspecies *P. margaritifera galtsoffi* (e.g. Gervis and Sims 1992).

Our ongoing research at Midway Atoll includes the serendipitous discovery of newly settled pearl oysters on experimental tiles in 2006-07, followed by a targeted study (2008-09) of *P. margaritifera* settlement and recruitment on spat collectors at multiple sites around the atoll (Fig. 1). In 2008, there was relatively high recruitment (0.7-2.5 recruits/spat collector/2 weeks) at three sites in the patch reefs north of Sand Island, and in the deep lagoon; recruitment had begun by August and continued at least until December, with over 450 recruits observed during this period. Despite searches of many sites throughout the atoll, we have found only six adult *P.*

margaritifera (18-20 cm diameter), plus three long-dead adult shells (Fig. 2). This pattern of widespread and prolonged juvenile recruitment but very few live adults suggests that juvenile survival and post-recruitment success are very poor, and we hypothesize that predation is the most likely cause, although other factors may also be involved. While we are continuing our settlement and distribution studies throughout 2009, more detailed studies of juvenile ecology and population dynamics are necessary before one can understand the causes and processes underlying the observed patterns and determine how best to conduct restoration efforts.

Various researchers and aquaculturists in other parts of the Pacific have concluded that predation on juveniles represents the greatest risk to pearl oysters (Gervis and Sims 1992), and that once *P. margaritifera* reaches an "escape size" of 80-100 mm (usually in its second year), mortality due to predation is low (Crossland 1957 in Gervis and Sims 1992). Reported predators of *P. margaritifera* juveniles include fishes (triggerfishes, puffers, emperors, groupers, and sharks and rays), octopus, sea stars, crabs, and predatory gastropods (Gervis and Sims 1992).

The primary goals of this application are to:

- 1) establish rates of natural mortality, predation, and growth in juvenile *P. margaritifera*;
- 2) explain the pattern of high recruitment but very low adult abundance at Midway Atoll;
- 3) test transplantation methods for a proposed restoration of this species.

We will test the hypothesis that protecting juveniles from predation will greatly increase survival and increase growth rates, and lead to establishment of adult populations. Our results on the biology of *P. margaritifera* and restoration methods will be relevant not only to restoration on Midway Atoll, but also on Pearl and Hermes Atoll and other PMNM reefs.

Secondary goals, relevant to the goal of informing successful restoration are:

- 1) obtain morphological data to describe changes during growth, and contribute to understanding of whether *P. margaritifera* in the NWHI should be treated as a genetically or ecologically distinct subspecies, or even species.
- 2) obtain data on adult longevity, adult growth increments, and environmental conditions from analyses of dead adult shells.

**7. Answer the Findings below by providing information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Monument:**

The Findings are as follows:

- a. How can the activity be conducted with adequate safeguards for the cultural, natural and historic resources and ecological integrity of the Monument?

We will use equipment (cages and tiles) and methods identical to those we have used previously to examine effects of herbivory on algal and coral recruitment in a previous experiment at Midway. In that study, cages and tiles were deployed for a year (2007-2008) and,

after removing the cages for analysis, the previously caged areas were indistinguishable from their surroundings only one week later. Therefore, these cages have little or no permanent impact on the habitat in which they are deployed, and hence are safe to use in the new experiments. We believe contributing to the ability to successfully restore an important depleted species, will ultimately lead to enhanced ecological integrity of the Monument.

We are very aware that pearl oysters play important cultural roles in traditional Hawaiian cultures. Our study is designed to minimize mortality of juveniles while maximizing data essential for successful restoration. If our hypothesis is correct, we may actually increase the numbers of pearl oysters present by protecting juveniles while protecting them until they reach a size at which their chances of survival to adulthood are greatly increased.

b. How will the activity be conducted in a manner compatible with the management direction of this proclamation, considering the extent to which the conduct of the activity may diminish or enhance Monument cultural, natural and historic resources, qualities, and ecological integrity, any indirect, secondary, or cumulative effects of the activity, and the duration of such effects?

Activity HMC-1.1 specifically identifies *Pinctada margaritifera* as a species which has been negatively impacted by humans and may be in need of restoration. Our study directly enhances this goal by providing data and developing tools that will be useful for management of *P. margaritifera*. Locally, the study itself may enhance pearl oyster populations by increasing survival of juveniles that would otherwise die early in life. Ultimately, some pearl oysters protected in our study should reach maturity as long-lived adults.

While our previous experience (2006-09) leads us to expect negligible indirect and secondary effects from this study, we will monitor the sites carefully throughout the study.

c. Is there a practicable alternative to conducting the activity within the Monument? If not, explain why your activities must be conducted in the Monument.

NO. Conditions within the Monument and at Midway are very different from those where *P. margaritifera* has been studied in the western and southern Pacific. Determining what causes high post-recruitment mortality at Midway can only be done by actually measuring post-recruitment survival under different predation regimes within the Monument. In addition, the likelihood that *P. margaritifera* is a genetically distinct species or subspecies in the NWHI means that it may have different ecological and physiological properties from those elsewhere in the Pacific.

d. How does the end value of the activity outweigh its adverse impacts on Monument cultural, natural and historic resources, qualities, and ecological integrity?

Local impacts will be minimal, while the additional knowledge and understanding of a key natural and cultural resource, and of potential restoration methods, will enhance plans to restore the species throughout the Monument.

e. Explain how the duration of the activity is no longer than necessary to achieve its stated purpose.

In the South Pacific, black-lipped pearl oysters reach 7 or 8 cm within a year and 10-19 cm within two years, by which time they are far less vulnerable to predation (Gervis and Sims 1992). Therefore, we must study the growth and survival of individual juvenile oysters and the post-recruitment processes affecting them for at least two years. Hence, we have requested a permit to cover these activities for two years (June 2009 to December 2010). By late 2010, we should have sufficient data to determine whether longer studies, or experiments at additional sites, would be desirable.

f. Provide information demonstrating that you are qualified to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.

Dr. Donald Potts has studied many aspects of the ecology and evolution of corals and reefs for over 30 years (mainly in Australia, Papua New Guinea, Hawaii), and several aspects of reef paleo-ecology, past climates and geological processes for over 10 years (in Papua New Guinea and the main Hawaiian Islands). He has been active in national and international marine science and biodiversity policy for over 15 years (see CV).

Kristin McCully is completing her third year of her Ph.D. research at the University of California, Santa Cruz, concentrating on the recruitment and distribution of pearl oysters and other bivalve species at Midway. She has already conducted three years of field work on Midway Atoll, and previously conducted field work on coral reefs in Australia and Mo'orea, French Polynesia (see CV).

g. Provide information demonstrating that you have adequate financial resources available to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.

Core funding for our research program at Midway Atoll comes from the Mitsubishi Corporation (Tokyo) under their Social Responsibility Program. These funds are committed for 5 years (2006–11) at \$100,000 per year. Our Midway work is one of three complementary projects forming the Mitsubishi Corporation's Global Coral Reef Conservation Project (other sites are in the Seychelles and the Ryukus).

We are also applying for other grants to supplement Mitsubishi funding. Kristin McCully has received a Friends of Long Marine Lab Student Research and Education Award (\$700) for supplies and other field costs for this project in 2009.

h. Explain how your methods and procedures are appropriate to achieve the proposed activity's goals in relation to their impacts to Monument cultural, natural and historic resources, qualities, and ecological integrity.

This study will not impact or involve any historic resources of the Monument. We will avoid known or potential sites with archaeological objects; if we should encounter any, we will take a GPS reading and report it to PMNM and USFWS personnel.

Identification of this species and other Hawaiian bivalves in the juvenile stage is extremely difficult, due to lack of museum specimens and few identifying characteristics. Therefore, we are requesting to collect up to 50 pearl oyster recruits/juveniles to create replicated size series to assist identification at very early ages and to assist elucidation of its taxonomic status. This collection will be a very small fraction of the number of recruits we have observed each year (over 450 recruits in 5 months), and we will use already dead shells from the spat collectors or our cages wherever possible.

We also propose to collect up to 5 long-dead adult pearl oyster shells from the reef to determine age at death, annual growth increments, date of death, and environmental conditions during life, using X-ray and isotopic techniques. If the shells are chemically unaltered, we will date the shells to determine how long ago they lived on the reef, using ratios of radioactive uranium/thorium isotopes in the shell.

i. Has your vessel has been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?

We use only Midway Atoll NWR's small boats, and we follow all PMNM, USFWS, and UCSC boating regulations and procedures.

j. Demonstrate that there are no other factors that would make the issuance of a permit for the activity inappropriate.

None known.

## **8. Procedures/Methods:**

At each site, we will attach 15 tiles to the reef: 5 with large-mesh cages; 5 tiles with small-mesh cages; and 5 without cages. We will attach up to 9 pearl oyster recruits on each tile, using small dabs of epoxy cement, on the underside of the shell. We will take recruits from our existing spat collectors and transfer them to tiles with minimal handling and disturbance. We will begin the experiment in June by transferring a total of 270 pearl oyster recruits from the spat collectors to the tiles. If mortality is high in any of the treatments, we will replace lost juveniles with new recruits from the recruitment study.

We will use the same 20x20 cm, unglazed ceramic tiles and cages (~30 cm high, plastic cylinder frame with plastic mesh on all sides, Fig. 4) that we are now using in the Community Dynamics study (activity 3 of Permit PMNM-2008-056). The large mesh cages will have 2.5 cm openings, while the small mesh will have 6-10 mm openings. The larger mesh will exclude larger predators (e.g. fish, lobster, starfish, snails) while the smaller mesh will also exclude smaller crabs, starfish, and predatory gastropods. Tiles and cages will be attached with plastic

cable ties to stainless steel lagscrews set in holes drilled into the base rock. Similar cages and tiles have remained in place for nearly a year and left no permanent effects.

The two sites on patch reefs north of West Beach and in the deep lagoon are more than 300 m from the nearest beach to avoid impacts on monk seals. Both areas had high recruitment in 2008, and both are similar to the habitats with the highest densities of pearl oysters at Pearl and Hermes Atoll, where adult pearl oysters are more common than at Midway (Keenan 2007). All six live adults seen so far are living in the patch reefs of the deep lagoon. The first site, West Beach (WB), will be within 1 km of 28°12'37.56"N, 177°23'32.21"W. The second site will be within 1 km of a patch we have called "Pinctada Patch" (PP) at 28°14'45.82"N, 177°22'41.25"W, because four living adults are there. We are unable to give more exact locations at this time because we must find places that are relatively protected, and have hard flat substrates with low coral cover to deploy the cages and tiles. We will attach the cages and tiles at 3-7 m depth to minimize the possibility of disturbance by waves or storms. We are using two locations to obtain indications of the magnitude of variation among sites and to begin to extend our conclusions beyond our sites. Depending on the results, we may request permission to repeat the experiments at other sites that appear suitable for restoration efforts.

We will count and measure each recruit on each tile every 2 - 4 weeks until the end of our field season in fall 2009. We will then leave the tiles and cages on the reef until we return in spring 2010 to provide information on growth and survival over the winter. If survival is low in any of the treatments, we will replace lost juveniles with new recruits from the recruitment study. We also plan to use our underwater video camera system (Activity 5 of Permit PMNM-2008-056) to observe oysters in the different treatments and to identify potential predators.

We plan to collect up to 50 pearl oyster recruits and juveniles in a range of sizes to create permanent reference size series to aid identification at very small sizes and to provide morphological data for assessing sub-specific rank. Each series will contain about 15 individuals from about 1 - 100 mm in diameter. We will deposit one size series in a permanent museum collection (e.g. Bishop Museum), retain one set for use by persons working at Midway, and a third in Santa Cruz to facilitate our statistical and laboratory analyses. These recruits and juveniles may come from either the recruitment study or these predation experiments. Wherever possible, we will use shells of individuals who have died leaving intact shells.

Any surviving recruits not needed for experiments or size-series will be placed in crevices on the reef near the spat collectors and left to grow naturally. Most survivors from the experiments will also be returned to the reefs

In 2008, we located three long-dead adult pearl oyster shells covered with coralline algae. We now request permission to collect these specimens to determine: 1) adult growth rates and age at death from X-ray analysis of density bands; 2) when they were alive on the reef, from carbon-14 and U/Th isotopic dating methods; and 3) environmental conditions when the shells were laid down during life, from various stable isotope ratios. (e.g. C, O, B, Cd).

**NOTE: If land or marine archeological activities are involved, contact the Monument Permit Coordinator at the address on the general application form before proceeding, as a customized application will be needed. For more information, contact the Monument office on the first page of this application.**

**9a. Collection of specimens - collecting activities (would apply to any activity): organisms or objects (List of species, if applicable, attach additional sheets if necessary):**

Common name:  
Black-lipped pearl oyster

Scientific name:  
*Pinctada margaritifera*

# & size of specimens:

1) 270 recruits (most <10 mm) to start the experiment; and up to 270 additional recruits to replace individuals during the next 12-18 months.

2) 50 recruits and juveniles from 1 mm (smallest pearl oyster recruit we have found in the recruitment study) to 10 cm, the escape size (8-10 cm) suggested by Crossland (1957 in Gervis and Sims 1992) mortality from predation declines greatly.

3) 5 already-dead adult shells for determining: a) when they died, b) their growth rates and age at death, and c) proxies for environmental conditions during life..

Collection location:

1 and 2) Recruitment spat collectors and experimental sites in Midway Atoll reef flats and the lagoon are shown in Fig. 1.

3) Locations of three dead shells are already known: one on Pinctata Patch, and two on the north-eastern reef flats. All will be collected from the reef flats and patch reefs of Midway Atoll.

Whole Organism  Partial Organism

**9b. What will be done with the specimens after the project has ended?**

1) Live oysters at the end of the experiment will be placed on the patch reefs where survival seems highest, in crevices or other micro-habitats likely to enhance continued survival.

2) We will deposit one size series of shells in a permanent museum collection (e.g, Bishop Museum); leave one set at Midway for use by ourselves, or by PMNM and USFWS personnel; and one in Santa Cruz to assist or current and future studies of this species.

3) When laboratory analyses of the adult shells are completed, we will add these shells to the permanent size series collections, or deposit them as museum voucher specimens.

**9c. Will the organisms be kept alive after collection?**  Yes  No

We are collecting live oysters only for use in the field experiments, and will be returning them to the sea almost immediately as we establish the experiments. We will not be keeping them for extended periods in aquaria on the island.

• General site/location for collections:

1 and 2) Recruitment spat collectors and experimental tiles in Midway Atoll reef flats and lagoonal patch reefs (see Fig. 1).

3) Locations of 3 are already known: one on Pinctata Patch, and two on the north-eastern reef margins. All will be collected from the reef flats and patch reefs of Midway Atoll.

• Is it an open or closed system?  Open  Closed  
N/A

• Is there an outfall?  Yes  No  
N/A

• Will these organisms be housed with other organisms? If so, what are the other organisms?  
N/A

• Will organisms be released?

Yes. Live oysters at the end of the experiments will be placed on the patch reefs where survival seems highest, in crevices or other micro-habitats likely to enhance continued survival. However, they will not be removed from the reef (or tiles on the reef) or maintained in aquaria on land during this study.

**10. If applicable, how will the collected samples or specimens be transported out of the Monument?**

Dried specimens will be carried out of the Monument on USFWS charter flights to Honolulu.

**11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:**

We will conduct this project in conjunction with other ongoing projects (permit PMNM-2008-056) to reduce total time needed at Midway, boat time, accommodation and travel costs, and other costs.

We have discussed this work and our methods with:

- 1) Elizabeth Keenan, a PMNM researcher who has conducted previous surveys for pearl oysters on PMNM reefs. We expect to share our data with her as the project proceeds;
- 2) Neil Sims, who has conducted research on recruitment and other aspects of pearl oyster biology and culture around the Pacific and began early phases of a pearl oyster restoration effort/pearl farm at Midway Atoll in 1995-1996;
- 3) Maria Hawes, University of Hawaii-Sea Grant aquaculture extension specialist, who has researched pearl oyster biology and culture throughout the Pacific and runs a pearl oyster hatchery in Hilo, HI.

Although Keenan and others have conducted surveys for adult and large juvenile pearl oysters at various reefs in the Hawaiian Archipelago, our research is the first to explore recruitment and post-recruitment processes in the Hawaiian Archipelago. Sims and Haws have advised us about techniques used on pearl culture farms that may be adapted to a pearl oyster restoration.

We have discussed possible collaborations with Dr. Jo-Ann C. Leong (Director) and Dr. Robert Toonen of the Hawai'i Institute of Marine Biology. We are now contacting them to see whether some of our material could be used in their genetic studies of connectivity among the reefs, and to clarify the taxonomic status of *P. margaritifera* in the PMNM.

X-ray and isotopic analyses of adult shells will be done as collaborations in USGS facilities at Menlo Park and Santa Cruz, and at UCSC in collaboration with Dr. Paul Koch (paleontologist) and Dr. Adina Paytan (biogeochemist)

**12a. List all specialized gear and materials to be used in this activity:**

- Air-drill, drill bits, and bolts to attach cages and tiles to hard substrate
- Cages (which are in storage at Midway)
- Tiles
- Epoxy to attach recruits to tiles
- Plastic cable (zip) ties
- Vernier calipers to measure recruits

**12b. List all Hazardous Materials you propose to take to and use within the Monument:**

None.

**13. Describe any fixed installations and instrumentation proposed to be set in the Monument:**

We will use 20x20 cm, unglazed ceramic tiles and plastic cages (~30 cm high, plastic cylinder frame with plastic mesh on all sides, Fig. 4). These are being used in activity 3 of Permit PMNM-2008-056 and were first deployed on Midway in October 2007. The large mesh has 2.5 cm openings, while the small mesh will have 6-10 mm openings. Tiles and cages will be attached with plastic cable ties to stainless steel lagscrews set in holes drilled into the base rock. Having used this method for the Community Dynamics study, we are confident that, in places protected from severe wave and current action, both cages and tiles remain in place for at least a year and leave no permanent marks. We plan to continue this study through fall 2010. We will remove all tiles, cages, and screws at the end of the study.

**14. Provide a time line for sample analysis, data analysis, write-up and publication of information:**

Jun 2009 - Dec 2010:	Field experiment initiated
Jan - Mar 2010:	Analyze 2009 data
Jun - Dec 2010:	Continue or repeat the experiments to obtain data on differences among years
Late 2010- mid 2011:	Final analyses and completing manuscripts.

This project will be integrated with the bivalve recruitment and distribution studies (under permit PMNM-2008-056) into Kristin McCully's Ph.D. thesis, which she plans to complete in 2012. We also anticipate using the results of this and associated studies to inform design of restoration effort of *P. margaritifera*, in collaboration with USFWS and PMNM.

**15. List all Applicants' publications directly related to the proposed project:**

2008 Five presentations at 11th International Coral Reef Symposium, Fort Lauderdale FL (pages in Abstracts volume)

- 1). McCully, K., Potts, D.C. Distribution and recruitment of the black-lipped pearl oyster, *Pinctada margaritifera*, at Midway Atoll, Northwestern Hawaiian Islands. p.531. [Poster]
- 2). Potts, D.C., Cover, W., McCully, K., O'Leary, J., Paytan, A. An integrative interdisciplinary research program on environmental change at Midway Atoll (NW Hawaiian Islands). p. 465. [Poster]
- 3). Potts, D.C. Are refugia based on triage principles the last hope for reef systems? p. 241. [Oral]
- 4). Cover, W., Potts, D.C. Direct species-specific impacts of urchins on live corals. p. 88. [Oral]
- 5). Cover, W., Potts, D.C. Coral recruitment at sites with and without cyanobacteria blooms on Midway Atoll, NW Hawaiian Islands. p. 325. [Poster]

2008 Cover, W.A., Potts, D.C. Urchins on Midway Atoll can directly impact live corals. Hawaii Conservation Conference (July 2008), Honolulu.

2008 Potts, D.C. Geo-biological responses to ocean acidification. American Geophysical Union, 2008 Fall Meeting (December), San Francisco. [Invited Symposium Speaker]

With knowledge of the penalties for false or incomplete statements, as provided by 18 U.S.C. 1001, and for perjury, as provided by 18 U.S.C. 1621, I hereby certify to the best of my abilities under penalty of perjury of that the information I have provided on this application form is true and correct. I agree that the Co-Trustees may post this application in its entirety on the Internet. I understand that the Co-Trustees will consider deleting all information that I have identified as “confidential” prior to posting the application.

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Signature

Date

**SEND ONE SIGNED APPLICATION VIA MAIL TO THE MONUMENT OFFICE BELOW:**

Papahānaumokuākea Marine National Monument Permit Coordinator  
6600 Kalaniana'ole Hwy. # 300  
Honolulu, HI 96825  
FAX: (808) 397-2662

**DID YOU INCLUDE THESE?**

- Applicant CV/Resume/Biography
- Intended field Principal Investigator CV/Resume/Biography
- Electronic and Hard Copy of Application with Signature
- Statement of information you wish to be kept confidential
- Material Safety Data Sheets for Hazardous Materials