State of Hawai'i
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Aquatic Resources
Honolulu, Hawai'i 96813

July 27, 2018

Board of Land and Natural Resources
Honolulu, Hawai'i

Request for Authorization and Approval to Issue a Papahānaumokuākea Marine National Monument Research Permit to Dr. Brian Bowen, University of Hawai'i, Hawai'i Institute of Marine Biology, for Access to State Waters to Conduct Genetic Survey Activities

The Division of Aquatic Resources (DAR) hereby submits a request for your authorization and approval for issuance of a Papahānaumokuākea Marine National Monument research permit to Dr. Brian Bowen, associate researcher, University of Hawai'i, Hawai'i Institute of Marine Biology, pursuant to § 187A-6, Hawai'i Revised Statutes (HRS), Chapter 13-60.5, Hawai'i Administrative Rules (HAR), and all other applicable laws and regulations.

The research permit, as described below, would allow entry and research activities to occur in Papahānaumokuākea Marine National Monument, including the NWHI State Marine Refuge and the waters (0-3 nautical miles) surrounding the following sites:

- Nīhoa Island
- Mokumanamana (Necker)
- French Frigate Shoals
- Gardner Pinnacles
- Maro Reef
- Laysan Island
- Lisianski Island, Neva Shoal
- Pearl and Hermes Atoll
- Kure Atoll

The activities covered under this permit would occur between August 15, 2018 and August 14, 2019. The proposed activities are largely a renewal of work previously permitted and conducted in the Monument.

INTENDED ACTIVITIES:

The applicant proposes to conduct genetic surveys of common reef fish and marine invertebrates to study the level of isolation between shallow and mesophotic reef ecosystems. Up to thirteen (13) individuals would conduct proposed activities consisting of: collecting reef fish and invertebrate samples (see appended collection list for total number of samples); swimming, snorkeling and SCUBA diving; touching living or dead coral; and collecting voucher specimens in the event that new records or new species of marine flora or fauna are encountered according to the Monument's *Voucher Specimen Guidelines*. The only lethal take of proposed species would be for fish using pole spears or hand nets which would be collected whole. All other

collections of invertebrate tissue samples would be non-lethal using tissue biopsy tools or by hand.

The applicant intends to conduct proposed research activities from NOAA Ship HI'IALAKAI (separately permitted under permit number PMNM-2018-001) during a research cruise scheduled from August 23 – September 16, 2018. All collected samples and specimens would be transported out of the Monument aboard the vessel. Proposed activity locations include marine areas within all Special Preservation Areas (SPAs) and Midway Atoll Special Management Area.

To safeguard Monument resources the applicant would abide by the following PMNM Best Management Practices (BMPs) while conducting the aforementioned activities within the PMNM:

- Best Management Practices for Boat Operations and Diving Activities (BMP #004)
- General Storage and Transport Protocols for Collected Samples (BMP #006)
- Marine Wildlife Viewing Guidelines (BMP #010)
- Disease and Introduced Species Prevention Protocol for Permitted Activities in the Marine Environment (BMP #011)
- Best Practices for Maritime Heritage Sites (BMP #017)

The activity would provide important insights on the genetic diversity and connectivity of reef fish species in the Monument. The applicant's proposed activities directly support the Monument Management Plan's Marine Conservation Science (MCS) Action Plan, Activity MCS-1.5: *Measure connectivity and genetic diversity of key species to enhance management decisions* (PMNM MMP Vol. 1, p. 123, 2008).

The activities described above may require the following regulated activities to occur in State waters:

- ☒ Removing, moving, taking, harvesting, possessing, injuring, disturbing, or damaging any living or nonliving monument resource
- ☒ Touching coral, living or dead
- ☒ Possessing fishing gear except when stowed and not available for immediate use during passage without interruption through the Monument
- ☒ Swimming, snorkeling, or closed or open circuit SCUBA diving within any Special Preservation Area or Midway Atoll Special Management Area

REVIEW PROCESS:

The permit application was sent out for review and comment to the following scientific and cultural entities: Hawai'i Division of Aquatic Resources, Hawai'i Division of Forestry and Wildlife, Papahānaumokuākea Marine National Monument (NOAA/NOS), NOAA Pacific Islands Regional Office (NOAA-PIRO), United States Fish and Wildlife Service Hawaiian and Pacific Islands National Wildlife Refuge Complex Office, and the Office of Hawaiian Affairs (OHA). In addition, the permit application has been posted on the Monument Web site since June 4, 2018 giving the public an opportunity to comment. The application was posted within 40 days of its receipt, in accordance with the Monument's Public Notification Policy.

Comments received from the scientific community are summarized as follows:

QUESTIONS:

None

COMMENTS / RECOMMENDATIONS:

1. The mesophotic team has done this multiple times over the years, in multiple locations within and outside of the Monument. No objection to their sampling methods, sample numbers, or targeted species.

   Noted.

2. NMFS requests that the researchers continue to review and abide by the diving protocols in place for the Monument.

   Noted and will do.

Comments received from the Native Hawaiian community are summarized as follows:

Cultural reviews support the acceptance of this application. No concerns were raised.

Comments received from the public are summarized as follows:

No comments were received from the public on this application.

Additional reviews and permit history:

Are there other relevant/necessary permits or environmental reviews that have or will be issued with regard to this project? (e.g. MMPA, ESA, EA) Yes ☐ No ☒
If so, please list or explain:

- An informal review of all aforementioned activities following section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA; 16 U.S.C. 1855(b)) is currently underway. The outcome of this review may require the applicant to

adhere to other NMFS-prescribed conditions. Such conditions would be reflected in the PMNM permit, prior to issuance.

- A request is currently underway to the National Marine Fisheries Service (NMFS) to cover all proposed activities under PMNM's programmatic ESA Section 7 informal consultation. The outcome of this consultation may require the applicant to adhere to other NMFS-prescribed conditions. Such conditions would be reflected in the PMNM permit, prior to issuance.

- The Department has made an exemption determination for this permit in accordance chapter 343, HRS, and Chapter 11-200, HAR. See Attachment ("DECLARATION OF EXEMPTION FROM THE PREPARATION OF AN ENVIRONMENTAL ASSESSMENT UNDER THE AUTHORITY OF CHAPTER 343, HRS AND CHAPTER 11-200 HAR, FOR PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT RESEARCH PERMIT TO DR. BRIAN BOWEN, HAWAI'I INSTITUTE OF MARINE BIOLOGY, FOR ACCESS TO STATE WATERS TO CONDUCT GENETIC SURVEY ACTIVITIES UNDER PERMIT PMNM-2018-031")

Has Applicant been granted a permit from the State in the past? Yes ☒ No ☐
If so, please summarize past permits:

- The Applicant was granted permits DLNR/NWHI/06R004, PMNM-2007-032, PMNM-2008-046, PMNM-2009-044, PMNM-2010-038, PMNM-2011-025, PMNM-2012-045 and PMNM-2015-030 to conduct similar work in 2006 through 2015.

Have there been any	a) violations:	Yes ☐	No	☒
	b) Late/incomplete post-activity reports:	Yes ☐	No	☒
Are there any other relevant concerns from previous permits?		Yes ☐	No	☒

STAFF OPINION:

PMNM staff is of the opinion that Applicant has properly demonstrated valid justifications for his application and should be allowed to enter the NWHI State waters and to conduct the activities therein as specified in the application with certain special instructions and conditions, which are in addition to the Papahānaumokuākea Marine National Monument Research Permit General Conditions. All suggested special conditions have been vetted through the legal counsel of the Co-Trustee agencies (see Recommendation section).

MONUMENT MANAGEMENT BOARD OPINION:

The MMB is of the opinion that the Applicant has met the findings of Presidential Proclamation 8031 and this activity may be conducted subject to completion of all compliance requirements. The MMB concurs with the special conditions recommended by PMNM staff.

RECOMMENDATION:

That the Board authorize and approve a Research Permit to Dr. Brian Bowen, Pacific Islands Fisheries Science Center, with the following special conditions:

a. That the Board declare that the actions which are anticipated to be undertaken under this permit will have little or no significant effect on the environment and is therefore exempt from the preparation of an environmental assessment.

b. Upon the finding and adoption of the department's analysis by the Board, that the Board delegate and authorize the Chairperson to sign the declaration of exemption for purposes of recordkeeping requirements of chapter 343, HRS, and chapter 11-200, HAR.

c. That the permittee provide, to the best extant possible, a summary of their Monument access, including, but not limited to, any initial findings to the DLNR for use at educational institutions and outreach events.

d. This permit is not to be used for nor does it authorize the sale of collected organisms. Under this permit, the authorized activities must be for noncommercial purposes not involving the use or sale of any organism, by-products, or materials collected within the Monument for obtaining patent or intellectual property rights.

e. The permittee may not convey, transfer, or distribute, in any fashion (including, but not limited to, selling, trading, giving, or loaning) any coral, live rock, or organism collected under this permit without the express written permission of the Co-Trustees.

f. To prevent introduction of disease or the unintended transport of live organisms, the permittee must comply with the disease and transport protocol attached to this permit.

g. Tenders and small vessels must be equipped with engines that meet EPA emissions requirements.

h. Refueling of tenders and all small vessels must be done at the support ships and outside the confines of lagoons or near-shore waters in the State Marine Refuge.

i. No fishing is allowed in State Waters except as authorized under State law for subsistence, traditional and customary practices by Native Hawaiians.

Respectfully submitted,

Maria Carnevale
Papahānaumokuākea Marine National Monument

APPROVED FOR SUBMITTAL

SUZANNE CASE
Chairperson

Common name	Scientific name	No., Size, Locations

SHALLOW REEF COLLECTIONS (< 130 feet depth)

Carpet zoanthid	*Palythoa tuberculosa*	30 fragments (< 1 gram) Nihoa 30 fragments (< 1 gram) Mokumanamana 30 fragments (< 1 gram) French Frigate Shoals 30 fragments (< 1 gram) Gardner Pinnacles 30 fragments (< 1 gram) Maro Reef 30 fragments (< 1 gram) Laysan 30 fragments (< 1 gram) Pioneer Bank 30 fragments (< 1 gram) Lisianski 30 fragments (< 1 gram) Pearl and Hermes 30 fragments (< 1 gram) Midway 30 fragments (< 1 gram) Kure
Whitespot surgeonfish	*Acanthurus guttatus*	30 all sizes Nihoa 30 all sizes Mokumanamana 30 all sizes French Frigate Shoals 30 all sizes Gardner Pinnacles 30 all sizes Maro Reef 30 all sizes Laysan 30 all sizes Lisianski 30 all sizes Pearl and Hermes 30 all sizes Midway 28 all sizes Kure
Cauliflower coral	*Pocillopora meandrina*	30 fragments (< 1 gram) Lisianski

DEEP REEF COLLECTIONS (> 130 feet)

FISHES		sample size deep/shallow (or just deep if only one number)
Goldring bristletooth	*Ctenochaetus strigosus*	20/0 all sizes Nihoa 20/0 all sizes Mokumanamana 20/0 all sizes French Frigate Shoals 20/0 all sizes Gardner Pinnacles 20/0 all sizes Maro Reef 20/0 all sizes Laysan 20/0 all sizes Lisianski 20/0 all sizes Pearl and Hermes 20/0 all sizes Midway 20/0 all sizes Kure
Hawaiian Chromis	*Chromis ovalis*	20/20 all sizes Nihoa 20/20 all sizes Mokumanamana 20/20 all sizes French Frigate Shoals 20/20 all sizes Gardner Pinnacles 20/20 all sizes Maro Reef 20/20 all sizes Laysan 20/20 all sizes Lisianski 20/20 all sizes Pearl and Hermes 20/20 all sizes Midway

F-2 Attachment 1

	28 all sizes Pearl and Hermes
	20 all sizes Midway
	20 all sizes Kure
Hawaiian Longfin Anthias *Pseudanthias hawaiiensis*	20 all sizes Nihoa
	20 all sizes Mokumanamana
	20 all sizes French Frigate Shoals
	20 all sizes Gardner Pinnacles
	20 all sizes Maro Reef
	20 all sizes Laysan
	20 all sizes Lisianski
	20 all sizes Pearl and Hermes
	20 all sizes Midway
	20 all sizes Kure
Potters Anglefish *Centropyge potteri*	20/20 all sizes Nihoa
	20/20 all sizes Mokumanamana
	20/20 all sizes French Frigate Shoals
	20/20 all sizes Gardner Pinnacles
	20/20 all sizes Maro Reef
	20/20 all sizes Laysan
	20/20 all sizes Lisianski
	20/20 all sizes Pearl and Hermes
	20/20 all sizes Midway
	20/20 all sizes Kure
Whitetip Soldierfish *Myripristis vitatta*	20 all sizes Nihoa
	20 all sizes Mokumanamana
	20 all sizes French Frigate Shoals
	20 all sizes Gardner Pinnacles
	20 all sizes Maro Reef
	20 all sizes Laysan
	20 all sizes Lisianski
	20 all sizes Pearl and Hermes
	20 all sizes Midway
	20 all sizes Kure
Yellowstriped squirrelfish *Neoniphon aurolineatus*	20 all sizes Nihoa
	20 all sizes Mokumanamana
	20 all sizes French Frigate Shoals
	20 all sizes Gardner Pinnacles
	20 all sizes Maro Reef
	20 all sizes Laysan
	20 all sizes Lisianski
	20 all sizes Pearl and Hermes
	20 all sizes Midway
	20 all sizes Kure

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: Bowen, Brian W.
Affiliation: Hawaii Institute of Marine Biology

Permit Category: Research
Proposed Activity Dates: 8/1/18 - 7/31/19
Proposed Method of Entry (Vessel/Plane): NOAA RV Hi'ialakai
Proposed Locations: Shallow reefs and mesophotic reef habitats (1 - 450 feet depth), focused on French Frigate Shoals, Maro Reef, Laysan, Lisianski, Pearl and Hermes Atoll, Midway Atoll, Kure Atoll. However, we request latitude to sample other regions as weather and opportunity dictate.

Estimated number of individuals (including Applicant) to be covered under this permit: 11
Estimated number of days in the Monument: 23

Description of proposed activities: (complete these sentences):

a.) The proposed activity would...

be a genetic survey of 1 shallow reef fish, 3 shallow/mesophotic fishes, 8 mesophotic reef fishes, and one shallow coral, designed to address the level of isolation between shallow and deep reef ecosystems across the Hawaiian Archipelago, and especially throughout the Papahanaumokuakea Marine National Monument.

Specimens will be collected on deep and shallow reefs to evaluate the hypothesis that these mesophotic reefs can serve as refugia to replenish shallow reefs. Genetic studies can validate or refute this hypothesis, which has clear implications for management and conservation of biological resources. Deep dives during previous permit periods were used to select species for genetic analysis (ones that are abundant and feasible to collect). Since then we have refined our list to include those species that we are continuously observing on our dives and are the most practical candidates for these studies.

In addition, we wish to collect specimens of any suspected new species encountered at depths greater than 130 feet, for genetic characterization, description, and vouchering in the Bishop

Museum (see Appendix 1, opportunistic collections). This is an essential activity to characterize the biodiversity of the Monument, and will only be invoked in cases where species are sufficiently abundant (encounter rate of 10+ per hour) to sustain collections without adverse impact.

b.) To accomplish this activity we would ....
survey 12 fishes at locations across the entire archipelago, using polespears and nets when possible, and using DNA sequencing technology to resolve novel evolutionary lineages, genetic diversity and connectivity among reef habitats.

We wish to collect the shallow cauliflower coral Pocillopora meandrina only at Lisianski. The northern range limit of cauliflower coral is at Laysan, but it may occur at the next island (Lisianski) so this part of the study is to serve biological inventory and genetic connectivity. Specimens would be vouchered at Bishop Museum as well as archives for genetic analyses at HIMB.

c.) This activity would help the Monument by ...
determining whether the Monument is a series of relatively fragile (isolated) ecosystems, or whether individual reef habitats are connected in a larger and more robust ecosystem. There is also a concern about whether the NWHI serves as a source of larvae to replenish depleted fisheries in the main Hawaiian Islands. The assays of population connectivity outlined here will address these issues in a format that has statistical power and scientific credibility.

For example, previous findings from this research indicate that the reef fauna is divided into 4-7 isolated populations within the Hawaiian Archipelago, including three populations in the PMNM (Toonen et al. 2011; Selkoe et al. 2016). This fish is heavily harvested for the ornamental fish trade, and so findings will realign management units for this species. Findings also indicate some connectivity between the Main Hawaiian Islands and the lower NWHI.

Other information or background: To preserve biodiversity, it is important to know how it arises (Bowen & Roman 2005). While the main objective is to assess genetic connectivity among shallow and deep reef habitats, a "value added" component is that we can assess the age and origin of Hawaiian fauna as well as the age and origins of populations on each island. A genealogical approach to relationships among mtDNA haplotypes will indicate whether the closest relatives to the Hawaiian fauna lie predominantly to the West (Ogasawara Arch, Wake Island, or Marshall Islands) or to the South (Johnston Atoll, Line Islands; Gosline 1955; Maragos & Jokiel 1986; Maragos et al. 2004). In these cases, populations of the widespread Indo-Pacific species will be compared to the Hawaiian endemic. The geographic source of the Hawaiian form (especially Hawaiian endemics) will be resolved with parsimony networks and phylogenetic tools (see Methods), and the age of colonization events will be estimated with the mtDNA molecular clock.

Reef fauna typically have a pelagic phase (eggs and larvae), which lasts 20-60 days, followed by settlement onto a reef where they remain through juvenile and adults stages. Long distance dispersal is accomplished almost exclusively during the pelagic larval phase. However, the geographic limits of such dispersal are uncertain (Bowen et al. 2006a; 2006b; Weersing & Toonen 2009). Recent research shows that effective dispersal of marine larvae can fall short of their potential (Swearer et al. 2002). This may be particularly true of the damselfishes, as recent evidence indicates (Ramon et al. 2008). We continue to collect damselfish to test this hypothesis.

NEW PROGRESS FOR THE 2014 - 2015 YEAR

In the previous year, despite few specimen collections (N < 30) we made substantial progress on four fronts, by processing previous specimens.

1) Coleman et al. (2014) has demonstrated that the the Indo-Pacific damselfish Abudefduf vaigiensis has invaded the Hawaiian Archipelago in large numbers over the last 40 years, by hitchhiking on marine debris. It is hybridizing with the endemic Hawaiian damselfish Abudefduf abdominalis. The recent invader may be hybridizing the native species into extinction. While hybrids are now detected throughout the archipelago, they are less common in the Monument, which may serve as the last refugia of the endemic Hawaiian species. This illustrates how invaders can enter the Hawaiian Archipelago via marine debris, reinforcing the justification for efforts to limit marine debris in the Monument.

2) Gaither et al. (2015) has demonstrated that the orangestripe surgeonfish (Acanthurus olivaceus, widespread in the Pacific Ocean) has a genetically unique population in Hawai`i. This study adds to the evolutionary distinctiveness of Hawaiian fauna.

3) Selkoe et al. (2014; 2016) usaed a meta-analysis of all species surveyed to date in this project to show that the length of the pelagic (ocean drifting) larval period explained up to half of genetic connectivity. Feeding specialists disperse less than generalists, and invertebrates disperse less than fishes. This study adds to our understanding of how gene flow (especially through pelagic larvae) will allow replenishment of depleted reef resources.

4) Tenggardjaja et al. (2014) has shown that populations of the damselfish Chromis verator are highly connected between shallow reef and the mesophotic reefs below 60 meters. This is the first publication from our research program on mesophotic reef fishes, and the finding of high connectivity confirms that deep cohorts of fishes can reseed depleted shallow reefs. However, findings from additional species are needed to evaluate the generality of this conclusion.

Section A - Applicant Information

1. Applicant

Name (last, first, middle initial): Bowen, Brian R.W.

Title: Research Professor at University of Hawaii Manoa

1a. Intended field Principal Investigator (See instructions for more information):
Michael Hoban for cruise in 2018

2. Mailing address (street/P.O. box, city, state, country, zip): [redacted]

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

3. Affiliation (institution/agency/organization directly related to the proposed project):
Hawaii Institute of Marine Biology, School of Ocean and Earth Science and Technology, University of Hawai

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):
Randall Kosaki, Ph.D., Research Diver, NOAA PMNM
Richard Pyle, Ph.D., Research Diver, B.P. Bishop Museum
Atsuko Fukunaga, Ph.D., Research Diver, NOAA PMNM
Keolohilani H. Lopes, M.S., Research Diver, NOAA PMNM

Stephen Matadobra, Research Diver, PMNM
Jason Leonard, Research Diver, PMNM
Brian Hauk, M.S., Research Diver, NOAA PMNM
LTJG Terril Effird, M.S., small boat coxswain, PMNM/NOAA Coprs
Joshua Copus, M.S., Research Diver, HIMB
Mykle Hoban, M.S., Research Diver, HIMB
(2) Research Divers, TBD

Hoban will be field P.I. for our research on the 2018 mesophotic cruise, with extensive experience in ship operations including the U.S. Antarctic Program. Kosaki, Pyle, Fukunaga, Leonard, Lopes, Matadobra, Hauk, Copus, and Hoban are members of the mesophotic team, covered under a separate permit application, who have agreed and are qualified to collect specimens. Lopes is a UH dive safety officer who will participate in multiple activities including dives (under Kosaki), and tissue collections for genetic analysis (under Bowen and field P.I. Kosaki).

Section B: Project Information

5a. Project location(s):

		Ocean Based	
☒ Nihoa Island	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Necker Island (Mokumanamana)	☐ Land-based	☒ Shallow water	☒ Deep water
☒ French Frigate Shoals	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Gardner Pinnacles	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Maro Reef			
☒ Laysan Island	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Lisianski Island, Neva Shoal	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Pearl and Hermes Atoll	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Midway Atoll	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Kure Atoll	☐ Land-based	☒ Shallow water	☒ Deep water
☒ Other			

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

Location Description:

Location	Longitude	Latitude
Kure Atoll	-178.19706492000	28.55825235580
Kure Atoll	-178.19623585400	28.29958375730
Kure Atoll	-178.45987884800	28.29958375730
Kure Atoll	-178.46070791400	28.55742328970
Midway Atoll	-177.19638223300	28.37419969920
Midway Atoll	-177.19721129900	28.13377055310
Midway Atoll	-177.52800864100	28.13459961920
Midway Atoll	-177.52800864100	28.37419969920
Pearl and Hermes Atoll	-176.08850981800	28.04643025580
Pearl and Hermes Atoll	-175.63289162600	28.04539944540
Pearl and Hermes Atoll	-175.63289162600	27.70729363750
Pearl and Hermes Atoll	-176.08954062900	27.70626282710
Lisianski Island	-173.67292570900	26.25150771120
Lisianski Island	-173.67292570900	25.83942708400
Lisianski Island	-174.23095155800	25.83942708400
Lisianski Island	-174.23095155800	26.25150771120
Laysan Island	-171.47900122300	25.96027179830
Laysan Island	-171.47725234300	25.65596666490
Laysan Island	-171.97918092500	25.65771554490
Laysan Island	-171.97918092500	25.96202067840
Maro Reef	-170.18133220600	25.69968866680
Maro Reef	-170.17958332600	25.21524888540
Maro Reef	-171.00505472200	25.21524888540
Maro Reef	-171.00505472200	25.69968866680
Gardner Pinnacles	-167.74832319300	25.26070709440

Gardner Pinnacles	-167.75087047400	24.34878019150
Gardner Pinnacles	-168.36221811900	24.35132747340
Gardner Pinnacles	-168.36476540100	25.26070709440
French Frigate Shoals	-165.93465851400	23.94630965900
French Frigate Shoals	-165.93465851400	23.56421738120
French Frigate Shoals	-166.45685129400	23.56421738120
French Frigate Shoals	-166.45685129400	23.94630965900
Necker Island	-164.13627752700	23.71705429230
Necker Island	-164.13373024500	23.20505064020
Necker Island	-164.92084033700	23.20505064020
Necker Island	-164.92338761900	23.71960157420
Nihoa Island	-161.66031956700	23.23816530420
Nihoa Island	-161.66286684900	22.94013332760
Nihoa Island	-162.05005369100	22.94268060940
Nihoa Island	-162.05260097200	23.23561802240

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:***
The proposed research is a genetic survey of reef fishes, plus an opportunistic collection of one coral at Lisianski, primarily designed to address the issue of population connectivity across the PMNM, and between deep and shallow reefs, using DNA sequencing technology.

Management need: An ongoing issue for management of the NWHI is whether this is a series of relatively fragile (isolated) ecosystems, or whether reef habitats are connected in a larger and more robust ecosystem. There is also a concern about whether the NWHI serves as a source of larvae to replenish depleted fisheries in the main Hawaiian Islands. The assays of population connectivity outlined here will address these issues in a format that has statistical power and scientific credibility.

The primary purpose of the proposed research is to define the level of isolation among reef communities in the NW Hawaiian archipelago. How fragile are the geographically isolated reef habitats of the NWHI? If these habitats are highly connected by larval dispersal, then any one of them can recover quickly from human or natural perturbation. If they are isolated, they have to recover without significant input from other islands and atolls.

Objectives: The objective of this permit request is a genetic (mtDNA) survey of fishes across the NWHI to assess the level of connectivity among isolated reef habitats. We can accomplish this with samples of 30 specimens/species/location. Each location is defined as an atoll or reef, and collections will be made at a low density of approximately 10 individuals per hectare with nets and polespears. The target species are chosen to be abundant and widespread in the archipelago, easy to identify, and easy to collect. Every effort is made to minimize the impact of these collections on the natural communities.

Management benefits: These data will provide information on connectivity required for management, and can also detect cryptic endemic species (DiBattista et al. 2011) and document the patterns and history of species entering the Hawaiian Archipelago. Furthermore, by documenting the pattern and magnitude of connectivity in a diverse set of taxa, we can determine if there are general patterns that can guide management decisions for understudied species (Toonen et al. 2011). The genetic surveys of connectivity among reef habitats substantially augment the scientific foundation for conservation measures. Specifically, this research will establish the boundaries of isolated reef ecosystems of the NW Hawaiian Islands. Each ecosystem is an independent management unit.

This is a multiyear project for which the first round of data on shallow reef connectivity has been published (see references below). One outcome is that the endemic fish species seem to have more population structure than the widespread Pacific species (Eble et al. 2009, Tenngardjaja et al. 2016). This somewhat counterintuitive finding indicates that the endemic species are poor dispersers. Once they colonize Hawaii, they are unable to maintain genetic connectivity with the source population outside the Hawaiian Archipelago (DiBattista et al. 2011). This finding, combined with the restricted range of endemic species, indicates a management concern for endemic species.

We will not film, video, or photograph federally protected species under this permit. We have reviewed the list of federally protected marine species to assure compliance.

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?

Our first step is to consult Hawaiian cultural practioners to identify the special locations and activities that could infringe on kanaka maoli spiritual beliefs. In pursuit of this goal, I have previously requested guidance from the Office of Hawaiian Affairs, and have reminded my research team that this training is essential to a successful project. Team members have already received some guidance in the first seven years of this project, including a review of the kapu principles that have promoted ecosystem health and sustainability. We also recognize the tradition of the mano aumakuas, and for this reason we refrain from lethal sampling of sharks.

To protect natural resources, we abide by the principles of taking only the absolute minimum necessary to provide the information required by the Proclamation for protection of the Monument. This research team is very experienced and knowledgable

about what organisms are sensitive to touch or contact, and we minimize contact with live coral stands.

To provide adequate protection of historical locations and objects, we do not set foot on uninhabited islands, and we do not touch or disturb submerged artifacts. We maintain a strict policy of no contact.

To maintain cultural integrity, we seek advice from the Office of Hawaiian Affairs, and Hawaiian cultural practitioners. We restrict lethal sampling to common, widespread, and abundant species that number in the millions. We collect at low density in any one area and spread the collections across multiple locations over multiple collecting years. Our collections total a few kilograms per island or atoll, and are miniscule when contrasted with the estimated 30,000 tons of fish taken by ulua and other large predators every year at a single atoll (Sudekum et al. 1991; Freidlander and DeMartini 2002).

We have reviewed the list of relevant best management practices as posted on the Monument web site and will abide by all relevant PMNM Best Management Practices, particularly those that apply to boat and diving operations, transportation and storage, and disease and introduced species prevention.

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?

We are fully compliant with conditions described in the Findings of Presidential Proclamation 8031, particularly Section 3.a.i.A-D concerning the compatibility with management direction of the proclamation. These concerns also include ecological integrity and minimal impact.

This research is mandated by the Proclamation directive to maintain ecosystem integrity.

We make every effort to maximize management benefits, and minimize negative impacts to the system, including decontamination between locations as outlined in the

Procedures below. We believe that we have implemented every reasonable safeguard for the resources and ecological integrity of the Monument in our research, and there is no detectable impact from our research sampling.

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.

There is no practical alternative to conducting this research in the Monument because it is a description of the Monument from the perspective of connectivity and isolation among reef habitats. Clearly we have to sample habitats within the NWHI to resolve connectivity in this region.

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

The end value of the research clearly outweighs the imperceptible impacts from our sampling. Our collections of a few kilograms of fishes (and less than one ounce of coral) spread across thousands of hectares, are miniscule compared to the tens of thousands of tons harvested naturally by apex predators (Sudekum et al. 1991; Freidlander and DeMartini 2002). In contrast, reef connectivity data will have a direct positive impact on the identification of vulnerable locations and species, and will inform the assessment of hazards for atolls and islands of the the Monument (Toonen et al. 2011). The connectivity issue is identified as an essential foundation for reef management in the journal Science (Dawson et al. 2006).

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

This is an ongoing multi-year project that will require one or two more years of collecting activities to complete the mesophotic survey.

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

P.I. Bowen and Robert Toonen will lead the project, each with 20+ years experience in this field, including six prior expeditions to the NWHI and over 100 scientific publications pertaining to reef biodiversity, endangered species, and conservation. They are known to

the PMNM staff, DAR staff, and USFWS staff, and are clearly qualified to perform this research.

Field P.I. Michael Hoban is the veteran of many previous expeditions, is a member of the deep diving team, and is thoroughly qualified to identify and capture permitted species with minimal collatoral damage.

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.

The field-based component of this project is supported by yet to be determined ship time on the NOAA research vessel Hiialakai, a line item in the budget of the Monument. Subsequent lab-based research is supported by the National Science Foundation.

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.

The genetic methods outlined herein have been employed by Bowen and Toonen in over 100 peer-reviewed publications, and are widely recognized as appropriate for the proposed activity. The fact that both Toonen and Bowen have been awarded highly-competitive NSF grants to expand these activities speaks to the quality of the research. The use of genetic sampling is widely regarded as the most efficient and robust way in which to answer questions of connectivity on these scales. To promote historical and cultural integrity, we completely avoid sacred sites and historical sites, we don't set foot on uninhabited islands, and we don't sample species that are designated as kapu (such as moi and mano).

Statistical rigor requires a minimum sample size of 30 should be obtained. Therefore, in the interest of maintaining statistical rigor while minimizing the number of samples collected, our target sample size is 30/location for most fish species. All species in our list are common reef organisms that can easily sustain such collection pressure.

All scuba equipment is soaked in a bleach solution between sampling locations, in compliance with decontamination protocols.

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

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

This is a continuation of research efforts that have been conducted through the entire history of the Monument. During these previous efforts, there have been no problems with permit violations by this research team, no safety issues, and no complaints of offensive behavior. In these circumstances there are no other factors that would make the issuance of the permit inappropriate.

8. Procedures/Methods:

FIELD METHODS

The fish and invertebrate species listed in Appendix 1 inhabit shallow and mesophotic reefs and are accessible via snorkeling and scuba dives. The methodology for collecting fishes is with the use of Hawaiian polespears and nets. We have made significant progress in nonlethal sampling, however most fish specimens are collected with polespears.

All coral collections will be made in compliance with state regulations.

Statistical rigor requires a minimum sample size of 30 individuals per location. In studies examining the statistical power for inferring connectivity based on molecular tools, Ruzzante (1998) showed that sample sizes of less than 30-50 had significant bias and could be misleading. Therefore, in the interest of maintaining statistical rigor while minimizing the number of samples collected, our target sample size is 30/location for most fish species. Note that in Appendix 1, some sample sizes less than 30 are requested, because we have archived specimens from previous expeditions.

All scuba equipment is soaked in a bleach solution between sampling locations, in compliance with decontamination protocols.

LAB METHODS

The primary lab methodology in this study will be sequencing of mtDNA cytochrome genes. In most species, a segment of approximately 800 base pairs of the mtDNA cytochrome b or cytochrome oxidase gene will be amplified and sequenced following protocols used daily in our laboratory. DNA sequences will be generated with an ABI 3100 automated DNA sequencer in our lab. Genomic DNA aliquots will be maintained in long-term storage at HIMB so that the genetic material collected will be available for future studies.

Advances in population genetics, especially coalescence theory, will greatly enhance our analysis, elucidating the history of reef organisms, including the effective population size, founder events, and patterns of population collapse and recovery (Harpending et al. 1998, Beerli and Felsenstein 2001, Emerson et al. 2001).

DNA sequence variation will be summarized with standard diversity indices and with an analysis of molecular variance (AMOVA) using ARLEQUIN vers. 2 (Schneider et al. 2000). Phylogenetic methods will include neighbor joining and maximum likelihood algorithms in PAUP version 4.0 (Swofford 2002). Population separations will be defined with using Fst values and the maximum likelihood approach of MIGRATE vers. 1.7.3 (Beerli and Felsenstein 2001).

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:
See Appendix 1

Scientific name:
See Appendix 1

& size of specimens:
See Appendix 1

Collection location:
See Appendix 1

☒ Whole Organism ☒ Partial Organism

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

To the greatest extent possible, specimens will be frozen and vouchered so that future research efforts can use archived material instead of collecting new specimens. Preserved tissue samples suitable for DNA work will be archived at HIMB for future permitted uses. PI Bowen will be responsible for the database which will track each sample and will be the lead contact for persons wishing to access the tissue sample collections. No samples will be provided to researchers outside HIMB until a material transfer agreement is available from the Monument.

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

• General site/location for collections:

• Is it an open or closed system? ☒ Open ☐ Closed

• Is there an outfall? ☐ Yes ☒ No

• Will these organisms be housed with other organisms? If so, what are the other organisms?
No

• Will organisms be released?
Live organisms will be released at point of capture.

10. If applicable, how will the collected samples or specimens be transported out of the Monument?
Frozen fish and fin clips for genetic analysis will be transported in the RV Hiialakai.

11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:
It is incumbent on us to make maximum use of specimens, especially when they are derived from lethal collections. Towards this end, we archive specimens for age, growth, and diet studies, and other accepted scientific analyses. Bowen will retain specimens until other researchers have permits to possess and study the specimens.
An electronic database of all samples is available, and will be updated upon completion of the studies outlined here. This database will be searchable against future permit requests and can reduce the need for return trips to collect tissue samples in the NWHI, and prevent duplicative sampling efforts.

12a. List all specialized gear and materials to be used in this activity:
Materials include snorkel and scuba gear (mask, fins, snorkel, wetsuit, tank, BCD), collection bag, polespear, hand nets, fish traps, tissue biopsy tools, and a high resolution digital camera in an underwater housing to photo-document the collections.

12b. List all Hazardous Materials you propose to take to and use within the Monument:
Tissue preservative solutions for DNA analyses include: 95% ethanol (EtOH; MSDS attached), and saturated salt buffer with dimethylsulfoxide (DMSO; MSDS attached). Both EtOH and DMSO are commonly sold for human consumption, and should not pose a significant health or environmental risk. Both chemicals will be used aboard the ship in the laboratory.

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

None

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

Major sampling for the shallow reef connectivity study was completed in 2015, and analysis of specimens is ongoing (e.g. Eble et al. 2009; Craig et al. 2010; Gaither et al. 2010; Wagner et al. 2010; Eble et al. 2011; Stat et al. 2011; Dibattista et al. 2011; Bird et al. 2011, Forsmen et al. 2011, Toonen et al. 2011; Gaither et al. 2011; Daly-Engel et al. 2012; Gaither et al. 2013, 2015; Andrews et al. 2014; Selkoe et al. 2014, 2016; Coleman et al. 2014; Tenggardjaja et al. 2014, 2016; Iacchei et al. 2016; Ahti et al. 2016; Waldrop et al. 2016; Johnston et al. 2017, and papers in preparation). Only a few shallow fishes species are requested for this permit, as we refocus our efforts on mesophotic reef connectivity. Data analysis and write-up usually take no more than an additional year, although the turn-around time for some journals can exceed 200 days, so time to publication can still be considerable post-submission of the study. We would like to conclude some mesophotic studies in 2018, but that depends on the pace of sample acquisition.

Results from these studies are made available to Monument, FWS, and Hawaii DLNR managers as quickly as possible. Brown-bag luncheons at HIMB allow researchers to highlight important or interesting new results and discuss them with the management personnel. These efforts ensure that research results are provided to the Monument co-trustees as quickly as they become available.

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

Craig, M.T., J.A. Eble, D.R. Robertson, B.W. Bowen. 2007. High genetic connectivity across the Indian and Pacific Oceans in the reef fish Myripristis berndti (Holocentridae). Marine Ecology Progress Series 334: 245–254.

Schultz, J.K., R.L. Pyle, E. DeMartini, and B.W. Bowen. 2007. Genetic homogeneity among color morphs of the flame angelfish, Centropyge loriculus. Marine Biology 151: 167-175.

Rocha, L.A., M.T. Craig, and B.W. Bowen. 2007. Phylogeography and the conservation genetics of coral reef fishes. Coral Reefs Invited Review 26: 501-512.

Faucci, A., R.J. Toonen & M.G. Hadfield. 2007. Host shift and speciation in a coral-feeding nudibranch. Proceedings of the Royal Society B: Biological Sciences. 274:111-119.

Wagner, D., S. Kahng & R.J. Toonen. 2007. New report of nudibranch predators of the invasive octocoral Carijoa riisei in the Hawaiian Islands. Coral Reefs 26(2):411.

Toonen, R.J. & A.J. Tyre. 2007. If larvae were smart: A simple model for optimal settlement choices of competent larvae. Marine Ecology Progress Series 349:43-61.

Bird, C.J., B.S. Holland, B.W. Bowen, and R.J. Toonen. 2007. Contrasting population structure in three endemic Hawaiian limpets (Cellana spp.) with similar life histories. Molecular Ecology 16:3173-3186.

Selkoe, K.A., B.S. Halpern & R.J. Toonen. 2008. Evaluating and ranking the vulnerability of regions within the Papahānaumokuākea Marine National Monument to anthropogenic threats. Aquatic Conservation: Marine and Freshwater Ecosystems 18:1149-1165.

Concepcion, G., M. Crepeau, Wagner, D., S.E. Kahng & R.J. Toonen. 2008. An alternative to ITS, a hypervariable, single-copy nuclear intron in corals, and its use in detecting cryptic species within the octocoral genus Carijoa. Coral Reefs 27(2):323-336.

Rocha, L.A., M.T. Craig, and B.W. Bowen. 2007. Phylogeography and the conservation genetics of coral reef fishes. Coral Reefs Invited Review 26: 501-512.

Rocha, L.A. and B.W. Bowen. 2008. Speciation in coral reef fishes. Journal of Fish Biology 72:1101-1121.

Schultz, J.K., J.D. Baker, R.J. Toonen, B.W. Bowen. 2009. Extremely low genetic diversity in the endangered Hawaiian monk seal (Monachus schauinslandi). Journal of Heredity 100:25-33.

Forsman, Z., D.J. Barshis, C. Hunter, and R.J. Toonen. 2009. Shape-shifting corals: Molecular markers show morphology is evolutionarily plastic in Porites. BMC Evolutionary Biology 9:45.

Christie, M.R., J.A. Eble. 2009. Isolation and characterization of 23 microsatellite loci in the yellow tang, Zebrasoma flavescens. Mol Ecol Res 9:544-546.

Franklin E.C., C. V. Brong, A. R. Dow, and M. T. Craig. 2009. Length-weight and length-length relationships of three endemic butterflyfish species (Chaetodontidae) from coral reefs of the Northwestern Hawaiian Islands, USA. Journal of Applied Ichthyology. 25(5):616-617.

Selkoe, K.A., B.H. Halpern, C. Ebert, E. Franklin, E. Selig, K. Casey, J. Bruno, R.J. Toonen. 2009. A map of cumulative impacts to a "pristine" coral reef ecosystem, the Papahānaumokuākea Marine National Monument. Coral Reefs 28(3):635-650.

Eble, J.A., R.J. Toonen, B.W. Bowen. 2009. Endemism and dispersal: comparative phylogeography of three surgeonfish species across the Hawaiian Archipelago. Marine Biology 156:689–698.

Wagner, D., S.E. Kahng & R.J. Toonen. 2009. Observations on the life history and feeding ecology of a specialized nudibranch predator (Phyllodesmium poindimiei), with implications for biocontrol of an invasive octocoral (Carijoa riisei) in Hawaii. Journal of Experimental Marine Biology and Ecology 372:64-74.

Weersing, K.A. & R.J. Toonen. 2009. Population genetics, larval dispersal, and demographic connectivity in marine systems. Marine Ecology Progress Series, Feature Article 393:1-12

Chan, Y.L., X. Pochon, M. Fisher, D. Wagner, G.T. Concepcion, S. Kahng, R.J. Toonen and R.D. Gates. 2009. Host genotypes and endosymbiotic dinoflagellate diversity in the coral Leptoseris sampled between 60-100 meter depths. BMC Ecology, Featured Article 9:21.

Gaither, M.R., R.J. Toonen, L. Sorenson, B.W. Bowen. 2010. Isolation and characterization of microsatellite markers for the Crimson Jobfish, Pristipomoides filamentosus (Lutjanidae). Conservation Genetics Resources 2:169 - 172.

Andrews, K.R., L. Karczmarski, W.W.L. Au, S. Rickards, C.A. Vanderlip, B.W. Bowen, R.J. Toonen. 2010. Rolling stones and stable homes; Social structure, habitat diversity, and population genetics of the Hawaiian spinner dolphin (Stenella longirostris). Molecular Ecology 19:732-748.

Gaither, M.R., R.J. Toonen, D.R. Robertson, S. Planes, and B.W. Bowen. 2010. Genetic evaluation of marine biogeographic barriers: perspectives from two widespread Indo-Pacific snappers (Lutjanus spp.). Journal of Biogeography 37:133-147.

Concepcion, G., S.E. Kahng, M. Crepeau, E.C. Franklin, S. Coles & R.J. Toonen. 2010. Resolving natural ranges and marine invasions in a globally distributed octocoral (genus Carijoa). Marine Ecology Progress Series. 401:113-127.

Daly-Engel, T.S., R.D. Grubbs, K.W. Feldheim, B.W. Bowen, R.J. Toonen. 2010. Is multiple paternity beneficial or unavoidable? Low multiple paternity and genetic diversity in the shortspine spurdog shark (Squalus mitsukurii). Marine Ecology Progress Series 403:255-267.

Reece, J.S., B.W. Bowen, K. Joshi, V. Goz, A.F. Larson. 2010. Phylogeography of two moray eels indicates high dispersal throughout the Indo-Pacific. Journal of Heredity 101:391 – 402.

Kahng, S.E., H. Spalding, R. Garcia, E. Brokovich, D. Wagner, E. Weil, L. Hinderstein & R.J. Toonen. 2010. Community ecology of mesophotic coral reef ecosystems. Coral Reefs 29:255-275.

Concepcion, G.T., N.R Polato, I.B. Baums & R.J. Toonen. 2010. Development of microsatellite markers from four Hawaiian corals: Acropora cytherea, Fungia scutaria, Montipora capitata and Porites lobata. Conservation Genetics Resources 2:11-15.

Wagner, D., M.R. Brugler, D.M. Opresko, S.C. France, A.D. Montgomery & R.J. Toonen 2010. Using morphometrics, in situ observations and genetic characters to distinguish among commercially valuable Hawaiian black coral species; a redescription of Antipathes grandis Verrill, 1928 (Antipatharia : Antipathidae). Invertebrate Systematics 24:271-290.

Craig, M.T., J. Eble, B.W. Bowen. 2010. Origins, ages, and populations histories: Comparative phylogeography of endemic Hawaiian butterflyfishes (genus Chaetodon). Journal of Biogeography 37:2125 – 2136.

Szabo, Z., B.K. Kimokeo, R.J. Toonen & J.E. Randall. 2011. On the status of the Hawaiian seahorses Hippocampus hilonis, H. histrix, and H. fisheri. Marine Biological Research. 7(7):701-709.

Gaither, M.R., S.A. Jones, C. Kelley, S.J. Newman, L. Sorenson, B.W. Bowen. 2011. High connectivity in the deepwater snapper Pristipomoides filamentosus (Lutjanidae) across the Indo-Pacific with isolation of the Hawaiian Archipelago. PLoS One 6(12): e28913. doi:10.1371/journal.pone.0028913.

Gaither, M.R., Z. Szabó, M. Crepeau, C.J. Bird, R.J. Toonen. 2011. Preservation of corals in salt-saturated DMSO buffer is superior to ethanol for PCR experiments. Coral Reefs 30:329 – 333.

Randall, J.E., J.D. DiBattista, C. Wilcox. 2011. Acanthurus nigros Gunther, a valid species of surgeonfish, distinct from the Hawaiian A. nigroris Valenciennes. Pacific Science 65: 265 – 275.

Wagner, D., R.G. Waller & R.J. Toonen. 2011. Sexual reproduction of Hawaiian black corals, with a review of reproductive processes within the order Antipatharia (Cnidaria: Anthozoa: Hexacorallia). Invertebrate Biology 130(3):211-225.

Selkoe, K.A. & R.J. Toonen 2011. Marine connectivity: a new look at pelagic larval duration and genetic metrics of dispersal (Review Article). Marine Ecology Progress Series. 436:291-305.

Gaither, M.R., B.W. Bowen, T.-R. Bordenave, L.A. Rocha, S.J. Newman, J.A. Gomez, L. van Herwerden, M.T. Craig. 2011. Phylogeography of the reef fish Cephalopholus argus (Epinephelidae) indicates Pleistocene isolation across the Indo-Pacific Barrier with contemporary overlap in the Coral Triangle. BMC Evolutionary Biology 11:189 doi:10.1186/1471-2148-11-189

Reece, J.S., B.W. Bowen, A. Larson. 2011. Long larval duration in moray eels (Muraenidae) ensures ocean-wide connectivity despite differences in adult niche breadth. Marine Ecology Progress Series 437: 269 – 277.

DiBattista J.D., Feldheim, K.A., B.W. Bowen. 2011. Microsatellite DNA markers for population genetic and hybridization analysis of two closely related surgeonfish species, Acanthurus nigricans and Acanthurus leucosternon. Conservation Genetic Resources 3: 159 – 162.

Wagner, D., X. Pochon, L. Irwin, R.J. Toonen & R.D. Gates (2011). Azooxanthellate? Most Hawaiian black corals contain Symbiodinium. Proceedings of the Royal Society B: Biological Sciences. 278(1710):1323-1328.

Kittinger, J. N., J. M. Pandolfi, J. H. Blodgett, T. L. Hunt, H. Jiang, K. Maly, L. McClenachan, J. K. Schultz, and B. A. Wilcox. 2011. Historical reconstruction reveals recovery in Hawaiian coral reefs. PLoS ONE 6(10):e25460. DOI: 10.1371/journal.pone.0025460

Cotton, C.F., R.D. Grubbs, T.S. Daly-Engel, P.D. Lynch, and J.A. Musick. 2011. Age, growth and reproduction of Squalus cf. mitsukurii from Hawaiian waters. Marine and Freshwater Research 62: 811-822

Work, T.M., Z.H. Forsman, Z. Szabó, T.D. Lewis, G.S. Aeby, R.J. Toonen. 2011. Inter-Specific Coral Chimerism: Genetically Distinct Multicellular Structures Associated with Tissue Loss in Montipora capitata. PLoS ONE 6(7): e22869. doi:10.1371/journal.pone.0022869.

Bird, C.E., B. Holland, B.W. Bowen & R.J. Toonen. 2011. Diversification of sympatric broadcast-spawning limpets (Cellana spp.) within the Hawaiian archipelago. Molecular Ecology. 20:2128-2141.

Bird, C.E. Evidence of adaptive diversification in sympatric Hawaiian limpets. 2011. Journal of Integrative and Comparative Biology. doi: 10.1093/icb/icr050, pp. 1-8.

Eble, J.A., R.J. Toonen, L. Sorenson, L.V. Basch, Y.P. Papastamatiou & B.W. Bowen. 2011. Escaping paradise: larval export from Hawaii in an Indo-Pacific reef fish, the Yellow Tang (Zebrasoma flavescens). Marine Ecology Progress Series. 428:245-258.

Toonen, R.J., K.R. Andrews, I.B. Baums, C.E. Bird, C.T. Concepcion, T.S. Daly-Engel, J.A. Eble, A. Faucci, M.R. Gaither, M. Iacchei, J.B. Puritz, J.K. Schultz, D.J. Skillings, M. Timmers, B.W. Bowen. 2011. Defining boundaries for applying ecosystem-based management: A

multispecies case study of marine connectivity across the Hawaiian Archipelago. Journal of Marine Biology, Volume 2011#460173, 13 pages.

Skillings, D., C.E. Bird & R.J. Toonen. 2011. Gateways to Hawai'i – genetic population structure of the tropical sea cucumber Holothuria atra. Journal of Marine Biology. Volume 2011, #783030, 16 pages.

Wiener, C.S., M. Rivera, R.J. Toonen, J. Leong, R.K. Kosaki, S.A. Karl, K. Keller & H. Johnson. 2011. Creating Effective Partnerships in Ecosystem Based Management: A Culture of Science and Management. Journal of Marine Biology. Volume 2011, #241610, 8 pages.

Timmers, M.A., K. Andrews, C.E. Bird, M.J. deMaintenon, R.E. Brainard & R.J. Toonen,. 2011. Widespread dispersal of the crown-of-thorns sea star, Acanthaster planci, across the Hawaiian Archipelago and Johnston Atoll. Journal of Marine Biology. Volume 2011, #934269, 10 pages.

Rivera, M., K. Andrews, D. Kobayashi, J. Wren, C. Kelley, G. Roderick & R.J. Toonen. 2011. Genetic analyses and simulations of larval dispersal reveal distinct populations and directional connectivity across the range of the Hawaiian Grouper (Epinephelus quernus). Journal of Marine Biology. Volume 2011, #765353, 11 pages.

DiBattista, J., C. Wilcox, M. Craig, L.A. Rocha & B.W. Bowen. 2011. Phylogeography of the Bluelined Surgeonfish, Acanthurus nigroris, reveals high connectivity and a cryptic endemic species in the Hawaiian Archipelago. Journal of Marine Biology Volume 2011, #839134, 17 pages.

Eble, J.A., L.A. Rocha, M.T. Craig, B.W. Bowen. 2011. Not all larvae stay close to home: Insights into marine population connectivity with a focus on the Brown Surgeonfish. Journal of Marine Biology Volume, Article ID 518516, 12 pp.

Stat, M., C.E. Bird, X. Pochon, L. Chasqui, L.J. Chauka, G.T. Concepcion, D. Logan, M. Takabayashi, R.J. Toonen & R.D. Gates. 2011. Spatial distribution of Symbiodinium ITS2 in corals: interpretations associated with a multi-copy intra-genomically variable marker. PLoS ONE 6(1): e15854.

Schultz, J.K., J.D. Baker, R.J. Toonen, A.L. Harting, B.W. Bowen. 2012. Range-wide genetic connectivity of the Hawaiian monk seal and implications for transplantation. Conservation Biology 25:124-132.

Timmers, M., C.E. Bird, D.J. Skillings, P.E. Smouse & R.J. Toonen. 2012. There's no place like home: Crown-of-Thorns outbreaks in the Central Pacific are regionally derived and independent events. PLoS ONE 7(2): e31159. DOI:10.1371/journal.pone.0031159173)

Whitney, N.M., W.D. Robbins, J.K. Schultz, B.W. Bowen, K.N. Holland. 2012. Phylogeography of the whitetip reef shark (Triaenodon obesus): a sedentary species with a broad distribution. Journal of Biogeography 39: 1144 – 1156.

Daly-Engel, T.S., J.E. Randall, B.W. Bowen. 2012. Is the Great Barracuda (Sphyraena barracuda) a reef fish or a pelagic fish? The phylogeographic perspective. Marine Biology 159: 975 – 985 DOI 10.1007/s00227-012-1878-9

Daly-Engel, T.S., K.D. Seraphin, K.N. Holland, J.P. Coffey, H.A. Nance, R.J. Toonen, B.W. Bowen. 2012. Global phylogeography with mixed marker analysis reveals male-mediated dispersal in the endangered scalloped hammerhead shark (Sphyrna lewini). PLoS ONE 7(1): e29986. doi:10.1371/journal.pone.0029986

Stat, M., A. Baker, A. Correa, Z. Forsman, M. Huggett, X. Pochon, D. Skillings, C. Starger, R.J. Toonen, M. van Oppen & R.D Gates. 2012. Molecular delineation of species in the coral holobiont. Advances in Marine Biology 63:1 - 66

O'Malley, J.M., J.C. Drazen, B.N. Popp, E. Gier & R.J. Toonen. 2012 Spatial Variability in Growth and Prey Availability of Lobsters in the Northwestern Hawaiian Islands. Marine Ecology Progress Series 449:211-220.

Toonen, R.J., T. Nakayama, T. Ogawa, A. Rossiter & J.C. Delbeek. 2012 Growth of cultured giant clams (Tridacna spp.) in low pH, high-nutrient seawater: species-specific effects of substrate and supplemental feeding under acidification. Journal of the Marine Biological Association of the UK 92(4):731-740.

Wagner D, Montgomery AD, Waller RG & Toonen RJ. 2012 Sexual reproduction of the commercially valuable Hawaiian black coral Antipathes griggi (Cnidaria: Antipatharia). Coral Reefs. 31: 795 – 806.

Wagner, D., D. Luuk & R.J. Toonen. 2012. Biology and ecology of antipatharians (Cnidaria: Anthozoa: Hexacorallia). Invited review: Advances in Marine Biology 63:67-132.

Bowen, B.W., L.A. Rocha, R.J. Toonen, S.A. Karl, M.T. Craig, J.D. DiBattista, J.A. Eble, M.R. Gaither, D. Skillings & C.E. Bird (2013). The origins of tropical marine biodiversity. Trends in Ecology & Evolution. 28:359-366.

Fernandez-Silva, I., B.N. Snelgrove & B.W. Bowen (2013) Twelve microsatellite DNA markers to resolve population structure of the Yellow-Striped Goatfish Mulloidichthys flavolineatus (family Mullidae). Conservation Genetics Resources 5:565 – 568.

Bird, C.E., E. Franklin, C. Smith & R.J. Toonen (2013). Between tide and wave marks: A unifying model of physical zonation on littoral shores. PeerJ. 1:e154 http://dx.doi.org/10.7717/peerj.154.

Toonen, R.J., T.A. Wilhelm, S. Maxwell, D. Wagner, B.W. Bowen, C. Sheppard, S. Taei, T. Teroroko, R. Moffitt, C. Gaymer, L. Morgan, M. Lewis, A. Sheppard, J. Parks, A. Friedlander &

Big Ocean Think Tank. (2013) One Size Does Not Fit All: The Emerging Frontier in Large-Scale Marine Conservation. Marine Pollution Bulletin. 77: 7-10.

Briggs, J.C. & B.W. Bowen (2013) Evolutionary patterns: Marine shelf habitat. Journal of Biogeography 40:1023 – 1035. doi:10.1111/jbi.12082

Baums, I.B., S. Godwin, E. Franklin, D. Carlon & R.J. Toonen (2013). Discordant population expansions in four species of coral-associated, Pacific hermit crabs (Anomura: Diogenidae) linked to habitat availability resulting from sea level change. Journal of Biogeography 41:339 – 352., doi: 10.1111/jbi.12181

Luck, D.G., Z.H. Forsman, R.J. Toonen, S.J. Leicht & S.E. Kahng. (2013) Polyphyly and hidden species among Hawaii's dominant mesophotic coral genera, Leptoseris and Pavona (Scleractinia: Agariciidae) PeerJ 1:e132 http://dx.doi.org/10.7717/peerj.132

Gaither, M., G. Aeby, M. Vignon, Y. Meguro, M. Rigby, C. Runyon, R.J. Toonen, C.L. Wood, B.W. Bowen (2013). An invasive fish and the time-lagged spread of its parasite across the Hawaiian archipelago. PLoS ONE. 8(2), e56940.

Andrews, KR., J.B. Puritz, W.F. Perrin, M. Oremus, L. Karczmarski, B.W. Bowen & R.J. Toonen (2013). The evolving male: Spinner dolphin ecotypes are divergent at a Y chromosome marker but not mtDNA or autosomal markers. Molecular Ecology 22(9):2408–2423.

Gaither, M.R., B.W. Bowen & R.J. Toonen (2013). Population structure in the native range predicts the spread of introduced marine species. Proceedings of the Royal Society B: Biological Sciences. 280(1760):20130409

Farrar, C.E., Z.H. Forsman, R.D. Gates, J.C. Leong & R.J. Toonen (2013). Observing the Coral Symbiome Using Laser Scanning Confocal Microscopy – Visualization challenge, Honorable Mention. Science. 339(6119):518-518.

Szabo Z., B. Snelgrove, M.T. Craig, L.A. Rocha, B.W. Bowen. 2014. Phylogeography of the Manybar Goatfish, Parupeneus multifasciatus reveals moderate structure between the Central and North Pacific and a cryptic endemic species in the Marquesas. Bulletin of Marine Science 90:493 – 512. http://dx.doi.org/10.5343/bms.2013.1032

Andrews, K.R., V. Moriwake, C. Wilcox, C. Kelley, E.G. Grau, B.W. Bowen. 2014. Population genetic analyses of Etelis coruscans and Etelis marshi reveal consistent patterns of genetic structure for deepwater fishes across the Hawaiian Archipelago. PLoS One 9: e91665.

Selkoe, K.A., O. Gaggiotti, K.R. Andrews, M.A. Bernal, C. Bird, H. Bolick, I. Baums, R. Coleman, G.T. Concepcion, M.T. Craig, J.D. DiBattista, J. Eble, I. Fernandez-Silva, M.R. Gaither, M. Iacchei, N.R. Polato, M.A.J. Rivera, L.A. Rocha, D. Skillings, M. Timmers, Z. Szabo, B.W. Bowen, R.J. Toonen. 2014. Emergent patterns of population genetic structure for a coral reef community. Molecular Ecology 23:3064 – 3079.

Coleman R.R., M.R. Gaither, B. Kimokeo, F. Stanton, B.W. Bowen, R.J. Toonen. 2014. Large-scale introduction of the Indo-Pacific damselfish Abudefduf vaigiensis into Hawai'i promotes genetic swamping of the endemic congener A. abdominalis. Molecular Ecology 23:5552 – 5565.

Tenggardjaja, K.A., B.W. Bowen, G. Bernardi. 2014. Vertical and horizontal connectivity in Chromis verater, an endemic damselfish found on shallow and mesophotic reefs in the Hawaiian Archipelago and Johnston Atoll. PLoS One 9: e115493. doi:10.1371/journal.pone.0115493

Gaither, M.R., M.A. Bernal, R.R. Coleman, B.W. Bowen, S.A. Jones, W.B. Simison, L.A. Rocha. 2015. Genomic signatures of geographic isolation and natural selection in coral reef fishes. Molecular Ecology 24:1543-1557.

Tenggardjaja, K.A., B.W. Bowen, G. Bernardi. 2016. Reef fish dispersal in the Hawaiian Archipelago: comparative phylogeography of three endemic damselfishes. Journal of Marine Biology: Article ID 3251814

Concepcion, GT, J Kenyon, IB Baums & RJ Toonen (2016) Genetic evidence for possible coral larval dispersal from the Northern Line Islands to the Hawaiian Archipelago. Galaxea Journal of Coral Reef Studies. 18(1):9-11.

Iacchei M., M.R. Gaither, B.W. Bowen, R.J. Toonen. 2016. Predicting provincial boundaries for phyllosoma: range-wide phylogeography of the pronghorn spiny lobster Panulirus penicillatus. Journal of Biogeography 43:1032-1044.

Pyle, R.L., R. Boland, H. Bolick, B.W. Bowen, C.J. Bradley, C. Kane, R.K. Kosaki, R. Langston, K. Longenecker, A. Montgomery, F.A. Parrish, B.N. Popp, J. Rooney, C.M. Smith, D. Wagner, H.L. Spalding (2016) A comprehensive investigation of mesophotic coral ecosystems in the Hawaiian Archipelago. PeerJ 4:e2475 DOI 107717/peerj.2475

Salerno, J.L., B.W. Bowen, M.S. Rappe. Molecular biogeography of reef-associated microorganisms across the Hawaiian Archipelago. FEMS Microbiology Ecology 92: fiw109. doi: 10.1093/femsec/fiw109

Ahti, A.P., R.R. Coleman, J.D. DiBattista, M.L. Berumen, L.A. Rocha, B.W. Bowen. 2016. Phylogeography of Indo-Pacific reef fishes: Sister wrasses Coris gaimard and C. cuvieri in the Red Sea, Indian Ocean, and Pacific Ocean. Journal of Biogeography 43:1103-1115.

Waldrop E., J.P. Hobbs, J.E. Randall, J.D. DiBattista, L.A. Rocha, R.K. Kosaki, M.L. Berumen, B.W. Bowen. 2016. Phylogeography, population structure, and evolution of coral-eating butterflyfishes (Subgenus Corallochaetodon). Journal of Biogeography 43:1116-1129.

Johnston, E.C., Z.H. Forsman, J-F Flot, S. Schmidt-Roach, J.H. Pinzón, I.S. S. Knapp & R.J. Toonen (2017) A genomic glance through the fog of plasticity and diversification in Pocillopora. Scientific Reports. 7: 5991, DOI:10.1038/s41598-017-06085-3.

LITERATURE CITED:

Ahti, A.P., R.R. Coleman, J.D. DiBattista, M.L. Berumen, L.A. Rocha, B.W. Bowen. 2016. Phylogeography of Indo-Pacific reef fishes: Sister wrasses Coris gaimard and C. cuvieri in the Red Sea, Indian Ocean, and Pacific Ocean. Journal of Biogeography 43:1103-1115.

Arbogast, B.S., Edwards, S.V., Wakeley, J., Beerli, P., Slowinski, J.B. 2002. Estimating divergence times from molecular data on phylogenetic and population genetic timescales. Ann. Rev. Ecol. Syst. 33:707-740.

Andrews, K.R., V. Moriwake, C. Wilcox, C. Kelley, E.G. Grau, B.W. Bowen. 2014. Population genetic analyses of Etelis coruscans and Etelis marshi reveal consistent patterns of genetic structure for deepwater fishes across the Hawaiian Archipelago. PLoS One 9: e91665.

Beerli, P and J Felsenstein. 2001. Maximum likelihood estimation of a migration matrix and effective population sizes in n subpopulations by using a coalescent approach. Proc. Natl. Acad. Sci USA 98: 4563-4568.

Bird, C.E., B.S. Holland, B.W. Bowen, R.J. Toonen. 2011. Diversification of endemic sympatric limpets (Cellana spp.) in the Hawaiian Archipelago. Molecular Ecology In press

Bowen, B.W. and J. Roman. 2005. Gaia's handmaidens: the Orlog model for conservation biology. Conservation Biology 19:1037-1043.

Bowen, B.W., A.L. Bass, A.J. Muss, J. Carlin, and D.R. Robertson. 2006a. Phylogeography of two Atlantic squirrelfishes (family Holocentridae): Exploring pelagic larval duration and population connectivity. Marine Biology 149:899-913.

Bowen, B.W., A. Muss, L.A. Rocha, and W.S. Grant. 2006b. Shallow mtDNA coalescence in Atlantic pygmy angelfishes (genus Centropyge) indicates a recent invasion from the Indian Ocean. Journal of Heredity 97:1-12.

Bowen, B.W., L.A. Rocha, R.J. Toonen, S.A. Karl, M.T. Craig, J.D. DiBattista, J.A. Eble, M.R. Gaither, D. Skillings, C.E. Bird. 2013. Origins of tropical marine biodiversity. Trend in Ecology and Evolution 28:359 – 366. doi.org/10.1016/j.tree.2013.01.018

Clement, M, D Posada and KA Crandall. 2000 TCS: a computer program to estimate gene genalogies. Mol. Ecol. 9: 1657-1659.

Coleman R.R., M.R. Gaither, B. Kimokeo, F. Stanton, B.W. Bowen, R.J. Toonen. 2014. Large-scale introduction of the Indo-Pacific damselfish Abudefduf vaigiensis into Hawai'i promotes genetic swamping of the endemic congener A. abdominalis. Molecular Ecology 23:5552 – 5565.

Craig, M.T., J.A. Eble, D.R. Robertson, B.W. Bowen. 2007. High genetic connectivity across the Indian and Pacific Oceans in the reef fish Myripristis berndti (Holocentridae). Marine Ecology Progress Series 334:345-354.

Daly-Engel, T.S., K.D. Seraphin, K.N. Holland, J.P. Coffey, H.A. Nance, R.J. Toonen, B.W. Bowen. 2012. Global phylogeography with mixed marker analysis reveals male-mediated dispersal in the endangered scalloped hammerhead shark (Sphyrna lewini). PLoS ONE 7(1): e29986. doi:10.1371/journal.pone.0029986Dawson, M.N. , R.K. Grosberg, L.W. Botsford. 2006. Connectivity in Marine Protected Areas. Science 313:43-44.

DiBattista, J.D., M.T. Craig, L.A. Rocha, K.A. Feldheim, B.W. Bowen. 2012. Phylogeography of the Indo-Pacific butterflyfishes, Chaetodon meyeri and Chaetodon ornatissimus: Sister species reveal divergent evolutionary histories and discordant results from mtDNA and microsatellites. Journal of Heredity 103:617 – 629.

Eble, J.A., R.J. Toonen, B.W. Bowen. 2009. Endemism and dispersal: comparative phylogeography of three surgeonfish species across the Hawaiian Archipelago. Marine Biology 156:689–698.

Emerson B, E Pardis, and C. Thebaud. 2001. Revealing the demographic histories of species using DNA sequences. Trends in Ecology and Evolution 16:707-716.

Fernandez-Silva, I., B.N. Snelgrove, B.W. Bowen. 2013. Twelve microsatellite DNA markers to resolve population structure of the Yellow-Striped Goatfish Mulloidichthys flavolineatus (family Mullidae). Conservation Genetics Resources 5:565 – 568.

Friedlander A.M., DeMartini E.E. 2002. Contrasts in density, size, and biomass of reef fishes between the northwestern and the main Hawaiian Islands: the effects of fishing down apex predators. Mar Ecol Prog Ser 230:253–264.

Gaither, M.R., S.A. Jones, C. Kelley, S.J. Newman, L. Sorenson, B.W. Bowen. 2011. High connectivity in the deepwater snapper Pristipomoides filamentosus (Lutjanidae) across the Indo-Pacific with isolation of the Hawaiian Archipelago. PLoS One 6(12): e28913. doi:10.1371/journal.pone.0028913.

Gaither, M.R., R.J. Toonen, B.W. Bowen. 2012. Coming out of the starting blocks: the importance of lag period and stochasticity in shaping patterns of genetic diversity in marine invaders. Proceedings of the Royal Society of London Series B 279:3948 - 3957.

Gaither, M.R., G. Aeby, M. Vignon, Y. Meguro, M. Rigby, C. Runion, R.J. Toonen, C.L. Wood, B.W. Bowen. 2013. An invasive fish and the time-lagged spread of its parasite across the Hawaiian archipelago. PLoS One 8: e56940. doi:10.1371/journal.pone.0056940

Gaither, M.R., B.W. Bowen, R.J. Toonen. 2013. Population structure in the native range predicts the spread of introduced marine species. Proceedings of the Royal Society of London Series B 280: 20130409. http://dx.doi.org/10.1098/rspb.2013.0409

Gaither, M.R., M.A. Bernal, R.R. Coleman, B.W. Bowen, S.A. Jones, W.B. Simison, L.A. Rocha. 2015. Genomic signatures of geographic isolation and natural selection in coral reef fishes. Molecular Ecology 24:1543-1557.

Harpending, HC, MA Batzer, M Gurven, LB Jorde, AR Rogers, and ST Sherry. 1998. Genetic traces of ancient demography. Proc. Natl. Acad. Sci USA 95:1961-1967.

Jaap WC, J Wheaton. 1975. Observation on Florida reef corals treated with fish-collecting chemicals. Florida Marine Research Publications 10: 1 – 18.

Ludt, W.B., M. Bernal, B.W. Bowen, L.A. Rocha. 2012. Living in the past: Phylogeography and population histories of Indo-Pacific wrasses (Genus Halichoeres) in shallow lagoons versus outer reef slopes. PLoS One 7: e38042 doi:10.1371/journal.pone.0038042

Johnston, E.C., Z.H. Forsman, J-F Flot, S. Schmidt-Roach, J.H. Pinzón, I.S. S. Knapp & R.J. Toonen (2017) A genomic glance through the fog of plasticity and diversification in Pocillopora. Scientific Reports. 7: 5991, DOI:10.1038/s41598-017-06085-3.

Maragos JE, and PL Jokiel. 1986. Reef corals of Johnston Atoll: One of the world's most isolated reefs. Coral Reefs 4:141-150.

Maragos, J, D Potts, G Aeby, D Gulko, J Kenyon, D Siciliano and D VanRavenswaay. 2004. 2000-2002 rapid ecological assessment of corals on the shallow reefs of the Northwestern Hawaiian Islands. Part 1: Species and distribution. Pacific Science, 58: 211-230.

Ramon, M.L., P.A. Nelson, E. DeMartini, W.J. Walsh, G. Bernardi. 2008. Phylogeography, historical demography, and the role of post-settlement ecology in two Hawaiian damselfish species. Mar Biol 153:1207-1217.

Rivera, MAJ, Kelley CD, and GK Roderick. 2004. Subtle population genetic structure in the Hawaiian grouper, Epinephelus quernus (Serranidae) as revealed by mitochondrial DNA analyses. Biological Journal of the Linnean Society 81: 449–468.

Ruzzante, D. 1998. A comparison of several measures of genetic distance and population structure with microsatellite data: bias and sampling variance. Can. J. Fish. Aquat. Sci. Vol. 55, 1-14.

Schneider, S., Roessli, D., & Excoffier, L. 2000 Arlequin version 2.000, a software for population genetics data anlaysis. Genetics and Biometry Lab, University of Geneva, Geneva, Switzerland. http://anthro.unige.ch/arlequin

Schultz, J.K., R.L. Pyle, E. DeMartini, and B.W. Bowen. 2007. Genetic homogeneity among color morphs of the flame angelfish, Centropyge loriculus. Marine Biology 151:167-175.

Selkoe, K.A., O. Gaggiotti, K.R. Andrews, M.A. Bernal, C. Bird, H. Bolick, I. Baums, R. Coleman, G.T. Concepcion, M.T. Craig, J.D. DiBattista, J. Eble, I. Fernandez-Silva, M.R. Gaither, M. Iacchei, N.R. Polato, M.A.J. Rivera, L.A. Rocha, D. Skillings, M. Timmers, Z. Szabo, B.W. Bowen, R.J. Toonen. 2014. Emergent patterns of population genetic structure for a coral reef community. Molecular Ecology 23:3064 – 3079.

Selkoe, K.A., O.E. Gaggiotti, E.A. Treml, J.L.K. Wren, M.K. Donovan, Hawaii Reef Connectivity Consortium, R.J. Toonen. (2016) Conserving genetic diversity of whole communities: identifying patterns and landscape drivers. Proceedings of the Royal Society B: Biological Sciences B 283(1829):20160354.

Seutin, G., White, B.N., Boag, P.T., 1991. Preservation of avian blood and tissue samples for DNA analyses. Canadian Journal of Zoology 69: 82-90.

Shoaf, W.T. 1976. Improved extraction of chlorophyll a and b from algae using dimethyl sulfoxide. Limnology and Oceanography 21: 926 – 928.

Sudekum, A.E., Parrish J.D., Radtke R.L., Ralston S. 1991. Life history and ecology of large jacks in undisturbed, shallow, oceanic communities. Fish Bull 89:493–513.

Swearer, S. E., Shima, J. S., Hellberg, M. E., Thorrold, S. R., Jones, G. P., Robertson, D. R., Morgan, S. G., Selkoe, K. A., Ruiz, G. M. & Warner, R. R. 2002. Evidence of self-recruitment in demersal marine populations. Bulletin of Marine Science 70: 251-271.

Swofford, DL. 2002 Phylogenetic Analysis Using Parsimony (*and other Methods). Version 4.0b10. Sunderland, MA: Sinauer.

Szabo Z., B. Snelgrove, M.T. Craig, L.A. Rocha, B.W. Bowen. 2014. Phylogeography of the Manybar Goatfish, Parupeneus multifasciatus reveals moderate structure between the Central and North Pacific and a cryptic endemic species in the Marquesas. Bulletin of Marine Science 90:493 – 512. http://dx.doi.org/10.5343/bms.2013.1032

Templeton, A. R., Crandall, K. A. & Sing, C. F. 1992 A cladistic analysis of phenotypic associations with haplotypes inferred from restriction endonuclease mapping. I. Basic theory and an analysis of alcohol dehydrogenase activity in Drosophila. Genetics 132: 619-633.

Tenggardjaja, K.A., B.W. Bowen, G. Bernardi. 2014. Vertical and horizontal connectivity in Chromis verater, an endemic damselfish found on shallow and mesophotic reefs in the Hawaiian Archipelago and Johnston Atoll. PLoS One 9: e115493. doi:10.1371/journal.pone.0115493

Tenggardjaja, K.A., B.W. Bowen, G. Bernardi. 2016. Reef fish dispersal in the Hawaiian Archipelago: comparative phylogeography of three endemic damselfishes. Journal of Marine Biology: Article ID 3251814

Toonen, R.J. 2001. Molecular Genetic Analysis of Recruitment and Dispersal in the Intertidal Porcelain Crab, Petrolisthes cinctipes. Ph.D. Dissertation, Center for Population Biology, Section of Evolution and Ecology, University of California, Davis, CA. 325 pp.

Toonen, R.J., K.R. Andrews, I.B. Baums, C.E. Bird, C.T. Concepcion, T.S. Daly-Engel, J.A. Eble, A. Faucci, M.R. Gaither, M. Iacchei, J.B. Puritz, J.K. Schultz, D.J. Skillings, M. Timmers, B.W. Bowen. 2011. Defining boundaries for applying ecosystem-based management: A multispecies case study of marine connectivity across the Hawaiian Archipelago. Journal of Marine Biology, Article ID 460173

Toonen, R.J., T.A. Wilhelm, S.M. Maxwell, D. Wagner, B.W. Bowen, C. Sheppard, S.M. Taei, T. Teroroko, R. Moffitt, C.F. Gaymer, L. Morgan, N. Lewis, A. Sheppard, J. Parks, A.M. Friedlander, The Big Ocean Think Tank. 2013. One size does not fit all: The emerging frontier in large-scale marine conservation. Marine Pollution Bulletin 77:7 – 10.

Waldrop E., J.P. Hobbs, J.E. Randall, J.D. DiBattista, L.A. Rocha, R.K. Kosaki, M.L. Berumen, B.W. Bowen. 2016. Phylogeography, population structure, and evolution of coral-eating butterflyfishes (Subgenus Corallochaetodon). Journal of Biogeography 43:1116-1129.

Whitney, N.M., W.D. Robbins, J.K. Schultz, B.W. Bowen, K.N. Holland. 2012. Phylogeography of the whitetip reef shark (Triaenodon obesus): a sedentary species with a broad distribution. Journal of Biogeography 39: 1144 – 1156.

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.

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

Papahānaumokuākea Marine National Monument
Compliance Information Sheet

1. Updated list of personnel to be covered by permit. List all personnel names and their roles here (e.g. John Doe, Diver; Jane Doe, Field Technician, Jerry Doe, Medical Assistant):

Brian W. Bowen, Ph.D., Principle Investigator
Randall Kosaki, Ph.D., Research Diver, NOAA PMNM
Richard Pyle, Ph.D., Research Diver, B.P. Bishop Museum
Atsuko Fukunaga, Ph.D., Research Diver, NOAA PMNM
Keolohilani H. Lopes, M.S., Research Diver, NOAA PMNM
Stephen Matadobra, Research Diver, PMNM
Jason Leonard, Research Diver, PMNM
Brian Hauk, M.S., Research Diver, NOAA PMNM
LTJG Terril Effird, M.S., small boat coxswain, PMNM/NOAA Corps
Joshua Copus, M.S., Research Diver, HIMB
Mykle Hoban, M.S., Research Diver, HIMB
(2) Research Divers, TBD

2. Specific Site Location(s): (Attach copies of specific collection locations):

Location	Longitude	Latitude
Kure Atoll	-178.19706492000	28.55825235580
Kure Atoll	-178.19623585400	28.29958375730
Kure Atoll	-178.45987884800	28.29958375730
Kure Atoll	-178.46070791400	28.55742328970
Midway Atoll	-177.19638223300	28.37419969920
Midway Atoll	-177.19721129900	28.13377055310
Midway Atoll	-177.52800864100	28.13459961920
Midway Atoll	-177.52800864100	28.37419969920
Pearl and Hermes Atoll	-176.08850981800	28.04643025580
Pearl and Hermes Atoll	-175.63289162600	28.04539944540
Pearl and Hermes Atoll	-175.63289162600	27.70729363750
Pearl and Hermes Atoll	-176.08954062900	27.70626282710
Lisianski Island	-173.67292570900	26.25150771120
Lisianski Island	-173.67292570900	25.83942708400
Lisianski Island	-174.23095155800	25.83942708400
Lisianski Island	-174.23095155800	26.25150771120
Laysan Island	-171.47900122300	25.96027179830
Laysan Island	-171.47725234300	25.65596666490
Laysan Island	-171.97918092500	25.65771554490
Laysan Island	-171.97918092500	25.96202067840
Maro Reef	-170.18133220600	25.69968866680
Maro Reef	-170.17958332600	25.21524888540

From:
To:

Describe any limiting factors in declaring specific dates of the proposed activity at the time of application: All dates are tentative and dependent upon ship and weather conditions. Ocean conditions strongly influence the dates that vessels can enter Monument waters, as well as when research can be conducted while in the Monument waters. Dates are also dependent on vessel and personnel schedules. Co-trustees will be notified of any changes to the dates currently provided.

Personnel schedule in the Monument: All personnel will remain on the NOAA vessel Hi'ialakai (or on small boats that are transported to the Monument by the main vessel) throughout the cruise duration. No individual will go on land to conduct this research.

Schedule not yet determined.

6. Indicate (with attached documentation) what insurance policies, bonding coverage, and/or financial resources are in place to pay for or reimburse the Monument trustees for the necessary search and rescue, evacuation, and/or removal of any or all persons covered by the permit from the Monument:
All divers are required to carry DAN insurance in addition to UH workers compensation that will cover any diving related injury or an accident that occurs while on a diving research cruise.

7. Check the appropriate box to indicate how personnel will enter the Monument:

X Vessel
☐ Aircraft

Provide Vessel and Aircraft information:

8. The certifications/inspections (below) must be completed prior to departure for vessels (and associated tenders) entering the Monument. Fill in scheduled date (attach documentation):

☐ Rodent free, Date:
☐ Tender vessel, Date:
☐ Ballast water, Date:

* PERMITS WILL NOT BE ISSUED TO INDIVIDUALS ENTERING THE MONUMENT VIA VESSEL UNTIL NOAA OLE HAS CONTACTED THE MONUMENT PERMIT COORDINATOR WITH A 'POSITIVE CHECK' READING.

10. Tender information:

On what workboats (tenders) will personnel, gear and materials be transported within the Monument? List the number of tenders/skiffs aboard and specific types of motors:

DAVID Y. IGE
GOVERNOR OF HAWAII

SUZANNE CASE
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

Robert Masuda
FIRST DEPUTY

Jeffrey Pearson P.E.
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

STATE OF HAWAI'I
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF AQUATIC RESOURCES
1151 PUNCHBOWL STREET, ROOM 330
HONOLULU, HAWAI'I 96813

July 27, 2018

TO: Division of Aquatic Resources File

THROUGH: Suzanne Case, Chairperson

FROM: Maria Carnevale
Papahānaumokuākea Marine National Monument

DECLARATION OF EXEMPTION FROM THE PREPARATION OF AN ENVIRONMENTAL ASSESSMENT UNDER THE AUTHORITY OF CHAPTER 343, HRS AND CHAPTER 11-200 HAR, FOR PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT RESEARCH PERMIT TO DR. BRIAN BOWEN, UNIVERSITY OF HAWAI'I, HAWAI'I INSTITUTE OF MARINE BIOLOGY, FOR ACCESS TO STATE WATERS TO CONDUCT GENETIC SURVEY ACTIVITIES UNDER PERMIT PMNM-2018-031

The following permitted activities are found to be exempted from preparation of an environmental assessment under the authority of Chapter 343, HRS and Chapter 11-200, HAR:

Project Title:
Papahānaumokuākea Marine National Monument Research Permit to Dr. Brian Bowen, University of Hawai'i, Hawai'i Institute of Marine Biology, for Access to State Waters to Conduct Genetic Survey Activities.

Permit Number: PMNM-2018-031

Project Description:
The research permit application, as described below, would allow entry and activities to occur in Papahānaumokuākea Marine National Monument, including the NWHI State waters from August 15, 2018 through August 14, 2019.

This project is to conduct a genetic survey of reef fishes, invertebrates and algae which would address the level of isolation between deep and shallow reef ecosystems across the Hawaiian Archipelago. The activities in the permit include collecting target reef fish, invertebrate and algal species. The target species were chosen to be abundant and widespread in the archipelago and easy to identify. Whenever possible, the permittee samples fishes non-lethally and removes a rice-grain sized piece of fin and releases the animal in the location from which it was collected. Although significant progress has been made in nonlethal sampling, most specimens are collected with polespears and nets. Nonlethal tissue biopsies will be collected from all invertebrates.

The proposed activities are in direct support of the Monument Management Plan's priority management need 3.1 – Understanding and Interpreting the NWHI (through action plan 3.1.1 – Marine Conservation Science). This action plan specifies to "measure connectivity and genetic diversity of key species to enhance management decisions." Activities to support marine conservation science, including connectivity and genetic diversity surveys such as those to be carried out by the permittee, are also addressed in the Monument Management Plan Environmental Assessment (December 2008) which resulted in FONSI. This EA summarizes that understanding the genetic diversity of species groups and how these populations change could be helpful to forecast, prepare for and mediate potential threats to populations within the Monument (PMNM MMP Vol. 2, p.171). Identification of genetic diversity and connectivity of reef fishes, such as those proposed, would enhance this understanding.

Consulted Parties:
The permit application was sent out for review and comment to the following scientific and cultural entities: Hawai'i Division of Aquatic Resources, Hawai'i Division of Forestry and Wildlife, Papahānaumokuākea Marine National Monument (NOAA/NOS), NOAA Pacific Islands Regional Office (NOAA-PIRO), United States Fish and Wildlife Service Hawaiian and Pacific Islands National Wildlife Refuge Complex Office, and the Office of Hawaiian Affairs (OHA). In addition, the permit application has been posted on the Monument Web site since June 4, 2015, giving the public an opportunity to comment. The application was posted within 40 days of its receipt, in accordance with the Monument's Public Notification Policy.

Exemption Determination:
After reviewing HAR § 11-200-8, including the criteria used to determine significance under HAR § 11-200-12, DLNR has concluded that the activities under this permit would have minimal or no significant effect on the environment and that issuance of the permit is categorically exempt from the requirement to prepare an environmental assessment based on the following analysis:

1. All activities associated with this permit, including the sampling and subsequent genetic and taxonomic study of reef fishes, have been evaluated as a single action. As a preliminary matter, multiple or phased actions, such as when a group of actions are part of a larger undertaking, or when an individual project is precedent to or represents a commitment to a larger project, must be grouped together and evaluated as a single action. HAR § 11-200-7. Since this permit involves an activity that is precedent to a later planned activity, i.e. the genetic study of patterns of reef fish, invertebrate and algal dispersal, the categorical exemption determination here will treat all planned activities as a single action.

2. The Exemption Class for Scientific Research with no Serious or Major Environmental Disturbance Appears to Apply. Chapter 343, HRS, and § 11-200-8, HAR, provide for a list of classes of actions exempt from environmental assessment requirements. HAR § 11-200-8.A.5. exempts the class of actions which involve "basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource." This exemption class has been interpreted to include fish collection for marine surveys and research, falling under Exemption Class #5, Exempt Item #15 which allows "aquatic life surveys, inventory studies, new transect lines, photographing,

recording, sampling, collection, culture and captive propagation" (DEPARTMENT OF LAND & NATURAL RESOURCES, EXEMPTION LIST published June 5, 2015).

The proposed sampling and genetic connectivity study activities here appear to fall squarely under the exemption class identified under HAR § 11-200-8.A.5., and are succinctly described under the 2015 exemption list, as involving the collection of aquatic animals to study migration patterns and life cycles. As discussed below, no significant disturbance to any environmental resource is anticipated from the sampling of common reef fish, invertebrate and algal species. Thus, so long as the below considerations are met, an exemption class should include the action now contemplated.

3. Cumulative Impacts of Actions in the Same Place and Impacts with Respect to the Potentially Particularly Sensitive Environment Will Not be Significant. Even where a categorical exemption appears to include a proposed action, the action cannot be declared exempt if "the cumulative impact of planned successive actions in the same place, over time, is significant, or when an action that is normally insignificant in its impact on the environment may be significant in a particularly sensitive environment." HAR § 11-200-8.B. To gauge whether a significant impact or effect is probable, an exempting agency must consider every phase of a proposed action, any expected primary and secondary consequences, the long-term and short-term effects of the action, the overall and cumulative effect of the action, and the sum effects of an action on the quality of the environment. HAR § 11-200-12. Examples of actions which commonly have a significant effect on the environment are listed under HAR § 11-200-12.

The Applicant has been conducting this type of work since 2006, with no deleterious effects noted. With this in mind, significant cumulative impacts are not anticipated as a result of this activity, and numerous safeguards further ensure that the potentially sensitive environment of the project area will not be significantly affected. All activities will be conducted in a manner compatible with the management direction of the Monument Proclamation in that the activities do not diminish monument resources, qualities, and ecological integrity, or have any indirect, secondary, cultural, or cumulative effects. The joint permit review process did not reveal any anticipated indirect or cumulative impacts, nor did it raise any cultural concerns, that would occur as a result of these activities.

These activities would be conducted from the NOAA Ship HI'IALAKAI. The ship will be conducting routine operations (PMNM-2018-001) and serving as a research platforms for other PMNM Applicants.

Since no significant cumulative impacts or significant impacts with respect to any particularly sensitive aspect of the project area are anticipated, the categorical exemptions identified above should remain applicable. Though there will be multiple projects operating from the ship, no other permitted projects will overlap in scope, habitat, nor species with this applicant.

4. Overall Impacts will Probably be Minimal and Insignificant. Any foreseeable impacts from the proposed activity will probably be minimal, and further mitigated by general and specific conditions attached to the permit. Specifically, all research activities covered by this permit will be carried out with strict safeguards for the natural, historic, and cultural resources of the Monument as required by Presidential Proclamation 8031, other applicable law and agency policies and standard operating procedures.

Conclusion. Upon consideration of the permit to be approved by the Board of Land and Natural Resources, the potential effects of the above listed project as provided by Chapter 343, HRS and Chapter 11-200 HAR, have been determined to be of probable minimal or no significant effect on the environment and exempt from the preparation of an environmental assessment.