MAY 29 2019

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JUN 08 2019

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
OFFICE OF CONSERVATION AND COASTAL LANDS
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

ref:OCCL:MC

CDUA HA-3843

Scott Glenn, Director
Office of Environmental Quality Control
Department of Health, State of Hawai'i
235 S. Beretania Street, Room 702
Honolulu, Hawai'i 96813

Dear Mr. Glenn,

With this letter, the Office of Conservation Lands (OCCL) hereby transmits the draft environmental assessment and anticipated finding of no significant impact (DEA-AFONSI) for the proposed Blue Fields off-shore macroalgae demonstration project in submerged waters 1.5 nautical miles SSE of Kaiwi Point, North Kona, Hawai`i County. Please publish this in the next available edition of the *Environmental Notice*.

Enclosed is a completed OEQC Publication Form and a hard copy of the draft Environmental Assessment. We are also emailing to your office a digital copy of the OEQC publication form, in word format, and a digital copy of the draft Environmental Assessment, in a searchable pdf format.

If there are any questions, please contact Michael Cain at 587-0048.

Sincerely,

Samuel J. Lemmo, Administrator
Office of Conservation and Coastal Lands

enclosures:
- OEQC Publication Form,
- Draft EA

via email:
- Notice of determination
- OEQC Publication Form (word file)
- Draft EA (searchable pdf)

19-370

APPLICANT
PUBLICATION FORM

Project Name:	Blue Fields
Project Short Name:	Off-shore macroalgae demonstration project
HRS §343-5 Trigger(s):	(1) Propose the use of state or county lands or the use of state or county funds; (2) Propose any use within any land classified as a conservation district
Island(s):	Hawai'i
Judicial District(s):	North Kona
TMK(s):	Off-shore; 1.5 nautical miles SSE of Kaiwi Point, North Kona, Hawai`i County
Permit(s)/Approval(s):	Conservation District Use Permit (CDUP) (CDUA HA-3843)
Approving Agency:	Office of Conservation and Coastal Lands
Contact Name, Email, Telephone, Address	Michael Cain, michael.cain@hawaii.gov; 808-587-0048; 1151 Punchbowl Room 131, Honolulu HI 96813
Applicant:	Kampachi Farms LLC and Makai Ocean Engineering
Contact Name, Email, Telephone, Address	Dennis Peters, Aquaculture Permitting Coordinator, petersd1@cox.net; 850-240-3414; 73-970 Makako Bay Drive, Hale Iako Room 202, Kailua-Kona, HI 96740
Consultant:	n.a.

Status (select one)	**Submittal Requirements**
__x_ DEA-AFNSI	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEA, and 4) a searchable PDF of the DEA; a 30-day comment period follows from the date of publication in the Notice.
____ FEA-FONSI	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; no comment period follows from publication in the Notice.
____ FEA-EISPN	Submit 1) the approving agency notice of determination/transmittal letter on agency letterhead, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEA, and 4) a searchable PDF of the FEA; a 30-day comment period follows from the date of publication in the Notice.
____ Act 172-12 EISPN ("Direct to EIS")	Submit 1) the approving agency notice of determination letter on agency letterhead and 2) this completed OEQC publication form as a Word file; no EA is required and a 30-day comment period follows from the date of publication in the Notice.
____ DEIS	Submit 1) a transmittal letter to the OEQC and to the approving agency, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the DEIS, 4) a searchable PDF of the DEIS, and 5) a searchable PDF of the distribution list; a 45-day comment period follows from the date of publication in the Notice.
____ FEIS	Submit 1) a transmittal letter to the OEQC and to the approving agency, 2) this completed OEQC publication form as a Word file, 3) a hard copy of the FEIS, 4) a searchable PDF of the FEIS, and 5) a searchable PDF of the distribution list; no comment period follows from publication in the Notice.
___ FEIS Acceptance Determination	The approving agency simultaneously transmits to both the OEQC and the applicant a letter of its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS; no comment period ensues upon publication in the Notice.
____ FEIS Statutory Acceptance	The approving agency simultaneously transmits to both the OEQC and the applicant a notice that it did not make a timely determination on the acceptance or nonacceptance of the applicant's FEIS under Section 343-5(c), HRS, and therefore the applicant's FEIS is deemed accepted as a matter of law.
____ Supplemental EIS Determination	The approving agency simultaneously transmits its notice to both the applicant and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is or is not required; no EA is required and no comment period ensues upon publication in the Notice.

____ Withdrawal — Identify the specific document(s) to withdraw and explain in the project summary section.

____ Other — Contact the OEQC if your action is not one of the above items.

Project Summary

The applicant proposes to grow four native species of algae on a submersible growth platform: *Gracilaria parvispora* (limu manuea, or ogo), *Caulerpa lentillifera* ("sea grapes"), *Sargassum echinocarpum* (limu kala), and *Asparagopsis taxiformis* (limu kohu).

The array will measure ten meters by forty meters. The growth platform will consist of a series of thirty-meter long algal lines which will be suspended between solid pipes. This platform will be suspended ten meters below the water surface.

The array will be moored to the bottom in approximately 120-meter water depth using either concrete blocks or embedment anchors. A 700-meter long pipe will extend beyond the eastern mooring anchor to the 300-meter water depth. A pump will be installed at the terminal end. This system is designed to provide deep sea water to the array.

The project will be serviced by a vessel which will run out of Honokōhau harbor.

The mooring and anchor will cover 0.36 hectares. As the array is designed to swing 360 degrees around the mooring, the total project area will encompass 28.2 hectares.

The project is intended to last for two years. The applicant predicts that a total of 12.5 tons of algae will be harvested during three harvests.

DRAFT

ENVIRONMENTAL ASSESSMENT

FOR

AN OFFSHORE NATIVE HAWAIIAN MACROALGAE DEMONSTRATION PROJECT

OFF KAIWI POINT, KONA, HAWAIʻI

PREPARED FOR:

Land Division,

Department of Land and Natural Resources

PREPARED BY:

Kampachi Farms
P.O. Box 4239, Kailua-Kona, HI, 96745

March 5, 2019

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LIST OF ACRONYMS AND ABBREVIATIONS

ACOE	- Army Corps of Engineers
ADP	- Aquaculture Development Program, a division of DOA
CDUA	- Conservation District Use Application
DAR	- Division of Aquatic Resources, a division of DLNR
DBOR	- Division of Boating and Ocean Recreation, a division of DLNR
DLNR	- Department of Land and Natural Resources
DOA	- State of Hawaiʻi Department of Agriculture
DOH	- State of Hawaiʻi Department of Health
EA	- Environmental Assessment
EPA	- Environmental Protection Authority
FAA	- Federal Aviation Authority
FAD	- Fish Aggregating Device
FONSI	- Finding of No Significant Impact
HIHWNMS	- Hawaiian Islands Humpback Whale National Marine Sanctuary
HOARP	- Hawaiʻi Offshore Aquaculture Research Project
HRS	- Hawaiʻi Revised Statutes
KBWF	- Kona Blue Water Farms, a division of BPI
KIA	- Kona International Airport
MHI	- Main Hawaiian Islands
NPDES	- National Pollutant Discharge Elimination System
NELHA	- Natural Energy Laboratory of Hawaiʻi Authority
NMFS	- National Marine Fisheries Service, a division of NOAA
PAO	- Pacific Area Office, an office within NMFS
NOAA	- National Oceanographic and Atmospheric Agency
NWHI	- Northwest Hawaiian Islands
OHA	- Office of Hawaiian Affairs
OSWM	- Office of Solid Waste Management, a division of DOH
OTEC	- Ocean Thermal Energy Conversion
CWB	- Clean Water Branch, a division of the State Department of Health
UH	- University of Hawaiʻi
UHSG	- University of Hawaiʻi Sea Grant Program
WHAP	- West Hawaiʻi Aquarium Project
ZOM	- Zone of Mixing

EXECUTIVE SUMMARY

Kampachi Farms is applying for the requisite permits for a Blue Fields Demonstration Project (Blue Fields Offshore Macroalgae (*limu*) Demonstration Project) in the offshore waters adjacent to Pawai Bay and the Old Airport County Recreation Park under Title 12, Conservation and Resources; Chapter 190D, Ocean and Submerged Lands Leasing, Hawaiʻi Revised Statutes (HRS), as amended, to establish and operate a short-duration open ocean demonstration of macroalgae (*limu*) cultivation, which aims to validate technologies that would allow this type of cultivation using only the energy that exists in the natural environment (wind, wave, current, and solar energies). This Environmental Assessment (EA) assesses the present environment and current human activities in the proposed demonstration area. It reviews alternative actions, and recommends the project proceed because of the relatively minor impacts of the project, and the economic and environmental benefits to be gained.

This EA assesses the potential impacts of the demonstration native Hawaiian macroalgae (*limu*) project, and describes means for reducing or mitigating these impacts. Given the depth of water, the bare sand substrate in the area, the high rate of water exchange through the area, and the distance to any nearby reef areas, the Blue Fields Demonstration Project will result in *de minimus* impacts on water quality and little to no detriment to benthic ecosystems.

A 3-year permit is requested to deploy the demonstration over the water surface area of 28.2 hectares, to accommodate one array consisting of a growing platform, deep water line, and the mooring and anchor array. The mooring and anchor array is anticipated to only cover approximately 0.36 hectares. However, it will swing 360° around the mooring, thus covering a total of 28.2 hectares considering the entire watch circle. The growing platform will be submersible and will normally be below the water surface. The proposed demonstration array will be moored to the ocean bottom in approximately 120m (400 ft) water depth, which provides further assurances of no significant impacts on water quality, coral reefs, or dolphin resting activity.

The issuance of a short-term permit for an offshore deep water demonstration will have little impact on public activities in the area. The depth of water is well beyond the limits of normal recreational diving. The proposed site is located outside of the 40 fathom (80m) deep ono lane, used by trolling fishing vessels. Reef fishing and ʻōpelu koʻa are found well inshore of the proposed site, along the edge of the reef, in waters up to 120 feet deep (40m). Fishing grounds for ʻōpelu at night are usually deeper than 40 fathoms (80m).

Kampachi Farms will not be seeking exclusive use of the demonstration area from fishing vessels, and as such, the public will be permitted to fish and traverse throughout the entire project area within safe operating distances from the project infrastructure. However, for safety and liability reasons, anchoring, SCUBA-diving, snorkeling or swimming by the public will be precluded in the permitted area.

The project will demonstrate the culture of native or endemic Hawaiian macroalgal species only. The applicant will not import any non-native algae for the purposes of culturing on the offshore project. The demonstration will cultivate a range of local Hawaiian species, including *Caulerpa lentillifera*, *limu* kohu (*Asparagopsis taxiformis*), *limu* manuea or ogo (*Gracilaria parvispora*), and *limu* kala (*Sargassum echinocarpum*). The suitability of these species for growth in the offshore environment is currently being testing in on-shore trials at the Kampachi Farms' algae yard in Kona, Hawaiʻi. However, validating these results offshore is important, and thus a range of species will be demonstrated throughout the short-term deployment. One of these species (*Gracilaria parvispora*) is endemic to Hawaiʻi and has been overharvested to the point of becoming rare in its habitat range. Wild *G. parvispora* is currently prohibited from collection when reproductive; and the State law includes stipulation on collection method and bag limits (HRS §13-93-2). Culture of these species offers the only viable alternative to declines in wild populations and reduced landings by the fishery, as well as – if feasible - providing alternative employment opportunities for fishermen.

Table ES-1 summaries the salient issues for offshore culture of native Hawaiian *limu* in Hawaiʻi, based on public comments from Kampachi Farms' meetings with the community. The determination for each issue, and relevant page in this document, is also presented in this listing of preliminary consultation concerns.

Table ES-1. Issues for Offshore Culture of Native Hawaiian Limu in Hawaiʻi

ISSUE OR CONCERN RAISED BY PUBLIC	ANALYSIS, DETERMINATION, MONITORING AND MITIGATION	PAGE NO.
Deterioration of water quality downcurrent of project	Only minor and nearly immeasurable impacts on water quality and the substrate beneath the site are anticipated in the immediate area of the Blue Fields Demonstration Project. The project uses DSW as the only nutrient source in oligotrophic waters at a maximum 1% concentration, and uses renewable energy to power pumping.	25
Attraction of reef fish and pelagic fishes (including sharks) to the platform array	It is not anticipated that reef fish would abandon their typical reef habitats to take up residence on such an exotic structure, located off shore, which wouldn't offer adequate food resources or nocturnal shelter. Reef fish are also unlikely to move extensively over open water. Sharks may be aggregated to the structures, but the number of sharks in the overall area will not increase.	27
Components of the platform may become detached from the mooring potentially impacting benthic EFH	There is no precious coral known from or likely to be occurring in the immediate project area. GPS units on array would send a signal to the Kampachi staff if the macroalgae platform array were to drift outside the operating area. The mooring concept is reliably used to moor ocean-going tankers, and as such minimizes risks for detachment.	28
Sea turtles and marine mammals may be disturbed by array or entangled in mooring lines	Taut line moorings will eliminate risk of entanglement. The macroalgae platform array and moorings will not present an obstruction to movements.	31

Table ES-1. Issues for Offshore Culture of Native Hawaiian Limu in Hawai‘i

The platform array would likely act as a FAD, and community fishermen may be excluded from the area	The entire Blue Fields Demonstration Project area would remain open to fishing activities.	33
Demonstration array conflicts with other recreational uses of the area	Local commercial and recreational fisherpeople and fishing charter boat operators were consulted in determining the final proposed siting location. The applicant is not seeking exclusivity of the project area from fishing vessels.	33
Activities would inhibit or restrict Kona crab (*Ranina ranina*) and nabeta (*Iniistius pavo*) fishing	There are virtually no benthic or pelagic fishing activities in this depth range, as the project site is too deep for free-diving, and for any significant SCUBA diving activity.	35
Potential impacts on traditional ‘ōpelu ko‘a due to a potential to draw fish away from ko‘as.	A local ‘ōpelu fisherman with fishing experience over the proposed Blue Fields Demonstration Project site region was consulted in preparation of this environmental assessment, who indicated that they did not anticipate any impact to the location of the ‘ōpelu ko‘a in the shoreward direction.	35

A finding of no significant impact (FONSI) is anticipated. Findings to support this determination based on established “Significance Criteria” (Chapter 200, HAR) are:

(1) Involves an irrevocable commitment to loss or destruction of any natural or cultural resource.
No. The offshore area contains no resources that would be significantly affected. The only potential cultural impact considered is the possibility of changing behavior of ‘ōpelu around the traditional ko‘as. This potential impact was determined to be extremely remote, insignificant, and not irrevocable due to the distant location and temporary nature of the Blue Fields Demonstration Project.

(2) Curtails the range of beneficial uses of the environment.
No. There is little existing recreational or subsistence use of the proposed lease area.

(3) Conflicts with the State’s long-term environmental policies or goals and guidelines.
No. This project may demonstrate commercial potential to grow human food, animal feed, and fuel biomass with 100% renewable energies. The proposed demonstration will validate technologies that support the State’s Clean Energy Initiative, which aims to move Hawai‘i from the most fossil fuel dependent state in the U.S. to 100% renewable energy by 2045. The project is another example that is compliant with the amended ocean leasing law (Chapter 190 D HRS), which was specifically crafted to allow a sustainable ocean-based commercial

aquaculture industry to develop in the State. The proposed project is consistent with the environmental policies established under Chapter 344 HRS.

(4) Substantially affects the economic or social welfare of the community or state.
No. The demonstration will provide economic benefits from increased employment in the science sector. If commercially feasible, the next application for the project would further increase employment for STEM graduates locally and provide consistent supply of high quality *limu* to restaurants and the public.

(5) Substantially affects public health.
No. The Blue Fields Demonstration Project will have no influence on public health.

(6) Involves substantial secondary impacts such as population changes or effects on public facilities.
No substantial secondary impacts will be involved.

(7) Involves a substantial degradation of environmental quality.
No. There will be no degradation of environmental quality associated with the project. Only native Hawaiʻi *limu* species will be grown. There is no impact foreseen to water quality and negligible impact likely to benthic fauna.

(8) Cumulatively has a considerable effect on the environment or involves a commitment for larger actions.
No. Implementation of the proposed project will not cause any significant cumulative effects, and does not involve any commitment for larger actions. The Blue Fields Demonstration Project is described in its entirety in the document. If commercial-scale production is validated through the demonstration, the applicant will be applying for a commercial permit – completely separate from this proposal and requiring an entirely new application and public outreach process before potential for approval.

(9) Substantially affects a rare, threatened or endangered species or its habitat.
No. The proposed project will not cause any substantial detriment to a rare, threatened or endangered species or its habitat. Humpback whales and monk seals may all transit through the project area, but the demonstration growth platform will not represent a significant barrier to movement of marine mammals, and there is *negligible* risk of entanglement in the taut-line array and mooring system.

(10) Detrimentally affects air or water quality or ambient noise levels.
No. In fact, the growth of *limu* uptakes carbon from the surrounding environment and would locally mitigate ocean acidification, thus improving water quality. No noise is anticipated to be generated from the algal array and the passive DSW pump activities.

(11) Affects or is likely to suffer damage by being located in an environmentally sensitive area.
The open ocean site is approximately 120m (400 ft) deep, with strong currents and coarse sand substrate. The project will not impede movement or otherwise disturb the spinner dolphins that rest in the shallow waters to the north at Honokōhau. The nearest reef (Pawai Bay) to the proposed project site is 1.454 km away.

Substantially affects scenic viewplanes or vistas.
No. The project would be moored at a distance of approximately 1.5 nautical miles south southeast of Kaiwi Point and approximately 3 to 3.5 nm west of Kailua-Kona. The project will use a submerged design that will provide better security, safety, and reduced wear on gear. Surface marker buoys will be deployed and lit in accordance with U.S. Coast Guard specifications, but these will not be a significant impact on the viewplane, given the existing land use of the residential and commercial operations at Honokōhau and Old Industrial Area.

(12) Requires substantial energy consumption.
No. There will be insubstantial amounts of energy used to power the boats and equipment for the Blue Fields Demonstration Project. Renewable energies will be used wherever possible for deployment and operations during the demonstration. Technologies will be validated to develop 100% renewable energy supported offshore culture of native Hawaiʻi *limu*.

1. CONSULTATIONS AND STATUS OF PERMITS

This section outlines the regulatory issues and coordination associated with Kampachi Farms' proposed offshore culture of native Hawai'i *limu* Blue Fields Demonstration Project in Kaiwi Point area of the Kona Coast. Regulatory issues include permits and concurrence with a number of Federal, State and County regulations. Consultation has included scoping meetings with a range of state and federal agencies, and the public. Kampachi Farms will also further the information sharing process throughout the public review period using the Kampachi Farms' website (kampachifarm.com).

1.1 PERMITS AND APPROVALS

Permitting procedures follow Chapter 190 D, HRS, as amended, and other relevant laws.

1.1.1 Federal

U.S. Department of the Army Permit

The Rivers and Harbors Act, Section 10, requires that a Department of the Army (DA) permit be issued for any activity that obstructs or alters navigable waters of the U.S. This project will require the deployment of a growing platform and moorings. As such, a Section 10 authorization will be required as part of the DA permit application.

The U.S. Army Corps of Engineers (ACOE) is responsible for administering and granting DA permits. The criteria for issuance of a DA permit are similar to those for issuance of an EA. At the discretion of the ACOE, the DA permit can be processed and issued concurrently with other permits.

NOAA National Marine Fisheries Service

For mariculture in Hawai'i, the Endangered Species Act, Section 7, requires a Federal consultation by the action agency with National Marine Fisheries Service about any species listed under the ESA, or the critical habitat of such species, for any Federally proposed activity.

1.1.2 State

Conservation District Use Application

Chapter 183C HRS and HAR 13-5 pertain to obtaining permits for any use of lands in the Conservation District. The Conservation District Use Application (CDUA) process is managed by the Land Division of DLNR. A CDUA permit is required before a lease can be considered by the Board of Land and Natural Resources (BLNR).

DOH Water Quality Certification

The State Department of Health Clean Water Branch (DOH-CWB) will require a Water Quality Certification application for the project. The proposed demonstration site is in Class AA waters, which will require an individual Water Quality certification. No NPDES will be required under 40 CFR §122.24 and 40 CFR §122.25.

Special Management Areas and Shoreline Setback

Use of the area is not subject to County Special Management Area (SMA) permit requirements.

Aquaculture License

The current proposal is only for a research demonstration and not a commercial for-profit project. Therefore, an Aquaculture License for sale of a State regulated species (under Chapter 187A-3.5 HRS and Sections 13-74-43 and 13-74-44 HAR) will not be required.

1.2 AGENCIES, CITIZEN GROUPS AND INDIVIDUALS CONSULTED

1.2.1 Meetings and Community Consultations

Kampachi Farms has acted as liaison and principal contact during review of the legislation, consideration of the project concept, initial meetings and drafting of the EA. Direct contact with Federal, State, and County agencies occurred on multiple occasions, and only the initial points of contact are itemized below.

A series of informational meetings were held during the development of the EA, to provide for community consultation. A formal presentation was made to the West Hawaiʻi Fishery Management Council on 11/15/2018. The project was introduced to the Kona Rotary Club Mauka on 12/11/2018. A public presentation was given at the Kona Science Café on 12/3/2018. Kampachi Farms has also been in contact with local fisherpeople and nearby landowners.

Kampachi Farms has discussed potential marine mammal and array interactions with an Endangered Species Biologist at NOAA/NMFS, ahead of the Section 7 consultation that will accompany the Section 10 permit review by the Department of the Army (application was submitted 12/28/2018; currently under review). Kampachi Farms also spoke over the phone with the Department of Health Clean Water Branch on 11/5/2018 to discuss the requirements of the application process. A presentation was given to the staff at the DLNR Division of Aquatic Resources Kona office, including Aquatic Biologist Dr. William Walsh, on 11/13/2018. A tour was conducted with local County Council Members from Districts 6, 7, and 8 on 2/14/2019 to discuss continuing community engagement through the permitting review process, and field any questions or concerns they represent from their districts.

Kampachi Farms has presented detailed descriptions of the project to various individuals, community groups and native Hawaiian organizations, with extensive question and answer sessions. Project outlines were presented to:

- Queen Liliʻuokalani Trust (Mana Purdy, phone call, 12/12/2018, follow-up Q and A),
- Kahalu’u Bay Education Center Director (Cindi Punihaole, toured the land-based research on 11/20/2018),
- Office of Hawaiian Affairs (Robert K. Lindsey Jr., 1/28/2019),
- Kona Rotary Club (presentation to a club luncheon on 12/11/2018),
- Spokesperson of the Hawaiʻi Big Game Fishing Club (11/19/2018),
- Representatives David Tarnas and Nicole Lowen (11/16/2018),
- Senators Lorraine Inouye (11/16/2018) and Dru Kanuha (1/22/2019),
- County Council Members from Districts 6, 7, 8, and 9 (Maile David, Rebecca Villegas, Karen Eoff, and Tim Richards)
- U.S. Small Business Administration Region 9, Regional Administrator (Michael Vallante, 1/21/2019)

Executive summaries of the project and invitations to tour the land-based research activities were extended to political representatives from the affected district via email, and several tours are pending at the time of this writing. Table 1 presents a listing of agencies and organizations consulted during development of the project concept and the EA.

Table 1-1: Agencies and Organizations Consulted

Agencies and Organizations Consulted	**Date**
Federal Agencies / Councils	
National Marine Fisheries Service - Aquaculture Coordinator	9/12/2018
Army Corps of Engineers	10/15/2018
Coast Guard	11/29/2018
National Marine Fisheries Service - Endangered Species Biologist	11/14/2018
Western Pacific Regional Fishery Management Council	2/26/2019
State Agencies	
DLNR Office of Conservation and Coastal Lands	9/12/2018
DLNR, Aquatic Resources	11/13/2018
Department of Health	11/5/2018
Office of Hawaiian Affairs	1/28/2019
Department of Agriculture Aquaculture and Livestock Support Services Branch	12/10/2018
City and County Agencies	
Hawaiʻi Office of Planning	9/12/2018
County of Hawaiʻi Parks and Recreation (Old Airport County Park)	12/10/2018
Community and Native Hawaiian Groups	
West Hawaiʻi Fishery Management Council	11/15/2018
Queen Lili'uokalani Trust	12/12/2018
Public Meeting at Kona Science Café	12/3/2018
Outreach to local fishermen – Group meeting at Kampachi Farms' Kona Office	1/18/2019
Kona Rotary Club Mauka	12/11/2018
Kona Bay Estates Management (reached out several times; management did not organize a meeting for the applicant to make a presentation to tenants)	11/29/2018
Hawaiʻi Big Game Fishing Club Representative	11/12/2018
Kahaluʻu Bay Education Center Director	11/20/2018
Hawaiʻi County Council Site Tour - Districts 6, 7, and 8	2/14/2019

1.2.2 Environmental Assessment and Ongoing Consultation via Kampachi Farms' Web-site

Throughout the consultative process, Kampachi Farms has compiled a mailing list (emails and other contact information) of individuals and groups to facilitate an ongoing exchange of information, during the permitting process and the deployment stages. To further encourage open sharing of the results of this Environmental Assessment, and to continue to foster the consultative process with the public, Kampachi Farms, LLC will make a copy of this document available through their web site (http://www.kampachifarm.com/) in a section under "Sustainable Seafood" and subsection "Projects."

2. DETERMINATION

The proposed demonstration native Hawaiian macroalgae (*limu*) project in the open ocean area offshore from Kaiwi Point, in Kona, will not have any significant effects in the context of Chapter 343 HRS and HAR 11-200-12. Therefore a finding of no significant impact (FONSI) is anticipated.

A brief summary of findings to support this determination follows (Table 2). Chapter 200, HAR, establish "Significance Criteria" to be used as a basis for identifying whether significant environmental impacts will occur. These criteria are addressed in more detail below.

Table 2-1: Significance Criteria, Findings, and Anticipated Determination for Each Criterion

Significance Criteria	Does Project meet Criterion?
1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource	No
2. Curtails the range of beneficial uses of the environment	No
3. Conflicts with the State's long-term environmental policies or goals and guidelines	No
4. Substantially affects the economic or social welfare of the community or state	No
5. Substantially affects public health	No
6. Involves substantial secondary impacts such as population changes or effects on public facilities	No
7. Involves a substantial degradation of environmental quality	No
8. Is individually limited, but cumulatively has a considerable effect on the environment or involves a commitment for larger actions	No
9. Substantially affects a rare, threatened or endangered species or its habitat	No
10. Detrimentally affects air or water quality or ambient noise levels	No
11. Affects or is likely to suffer damage by being located in an environmentally sensitive area	No
12. Substantially affects scenic view planes, viewsheds, or vistas	No
13. Requires substantial energy consumption	No

Significant environmental impacts are deemed to occur if any of the following hold true:

1. Involves an irrevocable commitment to loss or destruction of any natural or cultural resource.
There will not be an irrevocable commitment to loss or destruction of any natural or cultural resource. The offshore area contains no resources that would be significantly affected. The only potential cultural impact is the remote possibility of temporarily changing the behavior of ʻōpelu around the traditional koʻas. This was deemed not significant.

2. Curtails the range of beneficial uses of the environment.
Surveys indicate that the proposed action will not curtail the range of beneficial uses of the environment. There is little existing recreational or subsistence use of the proposed lease area.

3. Conflicts with the State's long-term environmental policies or goals and guidelines.
This demonstration will validate technologies that would support the State's Clean Energy Initiative, which has been working towards 100% renewable energy for the state by 2045.

4. Substantially affects the economic or social welfare of the community or state.
The project will not substantially affect the economic or social welfare of the community or State. There will be economic benefits from increased employment.

5. Substantially affects public health.
The project will not substantially affect public health.

6. Involves substantial secondary impacts such as population changes or effects on public facilities.
No substantial secondary impacts will be involved.

7. Involves a substantial degradation of environmental quality.
There will be no degradation of environmental quality associated with the project. There will be negligible impacts on water quality and benthic fauna.

8. Cumulatively has a considerable effect on the environment or involves a commitment for larger actions.
Implementation of the proposed project will not cause any significant cumulative effects, and does not involve any commitment for larger actions. The project is described in its entirety in the document and is a demonstration – not a commercial project.

9. Substantially affects a rare, threatened or endangered species or its habitat.
The proposed project will not cause any substantial detriment to a rare, threatened or endangered species or its habitat. Humpback whales and monk seals may all transit through the Blue Fields Demonstration Project area, but the project infrastructure will not represent a significant barrier to movement of marine mammals, and there is negligible risk of entanglement in the taut-line MAS point mooring system.

10. Detrimentally affects air or water quality or ambient noise levels.
None of the emissions from the research vessels, deployment vessels, or equipment are anticipated to have a substantial effect on air or water quality.

11. Affects or is likely to suffer damage by being located in an environmentally sensitive area.
The open ocean site is in waters that are from 120m (400 feet) to 300m (1,000 feet) deep, with moderate currents and coarse sand substrate. The Blue Fields Demonstration Project site will not impede movement or otherwise disturb the spinner dolphins that rest in the shallow waters north of this site at Honokōhau. The nearest reef (Pawai Bay) to the proposed project site is 1.454 km away.

12. Substantially affects scenic view planes or vistas.

The project will not significantly impact view planes or vistas.

13. Requires substantial energy consumption.
There will be insubstantial amounts of energy used to power the boats and equipment. Renewable energy technologies will be demonstrated in the project.

3. THE RATIONALE FOR OFFSHORE MARICULTURE OF NATIVE HAWAIIAN *LIMU*

3.1 THE ECONOMIC OPPORTUNITY

3.1.1 Tropical Macroalgae Cultivation – The Opportunity?

A large swath of the offshore U.S. Exclusive Economic Zone (U.S. EEZ) is currently inhospitable to commercial macroalgae cultivation for two driving reasons: costs to moor arrays, and lack of nutrients in surface waters. A significant portion of the U.S. EEZ that lacks surface nutrients also has access to deep seawater (DSW). Blue Fields addresses the issues of mooring and nutrient delivery by providing design and cost information for low-cost deep water Single-Point Moorings (SPMs) and DSW nutrient upwelling. These technologies have the potential to expand the areas where offshore algae cultivation is commercially feasible. Engineering, cost, and nutrient distribution analyses are presented below for this proposed for mooring and nutrient delivery solutions for algae cultivation in offshore oligotrophic (nutrient-limited) environments.

Blue Fields is a multifaceted project that addresses the primary challenges to commercializing offshore macroalgae cultivation in tropical environments. Offshore macroalgae cultivation in the tropics is an as-yet untested commercial endeavor. Several factors contribute to the challenge: the oligotrophic nature of tropical ocean waters causes most algae to grow relatively slowly; offshore depths render fixed grid or multiple point mooring arrays too expensive and the mooring line tensions too difficult to maintain; it is challenging to operate in offshore conditions; manual labor for harvesting is not cost-effective; and the destructive power of tropical storms. In the year of onshore research and engineering proceeding this application, the Blue Fields team has:

(a) Tested Deep Sea Water (DSW) nutrient additions from the Natural Energy Laboratory of Hawai‘i (NELHA)’s intakes on three promising species of tropical alga to determine their suitability for offshore culture. In-depth descriptions of the native Hawaiian macroalgae species under consideration for the deployment follows in Section 3.3.

(b) Completed a tradeoff study using a nutrient flux, hydro-mechanical, and techno-economic numerical model to determine a system design which provides effective, low energy, pulsed distribution of nutrients throughout the array and which shows greatest potential in $/Dry Metric Ton (DMT) and DMT/ha at larger scale. Designs are based on a single swivel-point mooring “reticulation,” combined with nutrient pulse and algal densities designed to optimize biomass production and nutrient uptake, while minimizing nutrient loss to the surrounding waters (and thus minimizing kW/kg nutrient delivered).

(c) In partnership with Makai Ocean Engineering, modeled and designed a single-point swivel mooring macroalgal array. The design reduces risk of mooring failure to *de minimus*, yet orients the array into prevailing currents to reduce design loads, optimize nutrient distribution (so that nutrient inputs always flow in one direction along the array), and conceptually allows for harnessing of current and wind energy for harvesting.

Now, following a year of on shore research and design, the team now seeks to:

(d) Deploy a demonstration system, including a mooring, array, and renewable energy powered DSW nutrient pump and supply pipe that tests these subsystems in the offshore ocean environment in Hawai‘i (the subject of this EA Application).

(e) Demonstrate the performance of a first-stage prototype harvester which is human-operated but "diverless," and could provide key enabling technologies for fully autonomous operation in the future; focusing now on developing a reliable and high yield cutting mechanism.

This will thereby validate the physical, chemical, and biological performance of the array under natural oceanic conditions, and provide a path to commercialization.

3.1.3 Identifying the Market

This is an innovative and disruptive approach that, to our knowledge, has never before been tested for macroalgae cultivation. (A similar system has been tested by Makai for ocean thermal energy systems). The designs and cost data produced during this work will be used as input for techno-economic (TEA) and lifecycle analyses (LCA). Coupled with cost sensitivity studies and an improved understanding of offshore construction and operations, these data will provide a useful assessment of the practicality and cost-effectiveness of these systems, which the applicant can use to incorporate these technologies towards commercialization.

The proposed Blue Fields Demonstration Project will validate the feasibility of deploying multi-anchor swivel- (MAS)-point mooring array, a DSW nutrient supply system, and cutting and collecting the algae from below the ocean surface with no divers. This is a complex engineering challenge that, if solved, would have wide commercial applications.

Through our TEA, Blue Fields estimates that, based on a reasonable set of assumptions about technical feasibility and lifecycle costs, it is plausible that these systems could achieve a cost of $80/DMT or less, and a yield density of 50 DMT/hectare (ha). The impact of achieving such economic targets would be immense for the industry, and could stimulate commercial investment.

The demonstration deployment will validate hydrodynamic designs and nutrient flux models for future offshore systems, serve as an engagement platform with the public about offshore aquaculture, and validate true costs and technical challenges of operation and installation in an offshore environment. Broad impacts will be realized primarily through the scale-up and commercialization of these technologies.

There are at least three intermediate markets for short- to medium-term commercialization, prior to achieving the scale needed for algae biomass production for energy, that will act as economic drivers and subsidize further technology refinement before economies of scale are achieved. These intermediate markets are:

(a) Open ocean culture of high-value seaweeds for direct human consumption (i.e. *limu* in Hawaiian);
(b) Offshore culture of seaweeds as a direct feedstock for herbivorous marine fish; and
(c) Offshore culture of seaweeds as input for biodigesters to produce single-celled proteins (SCPs) for feedstuffs for other marine fish (or other terrestrial livestock), or energy sources.

Commercialization of these technologies through these target markets can all be demonstrably achievable in Hawai‘i, which offers opportunities to deploy small-scale commercial operations, and increase the scale of operations as refinements to the technologies allow, and as markets mature.

Hawaiʻi presents abundant and ready opportunities for commercialization of macroalgae production due to the culture of the islands, and other agricultural activities already established. Macroalgal (*limu*) consumption in Hawaiʻi is established and growing, with most production currently from land-based operations. Hawaiian consumers are more receptive to both direct human consumption of *limu* and consumption of herbivorous fish, such as milkfish, mullet, and rudderfish. These fish species are often devalued in mainland-U.S. markets, because of their stronger "fishy" flavor to Western palettes. However, such species are considered highly desirable in Pacific islands. There is potential to expand production, reduce costs, and increase product availability through development of small-scale offshore farms for edible *limu*.

Construction of a feed mill on East side of Hawaiʻi Island has been completed, which could allow innovative macroalgae-based feedstuffs, such as single-celled proteins, to be tested in diets for fish that are currently targeted by Kampachi Farms (such as kampachi, *Seriola rivoliana*; mahimahi, *Coryphaena hippurus*; and *nenue* or rudderfish, Family Kyphosidae) or other freshwater, marine, or terrestrial species. Feed trials have shown encouraging growth on a diet of algae and pelleted feeds high in carbohydrates. Kampachi Farms is also working with researchers at University of Hawaiʻi, San Diego State University, University of California San Diego, National Renewable Energy Laboratory, and Lawrence Berkeley National Laboratory to identify microflora from kyphosid gastrointestinal tracts that may be adaptable to macroalgae biodigesters to produce single-celled proteins, which could be used in terrestrial animal feeds.

Oceanographically, Kona is an ideal location to begin commercial expansion of offshore macroalgal culture; waters in the lee of the Big Island of Hawaiʻi are protected from trade winds and prevailing seas. There is a steep offshore slope, with depths of 3,000 ft within 2.5 Nm of Kaiwi Point. This allows for deep-water moorings to be readily deployed, and for arrays to be regularly tended, and for easy access to nutrient-rich DSW from greater depths.

Furthermore, the Kona fishing community is already receptive to, and appreciative of, offshore aquaculture arrays. The local fishing and diving communities have witnessed the offshore kampachi project (founded by one of the principals in Kampachi Farms) in operation for over 10 years, with no significant environmental impacts.

Each of the specific commercialization opportunities are discussed separately, below:

Seaweeds for direct human consumption -

Polynesian and Asian cultures consider seaweed (*limu*) a normal component of many dishes, and seaweed cultivation for human food is practiced both in Hawaiʻi and extensively in Asia (Abbot, 1978). In the Hawaiian Islands prior to Western contact, seaweed was a regular part of the diet, accompanying most meals and contributing vitamins, minerals, flavoring, as well as some protein and fiber to the diet (McDermid and Stuercke 2003). As many as 40 species may have been in general use. Local residents still gather seaweeds, although local stocks are diminishing, most likely du to habitat change and competition with invasive macroalgal species. Much more can potentially be done with Hawaiian species of macroalgae as many local species are in demand and are consumed by groups such as Japanese, Koreans, Filipinos, and Chinese who visit or reside in the islands. Today, Hawaiʻi aquaculture includes cultivation of about five species of macroalgae (*G. coronopifolia, G. parvispora*, *G. Salicornia*, *G. tikvahiae,* and *Codium reediae*), which partially meets local demand.

In 2011, algae sales accounted for over 60% of aquaculture sales in Hawaiʻi, yet few local companies are currently engaged in commercial seaweed culture (Hawaiʻi Department of Agriculture 2011). One active producer, Royal Hawaiian Sea Farms, based at the NELHA facility, sells over two tons of *Gracilaria* per week to local and mainland markets (http://nelha.hawaii.gov/). With the growing popularity of *poke* (Hawaiian-style raw fish) and sushi, demand for fresh seaweeds is expected to increase in Hawaiʻi and the US mainland, with a global market forecast of $22B value by 2024 (Market Research Report 2016). An energy-efficient offshore array would be able to provide copious quantities of high-priced seaweed (*Gracilaria*, *Halymenia*, and *Dictyopteris*) to capitalize on this commercial trajectory.

Seaweeds as a direct feedstock for high-value herbivorous marine fish -
Kampachi Farms has been working since 2012 in exploring the potential for commercial culture of *nenue* (rudderfish, or chubs; Fam. Kyphosidae). *Kyphosus* sp are reef-dwelling demersal herbivores, native to Hawaiʻi, but found throughout the warmer water regions of the world, which graze on fleshy macroalgae, such as *Gracilaria* and *Sargassum* (Kampachi Farms, unp. obs.). This algae diet imparts a stronger "fish" flavor to the chub flesh, which is not appealing to most Western palettes. However, chubs are highly-esteemed food fish in Asia and the Pacific. Feed trials at Kampachi Farms' facility have shown commercially appealing growth rates. A chub that serendipitously recruited into the Aquapod in the Velella Beta-test reached a size of 1 kg in around 8 months of culture; upon harvest, this fish flesh proved to have almost sushi-grade fat levels (28% by dry weight; c.f. 30% by dry weight for cultured kampachi), with one fillet from this fish eliciting strongly favorable reviews from local seafood Chef Sam Choy.

The commercial opportunity for culture of chubs in Kona could be greatly improved if seaweed could be grown offshore, at scale, and used to feed the fish for most of their grow-out period. Fish feed is a major cost in culture of marine fish. In commercial kampachi farms, feed is approximately 60% of the operating costs of the farm. If this feed cost could be reduced by inclusion of locally-grown seaweed in the chub diet, then the profitability of the farm could be markedly improved. Less expensive production costs should also allow the fish to be marketed at a lower price-point, increasing the potential target market.

Principals in Kampachi Farms have extensive experience in developing and executing plans for offshore farming projects and they are in permitting stages of a net pen demonstration project – the Velella Epsilon – for deployment offshore of the Sarasota, Florida. The company's experience includes the essential components of integrating offshore fish farm operations with the complexities of marine fish hatchery production, and introduction of new fish species to the U.S. market. We therefore demonstrably possess all the essential prerequisites to be able to build a financial model for an offshore chub farm in Kona, obtain the permits for the farm and hatchery, raise the capital to finance the project, and initiate operations and sales. The demonstration is designed to provide sufficient evidence of the practicality, scalability and costs for production of macroalgae offshore of Kona. These parameters can then allow evaluation of the improved profit margins if such macroalgae were to be substituted into the chub business model for imported, extruded diets.

Demonstration in Kona of the profitability of offshore culture of seaweeds and chubs - either in an integrated operation or under independent customer-vendor relationships – could allow faster, farther expansion of offshore seaweed production. One of the major constraints to scale-up of existing near-shore grow-out of algae, such as *Kappaphycus* in SE Asia and the Western Pacific, is the added expense for drying and shipping the algae to the processing center (for conversion into carrageenan or agar). The culture of seaweeds and herbivorous marine fish in local waters would overcome both the need for drying the algae and the costs and inconvenience of shipping dried algae. We would therefore expect to see wide adoption of herbivorous fish culture systems supported by offshore algae culture projects throughout suitable tropical waters, such as Pacific Islands, SE Asia and the Subcontinent, East and West Africa, and the Caribbean and tropical Pacific coasts of the Americas.

Similar to chubs, rabbitfish (Family Siganidae) are also highly-valued herbivorous reef-fish, but are not native to Hawaiian waters, and so are not considered in any commercialization plan for Hawaiʻi. Rabbitfish culture trials are currently under way in Palau, however, and there may be opportunity to expand commercial offshore algae culture and fish farming to rabbitfish in Palau, and elsewhere within their native range (tropical Indo-Pacific waters, west and south of Hawaiʻi).

Seaweeds as feedstock for biodigesters -
The third pathway to commercialization of offshore macroalgal culture in Kona, Hawaiʻi, is still at the research and development stage. However, the production of single-celled proteins for animal feedstuffs could also provide methane or other hydrocarbon by-products, which could be an important step in the scaling of this technology to large-scale, dedicated energy production. This opportunity offers potential for far greater scale, as SCPs could be widely integrated into freshwater and marine fish diets, as well as feeds for poultry or pork or other animals. Aquaculture feed needs alone are projected to increase from 30 million mT in 2008 to around 71 million mT in 2020 (Tacon & Hasan, 2011). SCPs could provide a significant portion of the proteins needed to keep fish production apace with industry growth. SCPs are readily digestible, and often confer other health benefits to the fed animals.

There is, therefore potential for the increased use of SCPs in feed formulations for other so-called "carnivorous" marine finfish, such as kampachi, mahimahi, and tunas; as well as for freshwater fish and other aquatic animals; and terrestrial animal feeds (particularly in areas such as feeds for piglets or chicks, as a replacement for fishmeal). Kampachi Farms has conducted a number of feed trials testing varying inclusion rates of SCP from biodigesters fed with agricultural by-products and methane. Our team has previously partnered with Menon Feeds of San Diego to test use of *Gracilaria* as a feedstock in lieu of terrestrial agricultural by-products, which showed no significant difference in growth rate, FCR, survival or product quality between a control diet (containing 30% sardine meal) and two Menon feed treatments, with 13% and 25% SCP inclusion rates (Kampachi Farms, unp. data). Given that carrageenan, a product from *Kappaphycus* / *Eucheuma* and some other macroalgae, is universally the preferred substrate for laboratory-grade bacterial culture, it is a logical extension that macroalgae generally should provide good feedstocks for biodigesters for SCP production. However, the constituent carbon sources in macroalgae are very difficult to break down (e.g. seaweed washed onto beaches decomposes very slowly). The Kampachi Farms team, in conjunction with researchers from University of Hawaiʻi and Oceanic Institute, is pursuing research of microflora from the gastrointestinal tracts of herbivorous rudderfish as the inoculum to improve biodigestion of macroalgal feedstock to SCPs.

Taken together, these three avenues for commercialization represent a logical, step-wise process for increasing scale of offshore production, and business and process complexities. *Limu* cultured for human consumption is expensive, but even with the growing demand in the U.S. it will be a limited market for the foreseeable future. Using cultured seaweed as a primary diet for chubs requires both seaweed and fish biology and culture systems to be well-understood and highly efficient. The permitting, planning, capital-raising, operations and sales and marketing of a new marine fish species, based on offshore culture of algae, requires all of these elements to be brought together with professional proficiency.

The culture of algae offshore for SCP production (and possibly biofuels by-products) offers greatest opportunity for impact, and for achieving a global scale, but requires far greater understanding of microflora biology and organic chemistry, as well as intimate knowledge of the biofuels markets and biodigester operations. These areas of expertise are not presently part of our team; however, we have – over the course of our collective careers – amply shown our ability to reach out to key technology and business partners, to take innovative technologies into the marketplace, and to build businesses.

3.1.4 Innovativeness

The significant innovations involved in this project are: the use of DSW as a nutrient source in oligotrophic waters, and using renewable energy to power pumping; development of low-cost culture arrays and identification of alga species native to Hawaiʻi that are suitable for tropical offshore conditions; development of a mooring system that self-aligns with the current to drastically reduce loads, costs, and improve efficiency of nutrient distribution; and the demonstration of a diverless prototype macroalgal cutting system. We believe that these elements, when tested and refined together, have the opportunity to dramatically reduce capital and operating cost of macroalgae cultivation, while significantly increasing the range of deployment into exposed offshore environments.

Development of macroalgae cultivation in tropical areas of the US EEZ is key to achieving a scale of deployment for commercial operations. Tropical waters are subject to far greater year-round insolation than temperate waters, and are markedly less turbid, allowing for better light transmittance at depth. Thus, the solar energy available for conversion to biomass is significantly greater than coastal or temperate waters. Tropical seas are also generally more placid, and calmer sea states allow for algal arrays to be less expensive to build and maintain, and to have the algae positioned closer to the sea surface to harness the ample solar energy.

The greatest impediment to cultivating macroalgae in tropical offshore waters is the limited availability of nutrients in the surface waters. There are only a limited number of practical ways to provide nutrients to surface waters offshore; DSW upwelling, use of Integrated Multi-Trophic Aquaculture (IMTA), and recycling of nutrients from the macroalgae itself. Use of anthropogenic runoff was deemed impractical for offshore systems, as the nutrient concentrations dilute rapidly with distance from the coast, and it is not likely that large areas of ocean immediately adjacent to the usually densely populated coastline where this nutrient source is available would be open for macroalgae development. Furthermore, both anthropogenic and natural runoff are inconsistent and site-specific resources that we deemed could only unlock a small portion of US EEZ for cultivation. IMTA was rejected due to the reliance on an entirely separate biological system fraught with its own biological, engineering, and economic risks. Thus, DSW appears the only practical means of providing nutrients offshore. It is an abundant, stable, ubiquitous resource that could easily support large-scale levels of macroalgae deployment.

The nutrient availabilities in SSW and DSW in waters surrounding Hawai‘i (Figure 3-1) are consistent with SSW and DSW from ~80 ft., 2,000 ft., and 3,000 ft., provided by NELHA’s ocean pipelines at Blue Fields’ land-based facilities. After land-based trials with native Hawaiian algae species and performing nutrient flux modeling on realistic DSW upwelling systems, we have determined that our candidate species have potential to achieve sufficiently high growth rates if they are provided a 1 hour pulse of nutrients per day equivalent to 1% concentration of DSW pumped from between 200 and 600 meters depth. The flow rates necessary to saturate the array depend on the array size, but flow rates are not unreasonable. The next step was to quantify pumping power required.

Numerous other projects have explored the potential for upwelling of nutrient-rich deep seawater to the surface layers, but the energy costs for moving such large amounts of water have been prohibitive. After performing initial DSW pumping calculations, coupled with nutrient flux modeling, we believe that, enabled by the innovation of a MAS-point mooring that self-aligns with the current and positions itself in the path of upwelled nutrients, we can supply sufficient nutrients for high-growth algae for a fraction of the pumping power that other multiple point moorings would require. Furthermore, we believe it is technically feasible to integrate a wave driven pump requiring no energy input to provide these levels of DSW flows. A renewable energy powered pumping system such as this would be *required* to achieve the targeted 5:1 energy return ratio. Makai Ocean Engineering has already designed, built, and tested a working prototype of this wave-driven pumping mechanism, which will be scaled up for the demonstration deployment.

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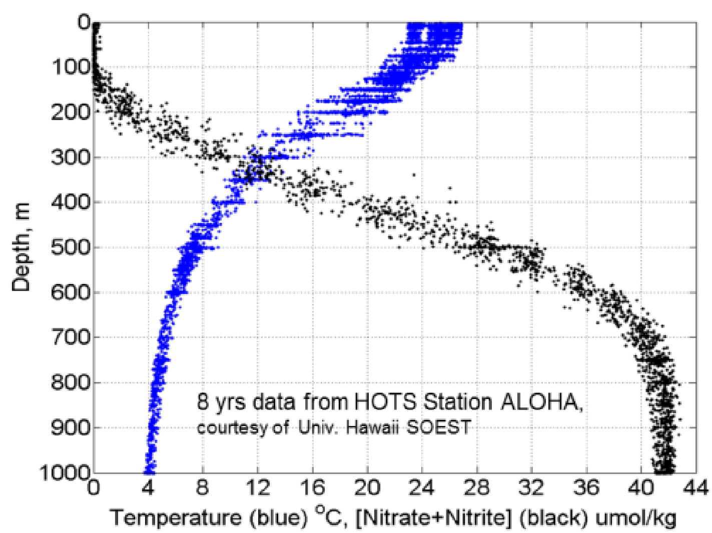

Figure 3-1. Gradients of nutrients (black) and temperature (blue) as a function of ocean depth in the waters surrounding Hawai‘i. This distribution of nutrients is near-zero in surface waters and substantial in deep waters and very typical of tropical offshore waters worldwide.

To our knowledge the use of an SPM in algae cultivation has never been previously tested in offshore conditions

The vulnerability of a single anchor and rope is overcome in this design by using three anchors converging on a single submerged pivot point engineered to remain in tension, thereby reducing the typical erosion corrosion issues of single anchor moorings and providing redundancy (Figure 3-2).

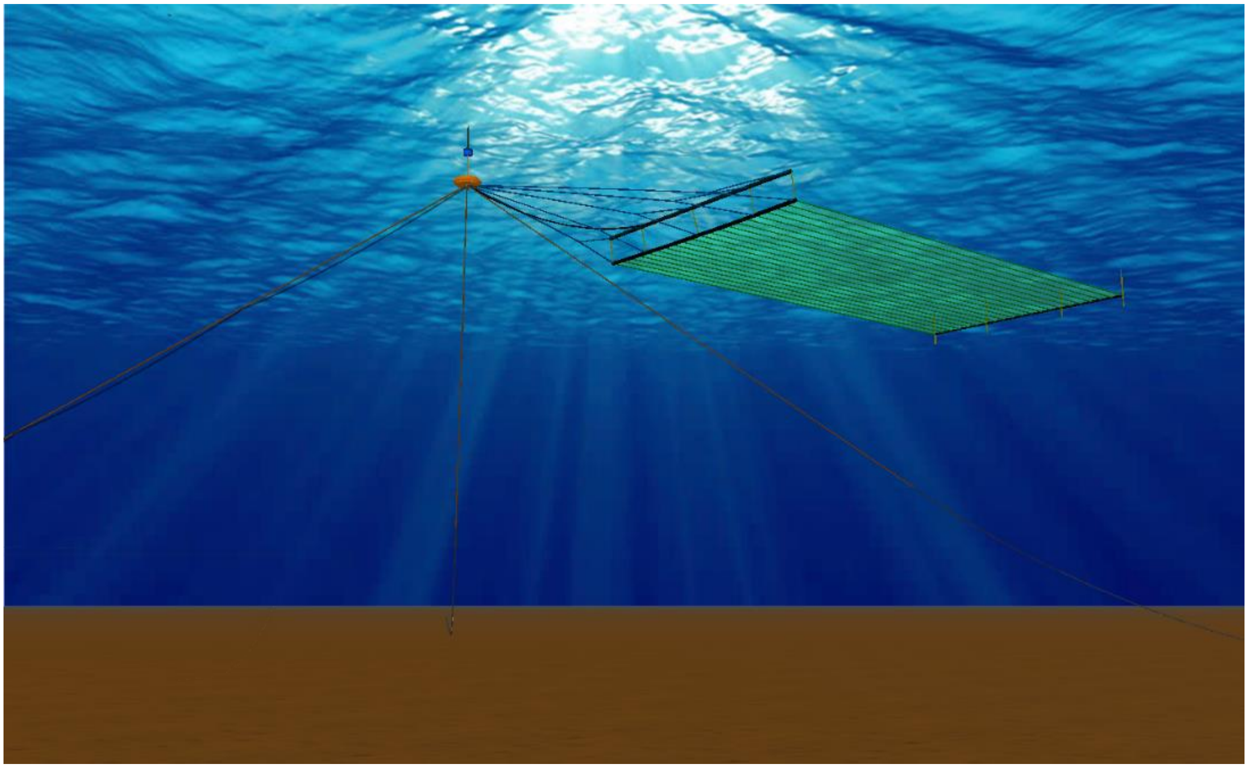

Figure 3-2. Schematic of the demonstration algae array proposed for deployment (not to scale).

There are two remarkable and primary advantages to a MAS-point mooring for offshore algae culture: efficiency of drag, and efficiency of nutrient distribution. The greatest drag will be on the leading edge of an algae array structure and a long MAS-point mooring system reduces the frontal areas. The bilateral symmetry of an MAS-point mooring array also means that the piping reticulation for nutrient distribution can be optimized for maximum efficiency of nutrient dispersal.

Nutrients injected at a particular point will always flow downcurrent, in one direction, and so the spacing and volume of the nutrient reticulation can be determined more readily; the only variable is current speed. In a grid array, the nutrient distribution model must consider speed of current and its direction. This makes nutrient flux modeling markedly more difficult, and vastly less efficient. Based on our nutrient flux modeling, we know that with even slightly less efficient nutrient distribution, the pumping costs (for DSW or any other nutrient source) would increase dramatically, eliminating the possibility of providing pumping power with a relatively small and simple energy harvesting device, and likely putting the 5:1 energy ratio out of reach. This is particularly critical in oligotrophic waters, where nutrient inputs are essential.

We add significantly to these advantages by potentially harnessing currents as the power source for energy-efficient harvesting. A MAS-point mooring array can be bilaterally symmetrical – with a "head" and a "tail" that provide, respectively, upcurrent and downcurrent faces. This enables the harvester to move from the upcurrent side of the array to the downcurrent side, offsetting energy requirements by using at least partially current-derived energy, minimizing energy costs required for harvesting and contributing towards achieving the 5:1 energy goal.

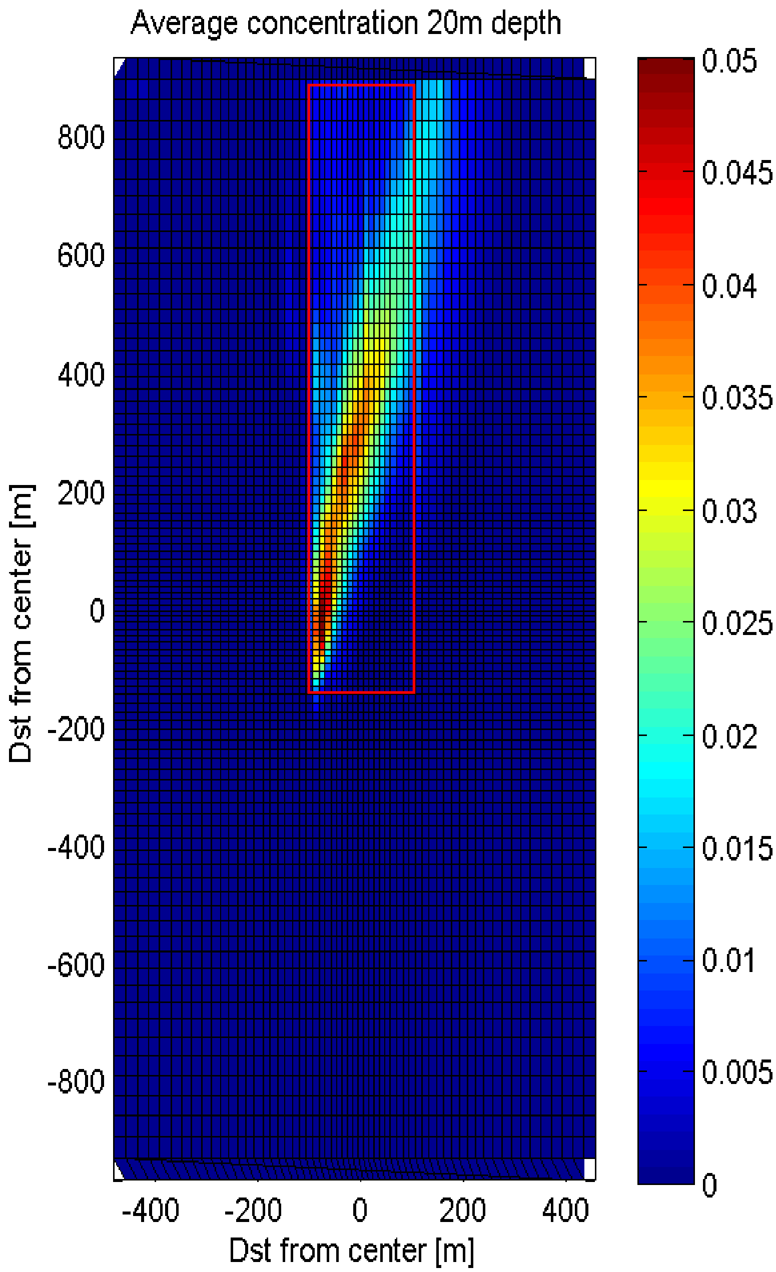

Figure 1-3 Nutrient flux modeling results showing plan view of nutrient concentrations (in percentage DSW, e.g. 0.01=1%) at 20 m water depth with a 750 gpm pulse of nutrients and ambient 0.5 m/s current moving upward in the vertical direction. Red rectangle represents full-scale 1km x 200m array.

3.2 THE ENVIRONMENTAL BENEFITS

This one demonstration array will not, by itself, lead to measurable environmental benefits in the short-term. However, long-term environmental benefits could be gained from the development of offshore macroalgae farming. Firstly, the expansion of offshore culture of macroalgae would not increase demand for land or freshwater, which is particularly important in areas where these resources are limiting. Secondly, development of offshore macroalgae farming should, over time, provide local reduction in ocean acidification due to uptake of carbon from the surrounding environment. Systems such as the one proposed in the demonstration - which achieve an energy return greater than all non-renewable energy inputs – have a net uptake of carbon from the surrounding environment. A rising level of dissolved carbon is the cause of ocean acidification, and so by uptaking carbon from the surrounding waters, the growth of macroalgae decreases dissolved carbon, thereby raising the pH. The relationship between macroalgae biomass and reduction in acidification is unknown, but this is something that could potentially be studied through future research related to this project.

The expansion of offshore macroalgae culture would be a laudable effort towards reducing the impacts of global climate change. The State of Hawaiʻi has set a goal to generate 100% renewable energy by 2045, which includes the application of biofuels (http://energy.hawaii.gov/renewable-energy). The principal goal of this demonstration, and indeed of the entire ARPA-E MARINER program, is to determine a suitable offshore production model to provide the amount of biomass that would be required for a biofuel industry.

The proposed demonstration will validate technologies that could be later used at a commercial scale. The successful application of wave-powered pumping technology to provide deeper water nutrients to the array (and for the algae to successfully grow on the very low concentrations of nutrients in the offshore environment) is the key component that will be validated through the demonstration.

Successful demonstration of offshore macroalgae growth using the proposed system could also result in greater research funds – both public and private – for commercializing this technology. More offshore culture of macroalgae might then become established in the islands, which will provide the infrastructure and the technology to initiate large-scale efforts towards the production of renewable biofuel energy. The operations of the proposed system will be no less than a 5:1 energy return ratio (for every one unit of non-renewable energy that goes in, the harvested macroalgae crop will have the potential to output 5 units of energy). As technology allows we see the possibility to power the system operations with 100% renewable energy. Both aspects contribute to the larger State of Hawaiʻi goal to generate 100% renewable by 2045.

The community in Kona has expressed interest in the potential to use the Blue Fields Demonstration Project as an opportunity for data collection on fish recruitment or FAD dynamics. One stakeholder at Queen Liliʻuokalani Trust, consulted in the preparation of this EA, specifically asked whether Kampachi Farms would undertake data collection to better understand trophic dynamics of FAD-aggregating species. Funding a companion monitoring study is beyond the reach of this demonstration, we are amenable to potential partnerships with outside organizations (or the State of Hawaiʻi) that may wish to conduct species abundance monitoring within the safety parameters of the deployment. We expect the array will likely recruit larval fish from the plankton, and we will collect basic information on the types of fish that our operations crew finds on the array.

3.3 SPECIES SELECTION

An exploratory year of land-based tank trial work with native Hawaiian *limu* species was conducted to determine the feasibility of their offshore culture. During that time seven species were considered for the Blue Fields Demonstration Project: *Ahnfeltiopsis concinna, Asparagopsis taxiformis, Caulerpa lentillifera, Chnoospora minima, Gracilaria parvispora, Halymenia hawaiiana, Sargassum echinocarpum,* and *Ulva fasciata*.

Based on this experimentation, four native *limu* species are proposed to be tested on the offshore array:

- *Gracilaria parvispora*
- *Caulerpa lentillifera*
- *Sargassum echinocarpum*
- *Asparagopsis taxiformis*

Gracilaria parvispora has a triphasic isomorphic life cycle. This includes one haploid gametophyte stage and two separate diploid stages: carposporophyte and tetrasporophyte. The morphology during both haploid and diploid phases are the same. *Gracilaria* grows from an apical meristem and is capable of both sexual and asexual reproduction, the latter through vegetative propagation. This species favors sandy habitats overlying rocky substrates with moderate water motion. The Hawaiian name for this endemic, edible species is *limu manauea* and it is added to *poke* or salted for later use (Abbott 1878, Abbott 1996, Abbott 1999, Abbott and Huisman 2004).

The exact life cycles of *Caulerpa* species are unknown, but its relatedness to the order Bryopsidales suggests it is most likely diplontic or biphasic. While it is not known if *Caulerpa* spends more of its life in a diploid phase, or an equal amount to its haploid phase, the morphology in *Caulerpa lentillifera,* is the same during both phases (isomorphic). While this species is capable of both sexual and asexual reproduction, there is little genetic variety in natural populations, suggesting that asexual reproduction is the more dominant reproduction method (Bast 2014). This species attaches to sand and eroded coral substrates with a horizontal stolon. *Caulerpa* is a siphonous green meaning that many nuclei divide without creating crosswalls between cells; it is the outer edges of the cells themselves that form the plants outer layer (Abbott and Huisman 2004, Bast 2014). *Caulerpa* does not have a Hawaiian name, any reason for this remains unknown, but other regions in Polynesia do recognize it. In Samoa, it is called *limu fuafua* where it is used as a relish (Chapman and Chapman 1980, Skelton 2003).

Sargassum has a diplontic life history, spending more of its life in a diploid stage. It is capable of both sexual and asexual reproduction, the latter through vegetative propagation. This species has two meristems, a basal meristem that allows growth between the axes and the holdfast, and an apical meristem, that allows growth at the end of its blades. *Sargassum echinocarpum* can be found in the mid-intertidal down to 22 meters depth, but most commonly found in mid-to low rocky intertidal zones, with at least moderate wave action. Dense patches are found where fresh water mixes with ocean water and during the winter, on shores exposed to larger waves. Historically, the blades of the Hawaiʻi endemic, *Sargassum echinocarpum,* or *limu kala,* were chopped and used in stuffing and soups or blades were deep fried whole. This species was also a part of the *Hoʻoponopono* ceremony of forgiveness. *Limu kala* is also used as bait when fishing for chubs/rudderfish (*nenue*) and unicornfish (*kala)*.

Asparagopsis taxiformis has a triphasic heteromorphic life cycle. This includes one haploid gametophyte stage and two separate diploid stages: carposporophyte and tetrasporophyte. The morphology during haploid and diploid are so drastically different they were once classified as separate species; the erect, uniaxial, fleshy gametophyte generation alternates with a diminutive, filamentous tetrasporophyte generation—the "*Falkenbergia*" phase. This species extends a horizontal creeping stolon that grips rocks in the intertidal to shallow subtidal using rhizoids and shoots erect fronds vertically by apical meristems (Bonin and Hawkes 1987, Abbott 1999). *Asparagopsis taxiformis*, or *limu kohu*, is a favored edible species; it is soaked overnight, pounded, salted, rolled into a ball, and used in *poke*. In Hawaiʻi, the edible, gametophyte stage is extremely seasonal, adding significant economic value (Abbott 1878, Abbott 1996, Abbott 1999).

3.3 SITE SELECTION

3.3.1 Criteria

This site was selected for its suitability, based on the following primary criteria:

1. The site is in deep-water area that will present less exposure to storm or wave damage.

2. There is little or no public use of this area. The site lies beyond the limits of normal recreational SCUBA-diving (around 120 feet) and the normal depths for offshore trolling for ono (wahoo, *Acanthocybium solandri*) (around 250 feet).

3. The site is afforded some measure of protection from strong trade winds. The proximity to shore also allows for a shore-based control and security facility, which reduces the need for vessels on site.

4. There is ready access from Honokōhau harbor, which provides support facilities such as slips, ramps, fueling, and rentable office space.

5. The site is directly offshore from the Old Kona Airport County Recreation Area and Old Industrial Area, and as such its use for aquaculture is consistent with the adjacent land uses.

3.3.2 Minimal Potential Conflict with Existing User Groups

The fact that the site is in deep water, yet shoreward of the normal trolling areas means that there is almost no traditional or customary use of the area. There are few fish found in sand bottoms at these depths, and large benthic organisms are scarce or absent.

In consultation with local fishing interests (commercial and recreational trollers, ʻōpelu fishers, spearfishers, and charter boat operators), the proposed site was identified as a suitable area with no fishing group conflicts. The site is clear of the heavily-used direct line of transit from Honokōhau Harbor to a well-known FAD to the South ("F Buoy"), and well outside of the 40 fathom isobar trolled for ono (wahoo, *Acanthocybium solandri*). The boating-accessible area between Kaiwi Point and Kailua Bay is described as an area of little fishing interest outside of the ʻōpelu koʻa described in 6.6. The proposed site is also clear of the charted cruise ship channel where passenger ships transit and anchor.

In discussions during community outreach and informational sessions regarding the project, no objections were voiced regarding the potential for conflict with verified existing uses. Use of the demonstration array as a potential fishing location by kayak fisherpeople and recreational fisherpeople is expected to occur due to the close proximity of the site to Honokōhau Harbor as well as shore-based launches for non-motorized recreational watercraft.

Local fishing user groups support access for fishing vessels within the project area. Kampachi Farms prefers to keep the area open to the passage of recreational users and fisherpeople, within safe operating distances from the surface structures, so long as use by the public is respectful and safe for our workers. The Coast Guard consultation process will determine the marking of the area and potential for passage of boat traffic within the watch-circle. It is a primary concern to the fishing stakeholder groups (as well as to Kampachi Farms) that the surface and near-surface components of the array be well marked and lit because of the high recreational watercraft use in Kailua Bay.

The Coast Guard is responsible for setting standards of navigational markings, and Kampachi Farms is currently in contact with the Coast Guard to complete their Private Aid to Navigation (PATON) process through the Coast Guard District 14 Waterways office.

There are no historical sites that would be directly impacted by the demonstration. For further discussion of the cultural uses of the region, see Section 6.6.

4. PROJECT DESCRIPTION

4.1 TECHNICAL AND OPERATIONAL CHARACTERISTICS

4.1.1 Location and Extent of the Demonstration Area

Kampachi Farms is proposing to deploy a demonstration offshore array for the cultivation of native Hawaiian *limu* in the waters adjacent to the Old Airport County Park and Industrial Area. The proposed dates of the short-term demonstration will be approximately October 2019-2022. The proposed site is located approximately 1.5 nautical miles (nm) SSE of Kaiwi Point (Figure 4-1). The submersible macroalgae culture array offers distinct operational and economic advantages, as the potential damage from storm surf or hurricanes is greatly reduced, normal wear-and-tear on the cage and the moorings is minimized by the dampening of the day-to-day wind and wave action at the surface, and security and aesthetic concerns are alleviated.

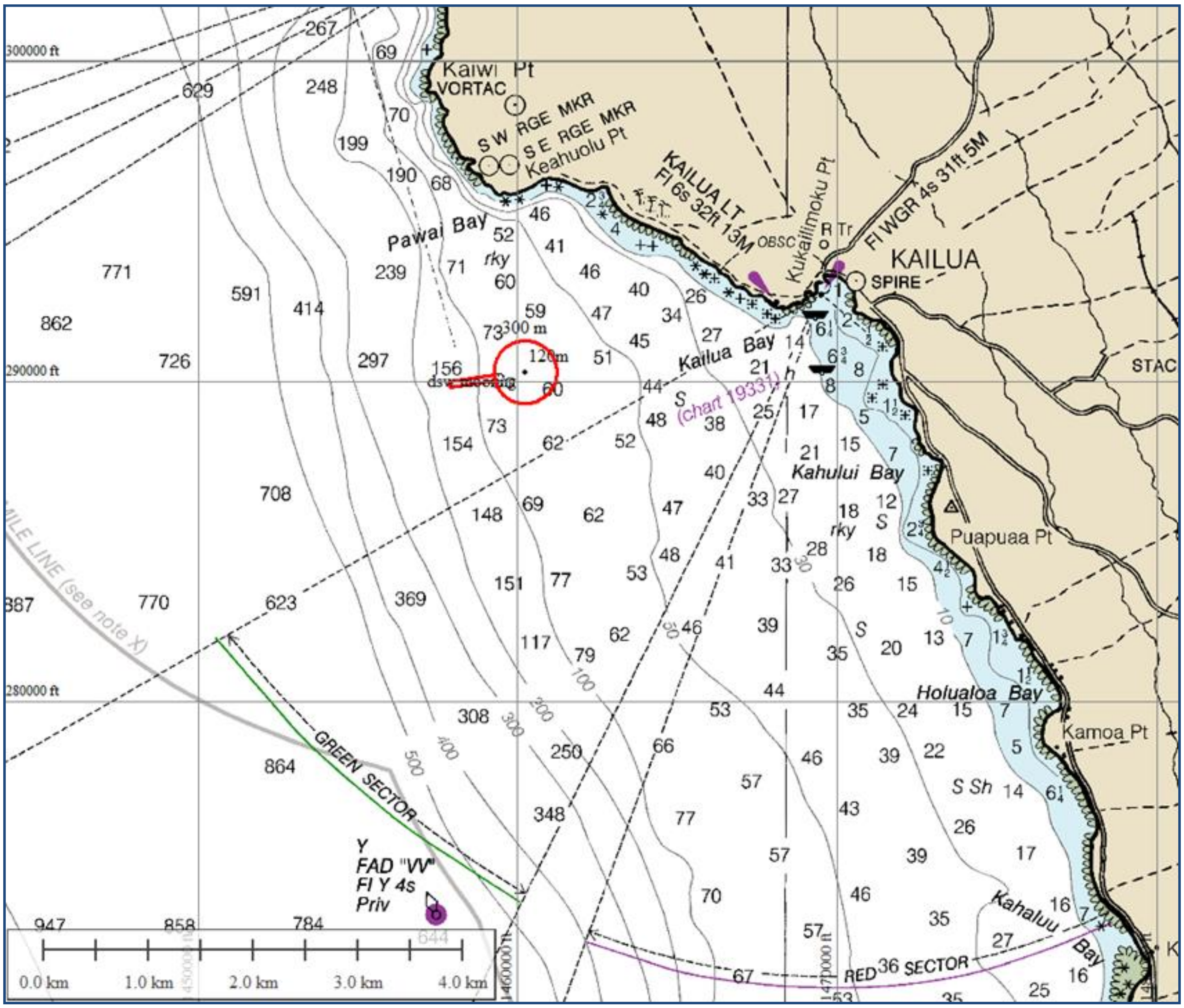

Figure 4-1: Project site location. Underlying chart: 19327 West Coast of Hawai‘i

The array will be moored to the ocean bottom in approximately 120m (400 ft) water depth utilizing three (3) deadweight (concrete block) anchors (or embedment anchors, if sufficient sand depth is identified). Each anchor will be spaced approximately 220m (722 ft) from the mooring center line and configured 120 degrees (°) from each other, with a total mooring radius of 300m (985 ft), or mooring footprint of approximately 282,744m^2 (28.3 ha).

Attached to each of the mooring anchors is 230m (755 ft) of Grade 2 steel chain (36mm [13/16 in] thick licks), which in turn is attached to 110m (361 ft) of AmSteel Dyneema® blue rope (14 mm [9/16 in] diameter); collectively the chain and rope comprise the mooring line. The three (3) mooring lines are bridled at a multi-anchor swivel (MAS) point mooring buoy. The center point location of the surface swivel buoy is at latitude 19° 37' 54.9149" N, and longitude 156° 01' 24.9638" W (Figure 4-2).

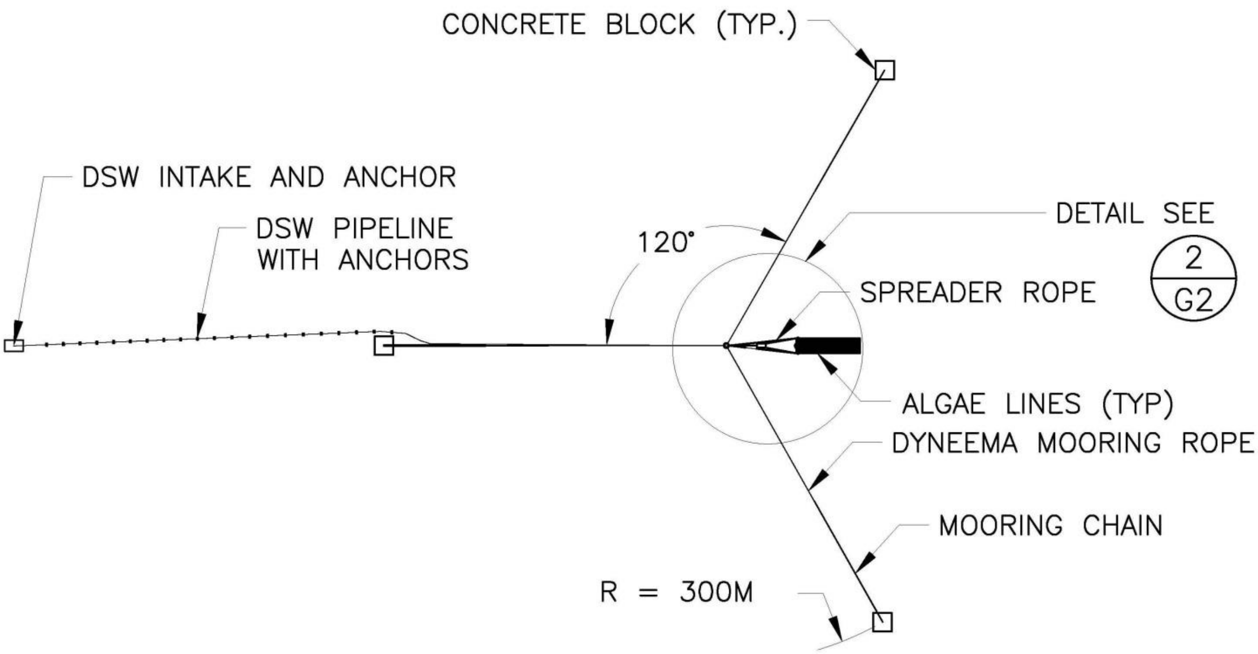

Figure 4-2: Plan View of the Macroalgae Mooring and Culture Array

Attached to the eastern catenary mooring line is a 700m (2,297 ft) long DSW HDPE (0.18m [6 in]) outside diameter (OD) pipe. This DSW pipeline extends approximately 300m (985 ft) beyond the eastern mooring anchor into roughly 300m (985 ft) water depth with an intake head and anchor at the terminus. Additional anchors are attached evenly spaced along the HPDE DSW pipeline between the eastern mooring anchor and the terminal anchor, securing its placement and minimizing any significant movement on the ocean seafloor. The DSW pipeline and anchor system lies within a 60m-wide quadrat encompassing roughly a 1.8 ha corridor. The four corners of the proposed corridor are identified as:

Longitude:	Latitude:
156° 01' 49.9550" W	19° 37' 51.9111" N
156° 01' 35.2239" W	19° 37' 54.1102" N
156° 01' 34.8571" W	19° 37' 52.2110" N
156° 01' 49.6109" W	19° 37' 49.9629" N

The sea surface end of the DSW pipeline will extend from the swivel buoy (at approximately 25m ([82 ft] below the sea surface) along one of two (2) 55m (180 ft) spreader lines comprised of AmSteel Dyneema® blue rope (14 mm [9/16 in] diameter). At the terminal end of the DSW pipeline is the current or wave driven DSW pump. The spreader lines are attached to the front surface float that supports two (2) DSW accumulators comprised of 10m (33 ft) long HDPE pipes (1.3m [4.3 ft] in diameter). A series of 40m (131 ft) long algal lines are suspended between the HDPE accumulator pipes and the 10m (33 ft) long HDPE rear bar pipe (0.6m [2 ft] in diameter). Each end of the he rear bar pipe is supported by a rear surface float. Collectively, this array system comprises the demonstration algal growth platform that is suspended approximately 10m (33 ft) below the sea surface by the front and rear surface floats. The DSW accumulators receive, diffuse, and distribute the DSW from the wave driven pump across the algal growth platform. Periodically, a support work barge may be moored to the swivel buoy and the front surface float between the two spreader lines.

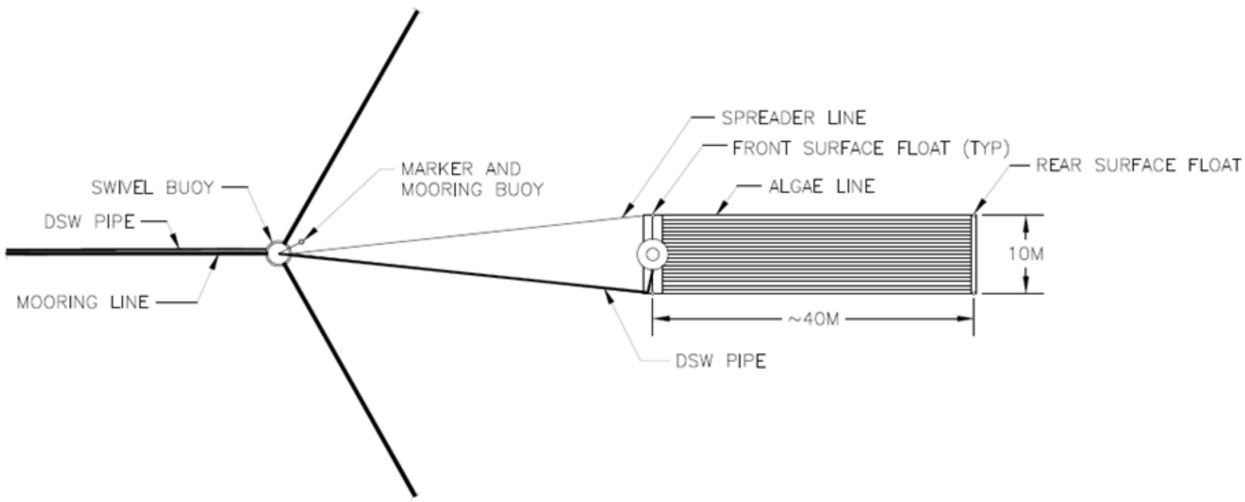

Figure 4-3: Plan View Close-up of the Macroalgae Mooring and Culture Array

The swivel buoy is specifically designed to ensure that the anchor lines are perpetually taut, to ensure that there is no risk of entanglement by marine mammals, and to keep lines away from the surface, where they might become a hazard to navigation. All components of the macroalgae mooring and culture array were engineered by the mooring manufacturers to withstand the worse storm and surf conditions that have been recorded for this site. Kampachi Farms and the mooring manufacturer also have strong commercial incentives to ensure that these structures will not fail, and have employed a healthy degree of over-engineering. Any emergent structures will be marked with Class C navigation lights (amber or yellow flashing, visible up to one nautical mile distant), as required by the Coast Guard.

This at-sea demonstration nutrient delivery system will validate numerical modeling of nutrient flux along the array, and demonstrate physical components of the DSW upwelling system. Initial modeling results indicate that a relatively small DSW pipe (< 30cm) and low flow rates (< 200gpm) will provide sufficient nutrients to the algal growth platform (40m x 10m). The current or wave driven pump serves as a passive upwelling system to pulse nutrients from depths of 300m. DSW flow rates and distributed nitrate measurements will be taken during the test, before and after the upwelling system is operational, to ascertain what concentration and residence time of DSW-supplied nutrients actually reach the four corners of our array. These data will be used to validate our numerical model and compare to the tank testing results to determine if the DSW upwelling system provides sufficient levels of nutrients to sustain commercially viable growth rates.

The proposed site is located between (inside of) the 100 fathom (200m) trolling ledge along the "grounds" offshore of Kaiwi Point, and (outside of) the 40 fathom (80m) ono lane. Reef fishing and ʻōpelu koʻa are found well inshore of the proposed site, along the edge of the reef, in waters up to 120 feet deep (40m). Fishing grounds for ʻōpelu at night are usually deeper than 40 fathoms (80m).

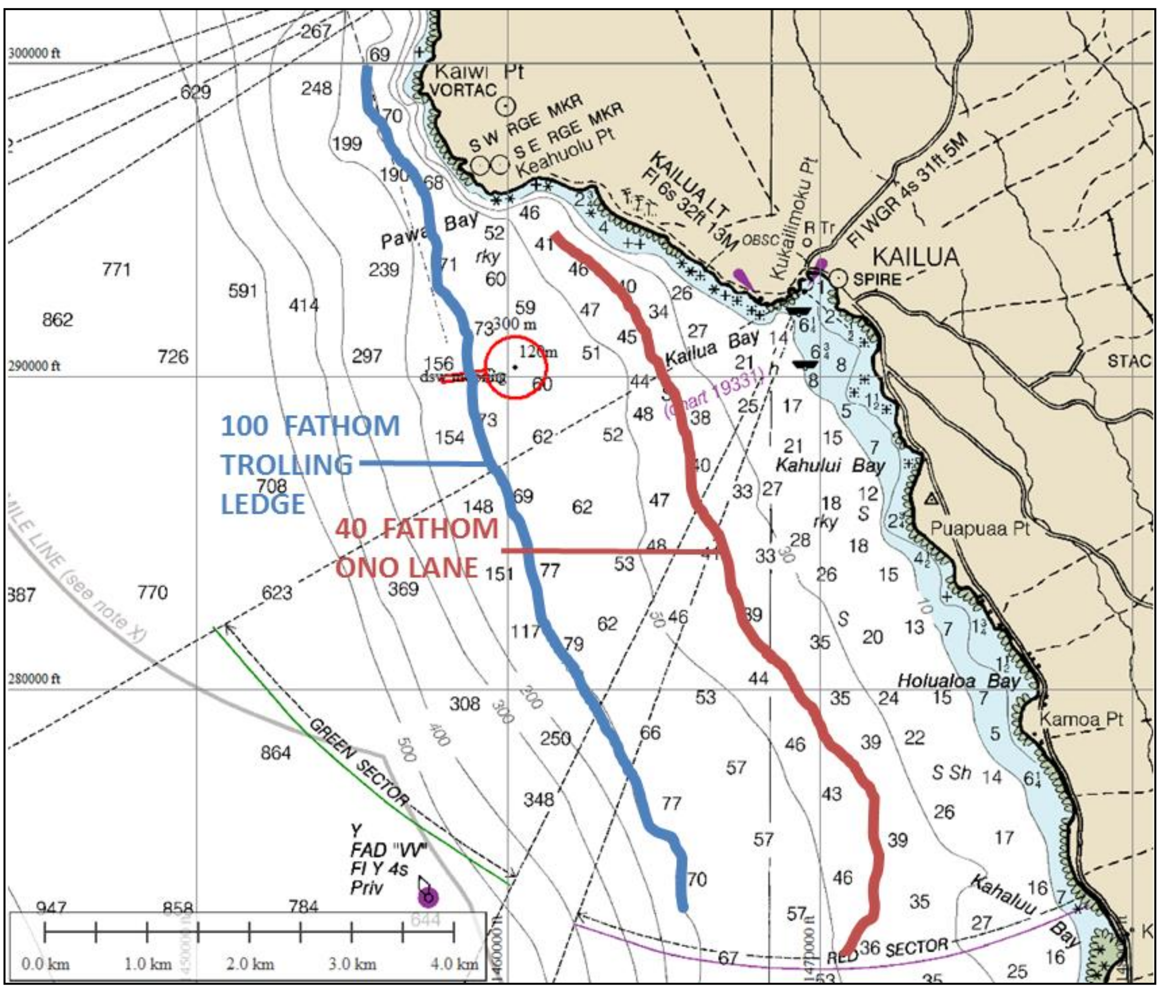

Figure 4-3: Proposed Site Location in Proximity of Offshore Fishing Areas

4.1.2. Culture Operations

The demonstration will be serviced by a tender vessel (around 20 ft length), which will serve as the platform to support the project. This vessel will run out of Honokōhau Harbor, and will shuttle the demonstration team, supplies, and harvested product back and forth between the harbor and the site. Heavy work, such as deployment of the array and anchors, will be contracted out to commercial marine construction companies.

The daily activities on the site will primarily consist of taking water samples, measuring growth of the *limu*, and recording fishery activities surrounding the array. Renewable energy powered harvesting prototypes will be tested periodically on the demonstration array. Harvesting will occur periodically, and transported to shore prior to the removal of the array from the ocean.

The Federal Aviation Authority and the State Airport Authority in the Department of Transportation will review all security equipment, to ensure that there is no conflict with airport operations.

Support activities will be based out of Honokōhau. The support vessel is currently in a rented slip at the harbor, and all demonstration work and prototype testing equipment will be based at suitable onloading and offloading areas of the harbor. The Blue Fields Demonstration Project work vessel will be powered by commercially-available outboard motors. Fuel supplies will be purchased as needed from the commercial fuel dock at Honokōhau Marina.

4.2 ECONOMIC CHARACTERISTICS

4.2.1 Economic Impacts of Project Operations

The Blue Fields Demonstration Project will likely have little direct impact on the local economy through employment, secondary support industries, and product availability. There will be employment of at least three full-time local people to staff the offshore operations, part-time support for three local engineers, and some increased employment for supportive industries. The Blue Fields Demonstration Project will support other local businesses for materials necessary to build and maintain the operations.

The demonstration offshore is the next imperative following the onshore research which developed the design for the array, and is precisely what ARPA-E's MARINER program was designed to do (test offshore culture systems). This demonstration is fundamental frontier research. The potential for commercial scale development of such systems is still several decades in the future. However, validation of this offshore macroalgae culture system will reinforce Kona as being a leading-edge center for offshore aquaculture development. There are three companies with offices at NELHA which are working on different aspects of offshore aquaculture (Forever Oceans, Blue Ocean Mariculture, and Kampachi Farms), employing approximately 60 people all together.

No significant commercial activity is anticipated from the sale of algae grown on the Blue Fields Demonstration Project. Edible *limu* produced over the course of the project will be made available to organizations such as the local Food Bank, or the local community college culinary program. The demonstration is meant to validate the culture system for a potential future proposal of a commercial farm capable of producing native Hawaiʻi *limu* for human food, animal feed, or biofuel applications with entirely renewable energy power sources. At such a time as a commercial permit is sought, the appropriate economic analysis will be conducted for the projection of revenues and creation of STEM jobs in Hawai‘i. This demonstration, and potential commercialization of the technologies used, would contribute to Kona’s reputation as a clean energy innovator.

The FAD effects could also contribute to the local charter boat industry, and local subsistence and artisanal fishing activity – since there will be potential for increased catches near to Honokōhau Harbor.

4.2.2. Impacts on the Market

The proposed work is for demonstration purposes only. There is no commercial production or sale of goods proposed from this activity. Perhaps the greatest public benefit to be gained from this Blue Fields Demonstration Project is in creating the commercial incentive for further research and increased infrastructure for the production of Hawaiian *limu*.

4.3 SOCIAL CHARACTERISTICS

The Kampachi Farms Blue Fields Demonstration Project will employ three full-time and three part-time research team members with STEM backgrounds, as well as support a local engineering firm, Makai Ocean Engineering, for design, deployment, and operations of renewable technologies on the project. These positions provide short-term income in a fisheries-related industry in Hawai‘i.

If commercial validation is obtained from the demonstration, a commercial permit will be sought. Offshore culture of native Hawaiian *limu* could increase the diversity of the economic base in the Big Island. This offers the capacity to strengthen the maritime support industries in rural coastal areas, such as dock facilities and boat maintenance, marine supplies and engineering, and seafood wholesalers. This could have broad social and economic implications in Kailua-Kona, particularly in times of economic hardship.

4.3.1 Public Use of Offshore Ocean Space

As discussed in Section 3.4 (Site Selection) the proposed area is little used, except for transit to or from fishing areas. We will not be seeking exclusive use of the demonstration area. We are proposing only that the permitted area be designated as no anchoring, no SCUBA-diving, no swimming, and slow low-wake speed by boats, rather than exclusive use.

In taking this action, Kampachi Farms trusts that Kona’s fisherpeople and divers will respect the demonstration array, and that pilfering, vandalism, or reckless endangerment of property, health or safety will not become a problem. If such problems do arise, Kampachi Farms may, at some later stage, request reconsideration of the level of exclusivity. If such a re-evaluation arises, Kampachi Farms understands that further consultation would be needed with the community; however, the company believes that this step will not be necessary.

Kampachi Farms believes that the normal movement of boats within the permitted area will not be affected by the presence of the Blue Fields Demonstration Project. Surface vessels could traverse freely through this area, so long as a slower speed was maintained as a safety precaution. Trolling and bottom-fishing would also be permitted under normal conditions in a buffer around the growing platform, although on the understanding that the anchor lines are present in this area, and that any fish that might be hooked may become entangled in these lines. Similarly, no anchoring of boats could be permitted within the entire site, because of the risk of entanglement of anchors in the mooring array. State law (HRS 520) decrees that the company must accept all liability for any accidents or injuries that occur within the lease area, thus, SCUBA-diving and swimming activities could not be permitted around the mooring lines or cages within the permitted area. Again, however, these waters are deep, and presently not used for such activities; hence this loss of access does not represent a significant impact on the public.

4.3.2 Demonstration of Offshore Aquaculture in Kona

Amending the ocean leasing law during the 1999 State legislative session caused much comment from State agencies and the public. Legislative committee members and many of those who testified at the hearings recognized that the future for ocean aquaculture in Hawaiʻi required a "user friendly" permit/lease regime, to test the feasibility and impacts of such leases.

Interest in ocean aquaculture is currently rising among the conservation community, policy-makers and private aquaculture entrepreneurs. However, the general public has limited experience with the issues, impacts and benefits from ocean farming in the nearshore or offshore environments. This is especially true in Kona, where the community wants sustainable, socially- and culturally-appropriate use of marine resources. The amended ocean leasing law was specifically crafted to provide a clear mandate from the legislature for the State to assess the impacts of ocean leases on the environment and the public.

Blue Ocean Mariculture, founded in 2009, operates a fully integrated mariculture facility, growing *Seriola rivoliana* to harvest size in offshore net pens. The net pens are located offshore, north of Keāhole Point. This Hawaiian *limu* Blue Fields Demonstration Project offers another opportunity to demonstrate the potential benefits that offshore aquaculture could bring, particularly when sited in an appropriate location for aquaculture.

4.3.3 Research, Training and Extension Opportunities

The Kampachi Farms Blue Fields Demonstration Project will promote aquaculture research and development, will increase the profile of Hawaiʻi as a site for innovative ocean aquaculture, and will potentially open up opportunities for training and extension work, to broaden the benefits from these developments. Kampachi Farms has a demonstrated capacity for research, training, and extension of innovative aquaculture enterprises. By increasing the level of offshore aquaculture expertise among Hawaiʻi's workers, this project will support the future growth of this industry in the State. It will also enable Hawaiʻi to leverage a greater role in the expanding Pacific aquaculture industry.

4.4 ENVIRONMNENTAL CHARACTERISTICS

Environmental impacts associated with the Hawaiian *limu* Blue Fields Demonstration Project are considered negligible and benign. The proposed project site is located in an open ocean area offshore from Kaiwi Point, in Kona.

The physical and biological attributes of the existing environment of the proposed site are described in detail below (Section 4). The area's topography and oceanography are distinguished by the depth of water; the deep sand substrate; the strong currents through the area; the exposure to high surf and strong trade winds; and the adjacent shoreline of a narrow coral bench reef with a steep basalt (lava) cliff. The existing uses of the area are negligible, because of its depth, the paucity of fish, and the barren benthos.

Only minor and nearly immeasurable impacts on water quality and the substrate beneath the site are anticipated in the immediate area of the Blue Fields Demonstration Project. The project uses DSW as the only nutrient source in oligotrophic waters, and uses renewable energy to power pumping. The nutrient pulse of the wave- and current-driven pump, combined with the appropriate algal densities, were designed to optimize biomass production and nutrient uptake, while minimizing nutrient loss to the surrounding waters. Further, the multi-anchor swivel (MAS) point mooring system supporting the long line macroalgal array reduces risk of mooring failure to *de minimus*, yet orients the array into prevailing currents to reduce design loads, optimizes nutrient distribution (so that nutrient inputs always flow in one direction along the array), and conceptually allows for harnessing of current and wind energy for harvesting. Given the strong long-shore currents, the deep water, and sand substrate, DSW nutrient impacts on SSW will be *de minimus*. As such, no nutrient loading onto the substrate is anticipated with the maximized uptake of the DSW nutrients during macroalgal growth.

The proposed site lies south of the southern boundary of the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS). The Sanctuary boundary runs directly west of Keāhole Point, and humpbacks are known to frequent the entire Kona coast area in winter. Information from National Marine Fisheries Service, and experience from other fish farming areas, indicate that the Blue Fields Demonstration Project itself will not interfere with the movement of the humpback whales. Some concerns have been expressed with the potential for entanglement of whales in the mooring lines of the fish farm net pens. However, entanglement records show that most events occur in slack net mesh (such as drift nets or fish weirs), slack vertical lines (such as crab pot or lobster pot floats), or surface lines (such as long-lining gear). With heavy mooring gear, and taut lines, the potential for entanglement is considered negligible (Celikkol, 1999; Wursig and Gailey, 2002; see also Section 5.2.2 d, below).

Although other Federally listed species are known to occur in the area, the demonstration does not present any potential detrimental impact on these animals. Leatherback and Green Sea Turtles and Monk Seals may occasionally stray into these deep-water areas. As with humpback whales, however, the taut-line mooring system will prevent animals from becoming entangled.

Nearby Honokōhau is frequented by large schools of spinner dolphins, on nearly a daily basis. These animals usually follow a daily pattern of movement, where they rest for some time during the middle of the day. The schools then follow an erratic zig-zag pattern in their return back to their deep-water feeding grounds. The Blue Fields Demonstration Project site will not impede the usual pattern of movement as the proposed site lies south of concentrated area of activity. As such, the potential for the Blue Fields Demonstration Project to disrupt the normal resting pattern of the dolphins is also considered remote and negligible. (refer to Section 5.2.2 c for more detailed analysis of biotic interactions).

5. ALTERNATIVES

5.1 ALTERNATIVES EVALUATED

Several other protected bodies of water in West Hawaiʻi, such as offshore of Kohala (north of Kawaihae) and Keāhole Point, were also considered as possible Blue Fields Demonstration Project sites, but were determined to be unsuitable because of the heavy recreational use, weather conditions, and former public perceptions of appropriate activities in these areas of the ocean.

5.1.1 Kohala

Kampachi Farms examined this alternative in the site selection process and during their benthic survey evaluations, and had rejected the area because of the high winds that frequent the area, the distance from the Kampachi Farms research facilities, and potential conflict with public use identified during public outreach for the project. During a prior investigation of this site, a resident of the area at that time, and operator of a weather station, testified that he had recorded wind speeds of up to 85 mph in the area, with winds in excess of 60 mph occurring throughout the year.

5.1.2 North of Makako Bay

Kampachi Farms examined this alternative in the site selection process and during their benthic survey evaluations, and had rejected the area because of coral reef in proximity to the proposed site and the reef at Mahaiʻula Bay less than 1 NM to the north of the proposed site.

5.2 NO ACTION ALTERNATIVE

The option of No Action is not recommended, given the potential economic benefits that could accrue from development of offshore macroalgae culture in Hawaiʻi, and the long-term environmental benefits that would accrue through development of *limu* for human consumption, feedstock for *nenue* culture, feedstock for a biodigester for single-cell proteins (SCP) and biofuels. To take no action would be a lack of responsibility for self-sufficiency and sustainability in human and food fish resources for Hawaiʻi.

If the option of No Action is taken, this would hinder the development of offshore aquaculture in Hawaiʻi, and probably discourage further research or development efforts in this area. The only alternative, then, would be to continue development of land-based marine macroalgal culture. These activities are very capital intensive energy intensive. They are therefore only suitable for high-value marine products. They also only offer limited employment and development opportunities to the community. To confine future marine aquaculture in Kona to shore-based activities would also limit the public and private investments into future research.

6. ENVIRONMENTAL SETTING

The waters offshore from Kailua-Kona, within the depth profile for the Blue Fields Demonstration Project (from 120m [400 feet] to 300m [1,000 feet] deep, with moderate currents and coarse sand substrate), are not utilized extensively by the community. These waters do not represent a unique asset, as they are comparable to similar offshore environmental settings along the Kona coast. Therefore, impacts by the Blue Fields Demonstration Project on the Kailua-Kona environment, and the broader Kona marine environment, are anticipated to be *de minimus*.

6.1 WATER QUALITY

6.1.1 Existing Water Quality

The Blue Fields Demonstration Project would be located in oceanic waters largely free of pollution. Surface waters in the area are well mixed; the project would be located in an area that is subject to gyres that periodically form offshore from west Hawaiʻi and move closer to shore from time to time. The surface waters in the proposed action area have very low concentrations of nitrogen compounds. Bacteria and phytoplankton rapidly acquire and use nitrogen and phosphorus introduced into surface waters. This accounts for the extremely low nutrient levels found in epipelagic tropical waters. Below the pycnocline, nutrient concentrations are much greater. This region of the ocean acts as a nutrient sink. Nutrient compounds descending below the pycnocline are essentially trapped, although some upward transport of nutrients does occur via diatom mats and anaerobic metabolism (Villareal et al. 1996, Duce et al. 2008, Ulloa et al. 2012).

Both natural and anthropogenic nutrient sources may affect water quality. Some natural inputs include excretion of wild animal metabolites (Smith and Johnson 1995, Price and Morris 2013). Duce et al. (2008) demonstrated that total annual atmospheric nitrogen inputs into the ocean from manmade sources have greatly increased since 1860 and are expected to continue to increase. While there are some natural nutrient inputs from runoff into the ocean, most increases in nutrient inputs from land-based sources are due to the use of agricultural fertilizers (Duce et al. 2008).

Additionally, since eddies vertically displace underlying nutrient rich waters, they cause mixing with nutrient poor waters, creating localized favorable biological conditions, especially in areas of eddy convergence. Increased nutrients in the surface waters allow phytoplankton to occur in high concentrations. Once established, these areas of higher productivity allow zooplankton to flourish, which in turn attract mid-trophic level species (fish and shrimp), which become prey for top-level predators such as sharks, billfish, and marine mammals (Seki et al. 2002, Woodworth et al. 2011). These biologically rich hot spots are “patchy,” and the conditions creating them do not lead to increased primary production over wide geographic areas.

6.1.1 Existing Water Quality Monitoring Program

The Water Quality Laboratory at the Natural Energy Laboratory of Hawaiʻi Authority has conducted an extensive water quality monitoring program around Keāhole Point, on a quarterly basis since 1989. This program is designed to detect any changes in water quality in the groundwater or on the fringing reef, from Hoʻona Bay to Wawaloli, resulting from the aquaculture activities at NELHA. Appendix 1(a) is a typical quarterly data summary available from this sampling, which provides an indication of the type of monitoring, and the typical parameter values found in the offshore waters around NELHA. As such, these data represent a comprehensive data set – in time and space - that reflects the offshore water quality in the general Kailua-Kona offshore areas.

The water quality parameters for the proposed offshore Blue Fields Demonstration Project are probably most comparable to those routinely sampled from NELHA Water Monitoring Station 5; Transect 6 (2018, NELHA Annual Report for the Comprehensive Environmental Monitoring Program). These waters are of low turbidity, with negligible levels of particulate organic matter. The 2017 – 2018 the geometric mean (across four sampling events) for turbidity was 0.05 NTUs. Similarly, ammonia nitrogen levels and nitrate levels at this same location were 1.3 and 3.9 ug N/L; respectively. Phosphate levels were at 2.7 ug P/L, while chlorophyll a was measured at 0.11 ug/L.

6.1.2 Currents

Large-scale ocean currents generally run east to west near the Hawaiian Archipelago, due to its position toward the southern edge of the north Pacific Sub-tropical gyre (WPFMC 2009a). On a large scale, both winds and ocean currents run from east to west. However, the Hawaiian Islands act as barriers, disrupting prevailing currents and winds. These disruptions create chaotic mesoscale oceanic and atmospheric eddies with relatively high velocities in the lee of the islands, such as in the action area to the west of the Island of Hawaiʻi (WPFMC 2009a, Jia et al. 2011, and Woodworth et al. 2011).

The area in the lee of the Island of Hawaiʻi is marked by an abundance of mesoscale eddies, both cyclonic (counterclockwise rotating) and anticyclonic (clockwise-rotating) (Jia et al. 2011). These eddies are generated mainly in two ways. First, ocean currents moving around a solid barrier, like the Island of Hawaiʻi, create an effect similar to areas of turbulence seen behind large rocks in streams. Second, winds forced around the Island of Hawaiʻi create wind shear inducing vertical movement in the water column helping to create mixing (WPFMC 2009a, Jia et al. 2011). Jia et al. (2011) found that there was a strong correspondence between eddy formation in the lee of the Island of Hawaiʻi and the prevalence of the trade winds indicating that wind shear may be the more significant factor in eddy creation in the lee of the Island of Hawaiʻi. However, mesoscale eddy strength and distribution in the area is complex and seems to be influenced by how small-scale and mesoscale eddies unpredictably interact with each other (Jia et al. 2011). In sum, the interaction of currents, winds, and the islands themselves create chaotic water movement in the lee of the Island of Hawaiʻi. This produces current velocities near the action area that generally exceed current velocities found in other parts of the State (Flament et al. 1998, Jia et al. 2011). Jia et al. (2011) found that while surface current direction in the action area is variable, surface current velocities average about 0.2 – 0.3 m per second. Flament et al. (1998) had similar results.

Authoritative current data is only available for the Keāhole Point area from a monitoring program conducted by the Look Laboratory of Oceanographic Engineering in 1979, to provide engineering information for deployment of OTEC pipelines for NELHA. These results show that extremely strong currents can occur along the shallow, shelf areas of Keāhole Point – probably due to the funneling effect as water moves past the point.

The proposed demonstration site, however, is a considerable distance south of Keāhole Point, and experiences less current speed than those recorded directly off the Point. The important conclusion from the evidence at hand is that there is more than sufficient current in this area to assure adequate functioning of the passive upwelling pump system.

6.2 BIOTA

Relevant biota can be divided into three types: terrestrial biota; marine biota; and rare, threatened, or endangered species. The potential effects of the proposed Blue Fields Demonstration Project on rare, threatened, or endangered species or their habitats are considered independently, in light of the regulatory requirements of the Migratory Bird Treaty Act (MBTA) and the Endangered Species Act (ESA).

6.2.1 Terrestrial Biota

The proposed Blue Fields Demonstration Project will not significantly impact any terrestrial biota, such as seabird populations. The proposed Blue Fields Demonstration Project area itself is infrequently used as a foraging area by seabirds. Observations indicate that most seabird activity in the area is confined to the fishing "grounds", which extend to the northwest of Keāhole Point.

6.2.2 Marine Biota

Most of the project would take place on or near the surface of the ocean at approximately 1.5 nautical miles SSE of Kaiwi Point. The area is sheltered from east-originating winds and waves, but is exposed to waves and winds from the west and southwest. Strong currents of varying directions affect the Blue Fields Demonstration Project area. Periods of low current flow may occur occasionally.

The proposed Blue Fields Demonstration Project area is located in deep ocean waters (360 ft). The epipelagic portion of the deep ocean ecosystem (0 - 656 ft) is home to a variety of primary and secondary producers (bacteria, phytoplankton, and zooplankton), forage species, and pelagic fishes (WPFMC 2009a).

Fishes –

The Kona Coast is an important sport fishing area for pelagic species. The centers and edges of eddies can be highly productive areas and may concentrate plankton and mid-trophic level prey for larger fish, birds, and cetaceans. Recreational, charter, and commercial fishermen target bigeye and yellowfin tuna (*Thunnus obesus* and *T. albacares*), swordfish (*Xiphias gladius*), blue marlin (*Makaira nigricans*), striped marlin (*Tetrapturus audax*), mahimahi (*Coryphaena spp*.), and wahoo (*Acanthocybium solandri*) in the area (WPFMC 2009c). All of these species are highly migratory and likely present in various life stages in the proposed action area. Blue marlins migrate into waters off west Hawaiʻi and tend to remain on peripheries of eddies (Seki et al., 2002).

Bottomfish fishing, another important commercial and recreational fishery, primarily occurs in shallower State waters in this region. Because the bottom topography drops steeply off the west coast of the Island of Hawaiʻi, there is no extensive bottomfish habitat within the project area.

The proposed Blue Fields Demonstration Project array would aggregate pelagic fish, as some fish are naturally attracted to objects floating at the surface. The 2011-2012 towed Velella Beta array attracted small plankton-eating fish (manta rays and whale sharks) and larger fish including tuna, mahi-mahi and sharks (Sims and Key 2012). Rainbow runners (*Elegatis bipinnulata*), were commonly seen around the moving pen as it was towed. Also, during the 2011-2012 towed Velella Beta, and 2013-2014 anchored Velella Gamma projects, recreational, commercial and charter fishermen frequented both the towed Velella Beta Trial cage, when it was within 12 nm of shore, and the relatively fixed Velella Gamma Trial cage, which was located within 3.5 to 7 nm of shore (Sims 2014).

Marlin, an important commercial recreational species, regularly occurs along the deep waters of the 1,000 fathom line, and this area is important for a commercial charter catch and release fishery. The proposed mooring is within this activity area. The applicant understands that other fishermen would access the same waters in the action area, and applicant would work to minimize and/or help to mediate user conflicts if they were to arise.

NOAA Fisheries has not conducted deep-water surveys in the location of the proposed array, and we have limited information with which to characterize the composition of the deep-water fauna likely to occur at the depths beneath the proposed project. Vetter et al. (2010), De Leo et al. (2012), and De Leo et al. (2013) report on species composition and density in waters 314-1500 m (1,030-4,900 ft) deep in around Hawaiian Islands. The authors documented relatively high abundances of macro-invertebrates including worms, tiny crustaceans, isopods and mollusks (clams and snail-like creatures) on the seafloor near submarine canyons. A wide range of fish species including grenadiers, conger eels, and sharks were also documented (Vetter et al. 2010, De Leo et al. 2012, and De Leo 2013). The authors indicate that species diversity and abundance are higher in submarine canyons than on bathypelagic slopes (Vetter et al. 2010, De Leo et al. 2012, De Leo 2013). At intermediate depths, De Leo et al. (2012) found that concentrations of benthic fish species decreased in the OMZ (about 2,600 ft).

At 1,000 ft, where the DSW pipeline is anchored, the sea bottom is likely devoid of habitat-structuring benthic organisms such as deep-water corals, sponges and macroalgae. There is no habitat for commercially important bottomfish in the seafloor beneath the project area. The mooring and DSW pipeline are likely to be anchored in an area of low topographic rugosity and at a depth that has a low likelihood of supporting precious corals. Researchers have not detected precious corals in the Blue Fields Demonstration Project location. Grigg (2002) places the nearest precious coral beds 40 nm north of the proposed action site.

Sharks –

There are nine species of pelagic sharks commonly found in the open ocean environment around Hawaiʻi (WPFMC 2009b). Sharks may occur in coastal waters and in waters around the project location. Many pelagic shark species are in decline.

Based on the previous two Velella projects, the applicant may encounter sharks at the array. Over the course of an earlier trial (Velella Beta Trial), divers encountered a number of sharks - oceanic white-tip sharks, Galapagos sharks (*C. galapagensis*), silky sharks (*C. falciformis*) and, on several occasions, whale sharks (*Rhincodon typus*). The applicant has dive safety protocols for different levels of response to shark sightings and aggression. The applicant's staff have occasionally observed a few sharks during the Velella Gamma (moored) trial.

Essential Fish Habitat -

The Magnuson-Stevens Act defines essential fish habitat (EFH) as "those waters and substrates necessary for fish spawning, breeding, feeding and growth to maturity." Additionally, the Magnuson-Stevens Act defines Habitat Areas of Particular Concern (HAPC) as "areas within EFH that are ecologically important, sensitive to disturbance, or rare." Thus, HAPCs often require more protection from activities that may adversely affect EFH. In general, marine organisms, managed in accordance with the Magnuson-Stevens Act, that occur in the water column include highly migratory species (HMS) and other pelagic fish species, and eggs and larvae of a range of species. Species associated with benthic habitats include bottomfish, seamount groundfish, precious corals and coral reef ecosystem management unit species, and crustaceans and eggs and larvae. Coral reef resources do not occur in the immediate vicinity of the Blue Fields Demonstration Project. Table 6-1 provides a synopsis of EFH for each MUS group in Hawaiʻi.

Table 6-1. Essential Fish Habitat and Habitat Areas of Particular Concern for Management Unit Species (MUS) Occurring in Hawaiʻi

MUS Group	EFH for Eggs and Larvae	EFH for Juveniles and Adults
Bottomfish	Water column down to 400m depth out to the 200-mile U.S. Exclusive Economic Zone (EEZ) boundary	Water column and all bottom from the shoreline down to 400m depth
Seamount Groundfish	Water column down to 200m depth of all EEZ waters bounded by 29°-35° N and 171° E-179° W	Water column and bottom from 200-600 m depth bounded by 29°-35° N and 171° E-178° W
Pelagics	Water column down to 200m depth from the shoreline out to the EEZ boundary	Water column down to 1000m depth from the shoreline out to the EEZ boundary (also HAPC)
Precious Corals	Known precious coral beds in the Hawaiian Islands including: off Keāhole Point, between Miloliʻi and South Point, The ʻAuʻau Channel, Makapuʻu, Kaʻena Point, the southern border of Kauaʻi, Wespac Bed, Brooks Bank, and 180 Fathom Bank	
Coral Reef Ecosystem	Water column down to 100m depth from the shoreline out to the EEZ boundary	
Crustaceans	Lobsters and Crabs: down to 150m depth from the shoreline out the EEZ boundary Deepwater Shrimp: The outer reef slopes between 500-700 m depth	Lobsters and Crabs: Bottom from the shoreline down to 100m depth Deepwater Shrimp: Outer reef slopes between 300-700m depth

Amendment 4 to the Fishery Ecosystem Plan for Fisheries of the Hawaiian Archipelago was approved on April 21, 2016. Amendment 4 revised EFH and HAPC for 14 species of bottomfish and three species of seamount groundfish in the Hawaiian Archipelago. The revised EFH and HAPC are listed in Table 6-2.

Table 6-2. Revised EFH and HAPC for Main Hawaiian Islands Bottomfish

Species Assemblage	EFH (eggs)	EFH (post-hatch pelagic)	EFH (post-settlement)	EFH (sub-adult/adult)	HAPC (all life stages)
Bottomfish Shallow Complex	Water column from 0–240 m depth extending from the shoreline to the outer boundary of the EEZ.		Water column from 0–240 m depth extending from the shoreline to the outer boundary of the EEZ.		Kaena Point, Oahu Kaneohe Bay, Oahu Makapuu, Oahu Penguin Bank, Oahu Pailolo Channel, Maui North Kahoolawe, Kahoolawe Hilo, Hawaii (see Amendment text and Appendices 4 and 5 for specific site locations).
Bottom Inter-mediate Complex.	Water column from 0–320 m depth extending from the shoreline to the outer boundary of the EEZ.		Water column from 40–320 m depth extending from the shoreline to the outer boundary of the EEZ.		
Bottom Deep Complex	Water column from 0–400 m depth extending from the shoreline to the outer boundary of the EEZ.		Water column from 80–400 m depth extending from the shoreline to the outer boundary of the EEZ.		
Seamount Groundfish	Pelagic waters 0-600 m depth within the EEZ north of 29° N., and west of 170° W.		Benthic or benthopelagic waters from 120– 600 m depth within the EEZ north of 29° N., and west of 179° W.	Benthopelagic waters from 120– 600 m depth within the EEZ north of 29° N. and west of 179° W.	All waters from 0–600 m depth within the EEZ north of 29° N., and west of 179° W.

Source: Proposed rule for RIN 0648-XD907, available at: https://www.federalregister.gov/articles/2016/02/12/2016-02843/pacific-island-fisheries-hawaiibottomfish-and-seamount-groundfish-revised-essential-fish-habitat#h-9

This revision refines EFH to update and clarify which life stages and species assemblages are associated with a particular depth range and were based on updated life history and depth range information for bottomfish MUS. Bottomfish MUS are now classified into three bottomfish species complexes (shallow, intermediate and deep). Life stage terms are now "post-hatch pelagic," "post-settlement," and "sub-adult/adult."

- HAPC for Hawaiian Islands bottomfish MUS was refined under Amendment 4. No HAPC for MHI bottomfish was established in the project area.
- HAPC for seamount groundfish was designated in all areas that comprise EFH for seamount groundfish. No EFH or HAPC for seamount groundfish occurs in the main Hawaiian Islands.

The overall EFH designations for Hawaiʻi bottomfish around Hawaiʻi Island remained the same.

6.2.3 Rare, Threatened or Endangered Species

Rare, threatened or endangered species include those protected species that may occur in the project area year-round, or seasonally. These include sharks, sea turtles, seabirds, marine mammals, and corals. The Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), the Migratory Bird Treaty Act, and the Magnuson-Stevens Act protect many of these species. The following provides baseline information on these species that may occur in the action area.

Sharks –

Many pelagic shark species are in decline. In response, NOAA Fisheries has implemented shark conservation measures including listing some species under the ESA and identifying the bigeye thresher shark and smooth hammerhead shark as candidates for listing (80 FR 48061 and 80 FR 48053, August 11, 2015).

On March 01, 2018, NOAA Fisheries listed the oceanic whitetip shark *(Carcharinus lonigmanus*) as Federally threatened (83 FR 4153; 50 CFR 223). The oceanic whitetip shark has a cosmopolitan distribution in tropical and sub-tropical waters. As a pelagic species, it is typically found offshore in the open ocean, on the outer continental shelf, or near oceanic islands in water depths greater than 600 feet. Occupying surface waters to depths of 498 feet, the oceanic whitetip sharks are considered surface-dwelling, preferring the mixed layer in warm waters (> 20°C).

Sea turtles -

Several species of sea turtles occur in Hawaiian waters and may be present in the action area. ESA-listed threatened green turtles (*Chelonia mydas*) and endangered hawksbill turtles (*Eretmochelys imbricata*) occur in nearshore waters throughout the archipelago. NOAA Fisheries and the U.S. Fish and Wildlife Service (USFWS) are proposing to reclassify green sea turtles into 11 distinct population segments (DPSs) under the ESA (80 FR 15271). The proposed Hawaiian DPS would remain listed as threatened. Commercial fishing vessels operating beyond 50 nm from Hawaiʻi have caught other sea turtle species including the endangered leatherback turtle (*Dermochelys coriacea*) and threatened olive ridley turtle (*Lepidochelys olivacea*) (Gilman et al., 2006; WCPFMC 2009). In 2011, NOAA Fisheries designated the North Pacific population of loggerhead turtles (*Caretta caretta*) as a distinct population segment (DPS). NOAA Fisheries designated this DPS as endangered under the ESA (76 FR 58868, September 22, 2011). Loggerheads occur near the action area.

A thorough review of the life history, status and trends, threats, and conservation efforts for sea turtles is available in section 5 of the September 19, 2014 Biological Opinion on the Hawaiʻi-based shallow-set longline fishery (NOAA Fisheries 2014d). Information about Pacific sea turtles' range, abundance, status, and threats is in the recovery plans for each species, available from the NOAA Fisheries website:

- Olive ridley: https://www.fisheries.noaa.gov/species/olive-ridley-turtle
- Leatherback: https://www.fisheries.noaa.gov/species/leatherback-turtle
- Loggerhead: https://www.fisheries.noaa.gov/species/loggerhead-turtle
- Hawksbill: https://www.fisheries.noaa.gov/species/hawksbill-turtle
- Green turtle: https://www.fisheries.noaa.gov/species/green-turtle
- East Pacific green turtle: https://www.fpir.noaa.gov/PRD/prd_green_sea_turtle.html

Seabirds –

Seabirds may occur in the proposed action area, including these ESA-listed:

- Hawaiian petrel (*Pterodroma sanwichensis*)
- Newell's shearwater (*Puffinus newelli*)
- Short-tailed albatross (*Phoebastria albatrus*)

The Hawaiian petrel and Newell's shearwater have breeding colonies in the MHI Islands (USFWS 1983). The ESA-listed short-tailed albatross does not appear to frequent the vicinity of the proposed action site. A few short-tailed albatrosses visit Midway Atoll every year in the Northwestern Hawaiian Islands (USFWS 2008).

The applicant did not observe any ESA-listed seabirds during the previous two Velella projects. During the 2011-2012 towed Velella Beta project, staff often observed unidentified seabirds in the project area. Some seabirds landed on the net pen and tender vessel, but staff did not observe seabirds diving on the net pen, and did not observe adverse impacts on seabirds from the operation. Several Brown boobies (*Sula leucogaster*) were frequently observed resting on the feed barge in the 2013-2014 Velella Gamma trial (October 2013 to June 2014), but these birds were not in any way harmed. The boobies departed the site once staff removed the feed barge.

The Migratory Bird Treaty Act makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit. The list of migratory bird species protected by the Act is in 50 CFR 10.13 and includes most seabirds. Other migratory seabirds occurring in the project area include black-footed and Laysan albatrosses (*Phoebastria nigripes* and *P. immutabilis*); Christmas, flesh-footed, wedge-tailed, and sooty shearwaters (*Puffinus nativitatis, P. carneipes, P. pacificus, and P. griseus*); and masked, brown, and redfooted boobies (*Sula dactylatra, S. leucogaster, S. sula*).

Additional information on seabird populations, distribution, life history, and status is available from the USFWS at http://www.fws.gov/birds/index.php and at http://ecos.fws.gov/tess_public/pub/SpeciesReport.do?groups=B&listingType=L&mapstatus=1

Marine Mammals -
Many species of marine mammals may occur in the proposed action area. These include pinnipeds (seals) and cetaceans (whales and dolphins). The following describes the occurrence and status of marine mammals that may occur in the action area.

Hawaiian Monk Seal
The Hawaiian monk seal (*Neomonachus schauinslandi*) is the only pinniped indigenous to Hawaiʻi. This seal is listed as Endangered under the ESA. Monk seals occur throughout the Northwestern Hawaiian Islands (NWHI), with subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, Necker Island, and Nihoa Island. They also occur throughout the main Hawaiian Islands (MHI) (NOAA Fisheries 2014a). According to NOAA Fisheries (2007), monk seals have declined in the NWHI since monitoring began in 1995. Since 1981, the number of monk seals in the MHI has increased. The best estimate of the current total Hawaiian monk seal population is 1,400 seals – about 1,100 in the Northwestern Hawaiian Islands (NWHI from Nihoa to Kure Atoll), and about 300 in the main Hawaiian Islands (MHI from Niʻihau to Hawaiʻi). The population in the NWHI has been declining annually due to low juvenile survival (NOAA Fisheries 2014a). Monk seal numbers in other parts of their range appear to be increasing, but population growth rate estimates are uncertain at this time (NOAA Fisheries 2014a). The species is depleted and well below its optimum sustainable population and is a strategic stock under the MMPA (NOAA Fisheries 2014a). Around the MHI, threats include disturbance, fishery interactions (hooking and

entanglement in fishing gear or marine debris); human interactions (including feeding and other harassment); diseases (leptospirosis and toxoplasmosis), and intentional killing.

According to NOAA Fisheries (2010), 5-10 monk seals visit the Island of Hawaiʻi every year. Monk seals may use areas within the critical habitat depth contour (200 m) for foraging, as well as certain coastal areas for pupping, nursing, and hauling out (NOAA Fisheries 2007). The proposed action area lies outside the 200 m depth contour and outside areas important to seals for pupping. During the Velella Beta and Gamma trials, the Kampachi Farms applicant did not observe any Hawaiian monk seals near either array (Sims 2014). There has been report of a Hawaiian monk seal which swam into an open, empty net pen at the marine fish farm near Keahole Point (circa 2017) and drowned after not relocating the opening to escape.

On August 21, 2015, NOAA Fisheries published a final rule for monk seal critical habitat (80 FR 50925; https://www.fpir.noaa.gov/PRD/prd_critical_habitat.html). The predominant portion of this critical habitat occurs in the nearshore waters where the applicant would transit for deploying, retrieving, operating, and maintaining the macroalgal culture array (Figure 6-1). Honokōhau Harbor, where the applicant would transit, is located near site HA-82. The critical habitat at the Island of Hawaiʻi includes the marine habitat through the water's edge, including the seafloor and all subsurface waters and marine habitat within 10m of the seafloor, out to the 200-m depth contour line (relative to mean lower low water) the shore. The essential features of this area of critical habitat are adequate prey quality and quantity for juvenile and adult monk seal foraging. The macroalgal culture array would be moored just on the extreme western (seaward) limit of the critical habitat designation boundary, due west of the northern limit HA-91, Oneo Bay, terrestrial boundary line.

MHI Insular False Killer Whale

The Main Hawaiian Islands (MHI) insular false killer whale (*Pseudorca crassidens*) distinct population segment (DPS) is listed as an endangered species under the ESA (77 FR 70915, Nov. 28, 2012). The MHI insular false killer whale DPS occurs in the proposed action area. Because NOAA Fisheries listed the MHI insular FKW DPS as endangered under the ESA, it is also a depleted stock under the MMPA. According to the latest MHI insular FKW stock assessment report, the minimum population estimate is 92 animals, and the population appears to be declining (NOAA Fisheries 2018).

On July 24, 2018, NOAA Fisheries publishes a final rule to designate critical habitat for the main Hawaiian Islands insular false killer whale distinct population segment (DPS) by designating waters from the 45-meter depth contour to the 3,200-meter depth contour around the main Hawaiian Islands from Niʻihau east to Hawaiʻi (https://www.fisheries.noaa.gov/action/final-rule-designate-critical-habitat-main-hawaiian-islands-insular-false-killer-whale). MHI IFKW Critical Habitat on the Island of Hawaiʻi is identified in Figure 6-2.

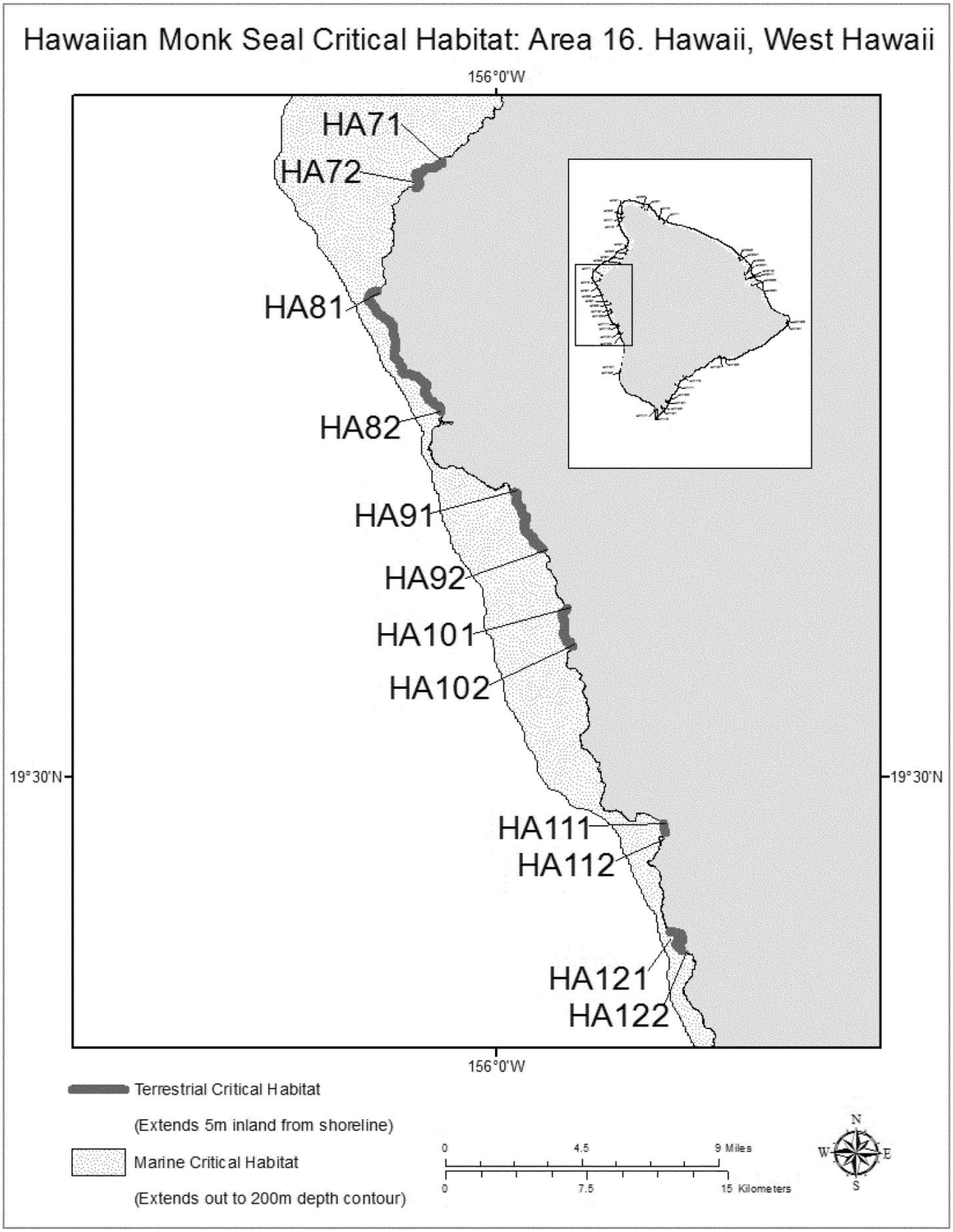

Figure 6-1. Monk Seal Critical Habitat on the Island of Hawai'i (80 FR 50925, August 21, 2015)

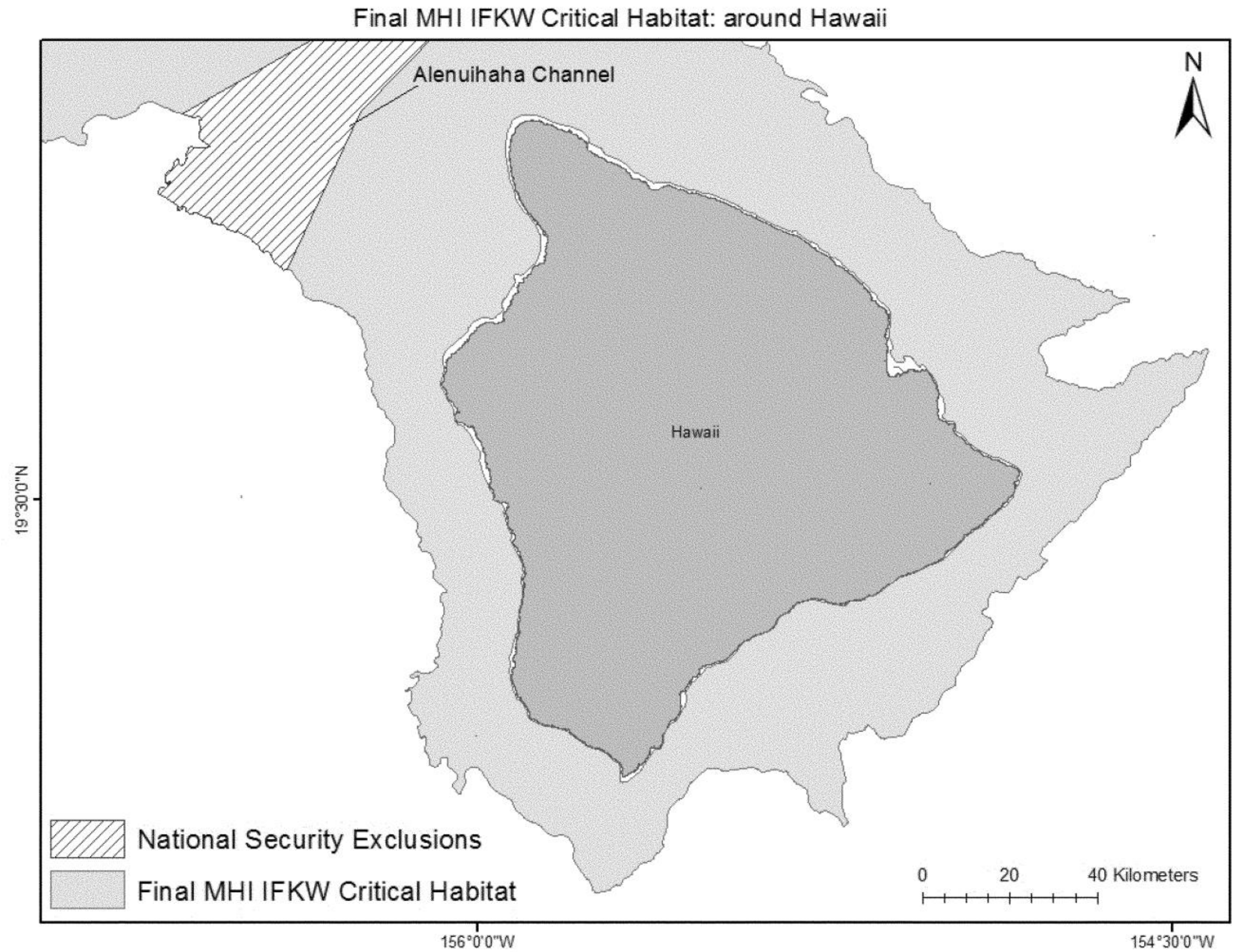

Figure 6-2. MHI IFKW Critical Habitat on the Island of Hawaiʻi (83 FR 35062, July 24, 2018)

Humpback Whale -

NOAA Fisheries has listed humpback whales as endangered under the ESA and depleted under the MMPA. Both mating and calving humpback whales may be present in or around the Blue Fields Demonstration Project area from November through March during the calving and breeding season. Humpback whales wintering in Hawaiʻi belong to the Central North Pacific (CNP) stock. The minimum population estimate for the CNP humpback whale stock is 10,103 animals and is growing seven percent annually (NOAA Fisheries 2017; https://www.fisheries.noaa.gov/species/ humpback-whale). NOAA Fisheries received a petition to list the CNP DPS under the ESA and to delist this DPS. NOAA Fisheries made a positive finding on the petition and has started a status review to determine if NOAA Fisheries should delist this DPS (79 FR 36281, June 26, 2015). If this DPS is delisted, the protections of the MMPA and the Hawaiian Islands Humpback Whale National Marine Sanctuary would continue to apply. Federal regulations prohibit persons on or in the water from approaching the whales within 100 yards (90 m) within the sanctuary and throughout waters of the Hawaiian Islands. Baird et al. (2015) found that the most biologically important areas for humpback whales around the Island of Hawaiʻi are outside of the proposed action area.

Other Marine Mammals in the Proposed Action Area -

Listed below are marine mammals that are not ESA-listed and that may occur in the Blue Fields Demonstration Project area. This list based on distribution information and previous sightings during other Kampachi Farms Velella trials.

- Blainville's beaked whale *(Mesoplodon densirostris*)
- Bottlenose dolphin or common bottlenose dolphin (*Tursiops truncatus)*
- Bryde's whale (*Balaenoptera edeni*)
- Common dolphin (*Delphinus delphis*)
- Cuvier's beaked whale (*Ziphius cavirostris*)
- Dwarf sperm whale (Kogia sima)
- False killer whale (*Pseudorca crassidens*) Hawai'i pelagic population
- Fraser's dolphin (*Lagenodelphis hosei*)
- Killer whale (*Orcinus orca*)
- Longman's beaked whale (*Indopacetus pacificus*)
- Melon-headed whale (*Peponocephala electra*)
- Minke whale (*Balaenoptera acutorostrata)*
- Northern elephant seal (*Mirounga angustirostris*)
- Pantropical spotted dolphin (*Stenella attenuata*)
- Pygmy killer whale (*Feresa attenuata*)
- Pygmy sperm whale (*Kogia breviceps*)
- Risso's dolphin *(Grampus griseus*)
- Rough-toothed dolphin or Steno's dolphin (*Steno bredanensis*)
- Short-finned pilot whale (*Globicephala macrorhynchus*)
- Spinner dolphin (*Stenella longirostris*)
- Spotted dolphin (*S. attenuata*)
- Striped dolphin (*S. coeruleoalba*)
- Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)

While northern elephant seals (*Mirounga angustirostris*) occasionally are sighted in Hawai'i, these are very rare occurrences. Due to very rare occurrences in Hawai'i, the Kampachi Farms staff are not likely to observer this species at the Blue Fields Demonstration Project site. During Kampachi Farms' Velella Beta trial, a graduate student, Kelsey Kozbi, from the University of Hawai'i at Hilo monitored the free-floating array to test whether marine mammal abundance was higher near the array than that encountered during line transect surveys away from the array. She found no significant difference in marine mammal abundance between the control area (away from the array) and the experimental area observations (near the cage). During this study, she sighted bottlenose dolphins, rough-toothed dolphins, spinner dolphins, and spotted dolphins near the array (Kozbi unpublished). In addition, the applicant's staff sighted rough-toothed dolphins at the Velella Gamma array on eight occasions (Sims 2014). However, staff obtained these observations opportunistically; and we can make no real conclusions concerning the effect of the moored array on cetacean behavior. The applicant did not detect interactions between cetaceans and the gear during the Velella Gamma trial (Sims 2014). Detailed information on these species' geographic ranges, abundance, bycatch estimates, and status is in the most recent marine mammal stock assessment reports (SARs), which are available online at: https://www.fisheries.noaa.gov/whales and https://www.fisheries.noaa.gov/dolphins-porpoises.

Corals -

At last reporting, NOAA Fisheries listed 15 coral species as threatened or endangered under the ESA. None of the ESA-listed coral species occur in the proposed Blue Fields Demonstration Project area, as no coral found in the Hawaiian Archipelago was included in the ESA listing action (79 FR 53851, September 10, 2014).

6.3 RECREATION

The demonstration area is beyond the depth of recreational SCUBA diving limits, and presents no conflict to fishing interests consulted for the project. It is clear of the heavily-used direct line of transit from Honokōhau Harbor to a well-known FAD to the South ("F Buoy"), and well outside of the 40 fathom isobar trolled for ono (*Acanthocybium solandri*). The boating-accessible area between Kaiwi Point and Kailua Bay was described as an area of little fishing interest outside of the koʻa ʻōpelu described in 6.6. The proposed site is also clear of the charted cruise ship channel where passenger ships transit and anchor.

There are no significant benthic plant or animal populations, and there are virtually no benthic or pelagic fishing activities in this depth range. Kona crab (*Ranina ranina*) and nabeta (*Iniistius pavo*) are the only benthic resources that occur on sand bottom near this depth. However, it is unlikely Kona crab will be present at the site location, as there needs to be contiguous sandy habitat from 20 fathoms to 60 fathoms (the proposed site region has non-contiguous sand across this depth range, therefore, it is unlikely Kona crab will exist at the proposed site depth of 60-70 fathoms). Based on fishing community consultation, no one crabs for Kona crab in the proposed area. Nabeta should exist in the proposed area, but fishermen report larger and more suitable fishing grounds for this species both several miles north and south of the site. Thus, the area proposed is not a significant fishing area for nabeta.

Kampachi Farms is not seeking exclusivity from fishing vessels in the project site, and prefers to keep the area open to the passage of recreational users and fisherpeople within safe modes of operation and distances from the surface structures. Kampachi Farms will request that there be no SCUBA diving or swimming in the project site for the safety of the public. The Coast Guard consultation process will determine the marking of the area and potential for passage of boat traffic within the watch circle.

6.4 NOISE AND AIR QUALITY

The project would be located in an area with ambient noise from wind and waves, as well as periodic noise from outboard motors on fishing and other boats.

There are no large sources of anthropogenic emissions into the atmosphere in the project area. Motorized fishing vessels are a small source of emissions in offshore waters, but trade wind conditions around Hawaiʻi are likely to disperse quickly these emissions. Fine particulate matter associated with the eruption of Kilauea Volcano, on the eastern flank of the Island of Hawaiʻi, can degrade air quality in the proposed action area depending on weather, wind direction and the amount of volcanic activity. According to the State of Hawaiʻi Clean Air Branch, the volcano is responsible for large inputs of sulfur dioxide into the local environment causing a form of air pollution called "vog."

Air quality varies, depending on the amount of vog in the air. On days of strong trade winds – predominantly over winter - a general northerly wind pattern results in negligible levels of vog. On days of weaker trade winds – generally more frequent over summer – a more southerly air flow brings vog-laden air from Kilauea volcano around and up to Kona on a southerly air stream, created by the adiabatic convection currents along the lee of the island. Usually the air is clear, dry and cooler in the mornings, with offshore winds predominating.

6.5 AESTHETICS

The aesthetic value of the proposed project site must be considered in light of both the intrinsic value of open ocean space, and the nearby shoreline activities. The waters surrounding the area are valued by the community for the big game fishing. Shoreline activities include recreational diving and fishing along the nearshore fringing reef.

The Blue Fields Demonstration Project would be moored at a distance of approximately 1.5 nautical miles south southeast of Kaiwi Point and approximately 3 to 3.5 nm west of Kailua-Kona. At night, a flashing light would be attached to the mooring buoy and would have a viewing range of approximately two miles. There are no other structures in the project area, but fishing and other vessels are common in offshore waters day and at night.

6.6 CULTURAL RESOURCES AND PRACTICES

The proposed site for permitting is too deep for free-diving, and for any significant SCUBA diving activity. There are no significant benthic plant or animal populations, and there are virtually no benthic or pelagic fishing activities in this depth range. Kona crabs (*Ranina ranina*) and nabeta (*Iniistius pavo*) are the only benthic resources that occur on sand bottom near this depth. However, it is unlikely Kona crab will be present at the site location, as there needs to be contiguous sandy habitat from 20 fathoms to 60 fathoms (the proposed site region has non-contiguous sand across this depth range, therefore, it is unlikely Kona crab will exist at the proposed site depth of 60-70 fathoms). Based on fishing community consultation, no one crabs for Kona crab in the proposed area. Nabeta should exist in the proposed area, but fishermen report larger and more suitable fishing grounds for this species both several miles north and south of the site. Thus, the area proposed is not a significant fishing area for nabeta.

The nearest land area of cultural significance to the project is the Keahuolū ahupuaʻa which stretches up the western slope of Hualālai. By historical account, the ahupuaʻa has been described in boundary as, "Kealakehe bounds it on the North side, the boundary at shore between the two lands is at Kaiwi; thence it runs *mauka* to Puʻuokaloa", including two accounts of, "ancient fishing rights extending out to sea" (Maly 2003). There are cultural resources and cultural sites along the shoreline which are managed by Queen Liliʻuokalani Trust (between Kaiwi Point and Pawai Bay).

Local fishermen describe the predominant currents at the proposed site location as running North-South or South-North. Shoreline locations in this area are named for their currents; and the area is known for the convergence of North and South currents which form a "figure eight" movement of water, and potentially dangerous conditions for landing canoes.

The only potentially-impacted cultural resource that was cited during extensive discussions with community and kupuna groups was the koʻa ʻōpelu (ʻholes' or schooling places for mackerel scad – *Decapterus macarellus*) that occur in the general region. The location of these koʻa are typically considered to be part of the traditional marine lore, and are considered inappropriate for publication, or for sharing outside of the families or community groups who have traditionally fished this koʻa. An important aspect of the koʻa ʻōpelu tradition is the maintenance of these koʻa by feeding of the school. To keep fish attracted to a koʻa, a fisherman will regularly drop bags of palu - grated vegetable matter - to the school (daily, or every second day). The knowledge of the names and locations of the koʻa is considered of historical significance, and is a tradition that the kupuna would like to see preserved and passed on to future generations.

ʻŌpelu aggregations usually occur in water around 120 ft deep, close to reef drop-offs, and the cultural contacts for the preparation of this assessment indicated that the koʻa ʻōpelu in this area occurs in the "same general direction" to Keahuolū ahupuaʻa from the proposed location, "but closer towards shore." The koʻa ʻōpelu along the QLT coastline is currently fished by commercial and recreational/artisanal fishermen. A local ʻōpelu fisherman of multigenerational fishing experience over the proposed site region was consulted in preparation of this assessment, who indicated that they did not anticipate any impact to the location of the koʻa ʻōpelu in the shoreward direction, but that if the site were to be moved closer to shore they would have concern of impact. Additionally, our cultural consultation process did not return any accounts of cultural significance occurring over the proposed site.

In consultation with cultural contacts nearest to the demonstration area, there was acknowledgement of potentially positive pelagic fish-aggregation benefits for fisherpeople during the deployment. Inquiry arose about the long-term impacts of FADs with regards to perceived threats to migration and spawning patterns. No such phenomena have been documented in the literature with regards to the dedicated FADs placed in the waters surrounding the Hawaiian Islands.

The coastline northward of Kaiwi Point is the site of Kaloko-Honokōhau National Historical Park – which contains coastal fish ponds (loko i'a). Historically, fish pond health depended on the cultivation and maintenance of *limu* within the ponds, as the base of the trophic system to be eaten by herbivores. Restoration of the Kaloko-Honokōhau ponds has been underway for some time to maintain the rock walls both as archaeological artifacts, and to return to cultivating *limu* and fish using aquacultural practices. *Limu* cultivation at the proposed site could therefore be considered historically and traditionally appropriate to the area. Collection of *limu* along the rocky shorelines of the West Hawaiʻi coastline is recorded in oral history as an integral part of daily life. *Limu* collection remains a part of Native Hawaiian cultural practice, and no impact to this practice will be made by the proposed project.

The species proposed to be grown on the Blue Fields Demonstration Project are all native or endemic to Hawaiʻi. The cultural importance of these species are:

- *Limu manauea* (*Gracilaria parvispora*) is commonly added to poke or salted for later use
- *Limu kala* (*Sargassum echinocarpum*) is found in dense patches where fresh water mixes with ocean water and during the winter on shores exposed to larger waves. Historically, the blades of this Hawaiʻi endemic were chopped and used in stuffing and soups or blades were deep fried whole. This species was also a part of the *hoʻoponopono*

ceremony of forgiveness. *Limu kala* is also used as bait when fishing for chubs/rudderfish (*nenue*) and unicornfish (*kala).*

- *Limu kohu* (*Asparagopsis taxiformis*) is a favored edible species. It is soaked overnight, pounded, salted, rolled into a ball, and used in poke.

6.7 LAND USE AND ENVIRONMENTAL COMPATIBILITY

6.7.1 Current Usage

Local commercial and recreational fisherpeople and fishing charter boat operators were consulted in determining the final proposed siting location. The proposed site presently offers no special environmental or public benefit to the community, beyond the relatively rare instance of use by recreational boats. The site is clear of the heavily-used direct line of transit from Honokōhau Harbor to a well-known FAD to the South (“F Buoy”), and well outside of the 40 fathom isobar trolled for ono (*Acanthocybium solandri*). The boating-accessible area between Kaiwi Point and Kailua Bay was described as an area of little fishing interest outside of the koʻa ʻōpelu described in 6.6. The proposed site is also clear of the charted cruise ship channel where passenger ships transit and anchor.

It is a primary concern to the fishing stakeholder groups we consulted (as well as to Kampachi Farms) that the array be well marked and lit because of the high recreational watercraft use of Kailua Bay. The Coast Guard is responsible for setting standards of navigational markings, and Kampachi Farms is currently in contact with the Coast Guard to complete their Private Aid to Navigation (PATON) process through the Coast Guard District 14 Waterways office.

Kampachi Farms is not seeking exclusivity from fishing vessels in the project site, and prefers to keep the area open to the passage of recreational users and fisherpeople within safe modes of operation and distances from the surface structures. Kampachi Farms will request that there be no SCUBA diving or swimming in the project site for the safety of the public. The Coast Guard consultation process will determine the marking of the area and potential for passage of boat traffic within the watch circle.

6.7.2 Submerged Lands Issues and the Public Trust

The proposed demonstration site constitutes part of the ceded lands trust, since all submerged lands are ceded lands. The 1999 amendments to the Ocean and Submerged Lands Leasing law (Chapter 190D HRS) directly addressed the issue of Office of Hawaiian Affairs’ share of the lease revenues, by stipulating that the designated 20% of lease payments should be due to OHA. As this is a non-commercial research project, however, the applicant would ask that no lease fees be payable.

6.7.3 Public Perceptions of Ocean Use

The public perceptions of ocean access and ownership in Hawaiʻi are an amalgam of two conflicting cultural traditions. The legal regime has, up to now, been largely based on the ancient western concept of Mares Librum – Freedom of the Seas, or the ocean as a common property resource. The traditional Hawaiian concepts of land-use and ocean-ownership practices were related to the principles of the ahupuaʻa, fishponds, and the konohiki fisheries. This provided for ownership of ocean resources, and was recognized as a sustainable, efficient means of managing the ocean, and reducing conflicts.

The 1999 amendments to the Ocean and Submerged Lands Leasing law (Chapter 190 D HRS) were the first major step to view the oceans as a resource that could be occupied and sustainably utilized, rather than simply exploited. This represents a sea change in the legislative and community thinking. It could be interpreted to represent a shift in current policies away from the Western Mares Librum ideas towards the more traditional Hawaiian concept. It might also reflect increasing recognition – evident in increased regulation and licensing of fishing activities in the state - that open-access fisheries, and unrestricted access to the ocean does not appear to provide sufficiently for effective management of ocean resources.

7. POTENTIAL IMPACTS AND MITIGATION

7.1 IMPACTS DURING CONSTRUCTION

Primary impacts during the deployment and construction of the demonstration macroalgal growth platform array are confined to the areas where permanent structures are to be located (i.e., the anchoring of the mooring lines for the platform. The submersible macroalgal platform will be moored to the ocean bottom in approximately 120m (400 ft) water depth utilizing three (3) deadweight (concrete block) anchors (or embedment anchors if sufficient sand depth is identified). Each anchor will be spaced approximately 220m (722 ft) from the mooring center line and configured 120° from each other, with a total mooring radius of 300m (985 ft), or mooring footprint of approximately 282,744m^2 (28.3 ha). Attached to the eastern catenary mooring line is a 700m (2,297 ft) long DSW HDPE (0.18m [6 in]) outside diameter (OD) pipe. This DSW pipeline extends approximately 300m (985 ft) beyond the eastern mooring anchor into roughly 300m (985 ft) water depth with an intake head and anchor at the terminus. Additional anchors are attached evenly spaced along the HPDE DSW pipeline between the eastern mooring anchor and the terminal anchor, securing its placement and minimizing any significant movement on the ocean seafloor. Anchor lines and anchor blocks will be moved to the site from Honokōhau Harbor, and will be deployed from large boats or barges. The anchors will result in only minimal resuspension of soft sediments, which will have no measurable impacts on the biota of the area (unless they are within the immediate footprint of the anchor block, which is unlikely, given the scarcity of benthic fauna in the area).

The algal growth platform array (including the mooring infrastructure) will be constructed according to manufacturer's (Makai Oceana Engineering, Inc.) specifications and instructions, launched in Honokōhau Harbor, and then towed down to the site for a distance of approximately 2.6 nautical miles. Once in position, the macroalgal growth platform will be attached to the anchor lines. Similar multi-anchor swivel (MAS) point mooring systems have been extensively tested throughout the world, in offshore conditions far worse than those normally experienced locally in Hawaiʻi.

There will be a very slight risk of pollution from spills of fuel, oil, or hydraulic fluids from the boats used in deploying the anchors and the macroalgal growth platform array. However, this risk will be no greater than for any other boat in Kona waters. Standard precautions (best management practices) and Coast Guard regulations for working on the ocean will be adhered to during the towing and deployment operations.

7.2 LONG TERM IMPACTS

<u>7.2.1 Water Quality</u>

The renewable energy powered DSW pump provides a 1% concentration of DSW pumped from 300 meters deep. Meaning the concentration of water at the proposed location will not exceed 1% DSW to 99% surrounding waters (surface sea water; SSW). The nitrogen (nitrate + nitrite) concentrations of the DSW from the 300-meter depth are estimated to be approximately 12 umol/kg, compared to estimated nitrogen (nitrate + nitrite) concentrations of SSW to be approximately 0.5 umol/kg. As such, the DSW accumulators receive, diffuse, and distribute the DSW from the passive, wave driven pump across the algal growth platform. The piping reticulation design for nutrient distribution has been optimized for maximum efficiency of nutrient dispersal. Upwelled water will always flow downcurrent, in one direction, through the macroalgae crop.

Only minor and nearly immeasurable impacts on water quality are anticipated in the immediate area of the Blue Fields Demonstration Project. The project uses DSW as the only nutrient source in oligotrophic waters, and uses renewable energy to power pumping. The nutrient pulse of the wave and current driven pump, combined with the appropriate algal densities were designed to optimize biomass production and nutrient uptake, while minimizing nutrient loss to the surrounding waters (and thus minimizing kW/kg nutrient delivered).

Further, the growth of *limu* uptakes carbon from the surrounding SSW and would locally mitigate ocean acidification, thus improving water quality. A rising level of dissolved carbon is the cause of ocean acidification, and so by uptaking carbon from the surrounding waters, the growth of macroalgae decreases dissolved carbon, thereby raising the pH. The relationship between macroalgae biomass and reduction in acidification is unknown, but this is something that could potentially be studied through future research related to this project.

Negligible, temporary, and localized impacts to water quality associated with increased turbidity in the immediate vicinity of the moorings may occur during anchor deployment and placement due to resuspension of sediments. This condition is anticipated to dissipate quickly, resulting in no long-term impacts to water quality.

Monitoring and NPDES Permit Requirements -

Correspondence (01/08/2019) with Darryl Lum, Chief at the State of Hawaiʻi Department of Health, Clean Water Branch (CWB) determined that the upwelling nutrients from the passive DSW current-driven pump are not considered a point source discharge. As such, a National Pollutant Discharge Elimination System (NPDES) permit will not be required.

7.2.2 Biota

Terrestrial Flora -

There are no terrestrial flora or marine macroflora in the proposed Blue Fields Demonstration Project area. Few algae are able to grow at these depths, or under these substrate and current regimes. There would be no increase in organic loading in the substrate and therefore, no supplemental growth of benthic algae is anticipated.

Terrestrial Fauna -

The project would not impact terrestrial fauna. This area is not considered important for birdlife.

Marine biota -

Marine Benthic Organisms

There may be an increase in the amount of marine benthic fauna both on the mooring lines and anchors. Fouling on mooring line and anchors would probably include macroalgae, bivalves (several species of mussels and oysters (*Pteria* and *Pinctada* spp), corals (*Pocillopora* and *Porites*), sea urchins (*Echinothrix calamaris*) nudibranchs (*Stylocheilus longicauda*) and sponges. These would all settle out of the plankton, and there would be no measurable impacts on adjacent communities. The presence of these organisms would primarily be a function of the presence of the artificial substrates, rather than any other perturbation to the environment. Grazing and browsing fishes may remove much of this fouling, but occasionally divers would need to scrape occluding fouling from these surfaces. Some of this fouling would fall to the bottom, and become part of the general benthic processes of detritivores and decomposers in the soft substrate. Any change in the marine benthic community that may occur will be localized and temporary.

Fishes

The macroalgae platform array likely would aggregate pelagic fish as some fish are naturally attracted to objects floating at the surface (Fish Aggregation Devices [FAD]). The 2011-2012 towed Velella Beta array attracted small plankton-eating fish (manta rays and whale sharks) and larger fish including tuna, mahi-mahi and sharks (Sims and Key 2012). Rainbow runners (*Elegatis bipinnulata*) were commonly seen around the moving pen as it was towed. Also during the 2011-2012 towed Velella Beta and 2013-2014 anchored Velella Gamma projects, recreational, commercial and charter fishermen frequented both the towed Velella Beta Trial cage, when it was within 12 nm of shore, and the relatively fixed Velella Gamma Trial cage, which was located within 3.5 to 7 nm of shore (Sims 2014).

Fish may also be attracted to the site due to the fouling on the structures. Schools of mackerel scad (ʻōpelu: *Decapterus macarellus*) may also be occasionally attracted to the area around the macroalgae platform array, but are not anticipated to take up permanent residence. Carnivorous pelagic fish, such as false albacore tuna (kawakawa: *Euthynnus alletteratus*), yellowfin tuna (ahi: *Thunnus alabacares*), and occasionally ono (wahoo: *Acanthocybium solandri*) and amberjack (kahala: *Seriola dumerili*) may also be attracted to the area by the baitfish, or by the structural presence of the macroalgae platform array.

The macroalgae array would not serve as a "fish sink" to pull fish away from neighboring reefs. Most reef fishes are site resident with varying home ranges (Howard et al., 2013). It wouldn't be anticipated that they would abandon their typical reef habitats to take up residence on such an exotic structure located offshore, which wouldn't offer adequate food resources or nocturnal shelter. Meyer et al. (2010) documented natural boundaries that are typically situated along major habitat breaks (e.g., large sand channels between reefs) in reef ecosystems, and serve as natural barriers to reef fish movements. In this study, most fish utilized between 0.2 and 1.6 km of coastline within the reef. Where a wide variety of reef fishes captured inside the marine protection area (MPA) were documented to swim back and forth across the MPA boundary (porous to reef fish movements) intersecting continuous reef, only 1 of 11 species tagged crossed a wide expanse of a sandy channel inside Kealakekua Bay. In an earlier study, Meyer and Holland (2004) documented bluespine unicornfish (*Naso unicornis*) movement patterns, home range size, and habitat preferences in a small Hawaiian marine reserve. The bluespine unicornfish were documented to be site-attached to home ranges situated within the reserve boundaries and their movements were associated with discrete topographic features that defined the home range size.

The nearest reef (Pawai Bay) to the proposed project site is 1.454 km; and with the distances of 1.705 km and 3.201 km to the nearest Division of Aquatic Resources (DAR) monitoring sites #13 and #14, respectively. As such, reef fish are unlikely to move that extensively over open water to take up residence with an artificial FAD, such as the macroalgae array of the Blue Fields Demonstration Project.

Marlin, an important commercial recreational species, regularly occurs along the deep waters of the 1,000 fathom line, and this area is important for a commercial charter catch and release fishery. The proposed mooring is within this activity area. The applicant understands that other fishermen would access the same waters in the action area and would work to minimize and/or help to mediate user conflicts if they were to arise.

<u>*Sharks*</u>

Sharks often investigate floating objects in their environment, and fish congregating around the array would present a potential food source. On several occasions during previous trials, divers exited the water because of aggressive behavior by oceanic white-tip and Galapagos sharks. Sharks tended to travel on and did not stay with the towed array. Because sharks may aggregate near the array, a slight increase in fishermen-shark interactions could occur. This effect would likely be similar to any other FAD in Hawaiʻi. Tension on the array's lines (i.e., mooring) would also preclude sharks from entangling themselves.

No evidence exists suggesting that FADs or aquaculture operations cause changes to pelagic shark movement patterns in the open ocean. Sims (2014) observed that, while the Velella Beta and Velella Gamma arrays attracted pelagic sharks, individual sharks did not seem to continually associate with those projects. Sharks may be aggregated to the structures, but the number of sharks in the overall area will not increase.

There may be some concerns that if sharks are drawn to in-water structures, such as the macroalgae platform, it could lead to increased predation on dolphins or other marine mammals in the area. However, the macroalgae platform will not in any way impact the natural balance between the sharks and their natural prey. The vulnerability of dolphins or other mammals to predation by sharks would remain the same, whether or not the macroalgae platform is present.

<u>*EFH*</u>

While deployed, the macroalgae platform array's potential area of effect would overlap the following EFH: EFH for bottomfish, pelagic, coral reef ecosystem species, and crustacean eggs and larvae from the surface down to 100m in the immediate vicinity of the array. The macroalgae Blue Fields Demonstration Project would not have any substantial effects on water quality (see Section 7.2.1).

The macroalgae platform array likely would on occasion aggregate pelagic fish, as some fish are naturally attracted to objects floating at the surface. Other aquaculture projects found schools of mackerel scad (ʻōpelu: *Decapterus macarellus*) to be occasionally attracted to the structures due to their FAD effect, but they did not take up permanent residence. Carnivorous pelagic fish, such as false albacore tuna (*kawakawa*: *Euthynnus alletteratus*), yellowfin tuna (*ahi*: *Thunnus alabacares*), and occasionally ono (wahoo: *Acanthocybium solandri*) and amberjack (*kahala*: *Seriola dumerili*) may also be attracted to the area by the baitfish, or by the structural presence of the macroalgae platform array. Since the array's structures are made of new inert materials, and since no anthropogenic feed sources (only natural DSW nutrients) are associated with the project's operation, it is unlikely that the macroalgae platform would serve as a sink. It is plausible that fish may recruit from the plankton onto the array, but this would not inhibit or interfere with normal reef recruitment in West Hawaiʻi. As such, the natural fish population balance of the nearby reefs would not be impacted by the presence and operation of the macroalgae platform array.

Benthic EFH for bottomfish management unit species (BMUS), coral reef ecosystem management species (CREMUS), and crustacean management unit species exists within the general area of the project site. The macroalgae platform array would not likely have any impacts on these areas. Deployment and retrieval of the macroalgae platform array would require transiting through areas with benthic EFH. Additionally harvest and maintenance operations would require support vessels to transit through areas with benthic EFH.

During deployment and retrieval operations, the applicant would transit through areas with designated BMUS, CREMUS, and crustacean management unit species benthic EFH. These operations would cross through areas with benthic EFH for only a few hours at a time and vessels would use existing channels to enter and exit harbors. If, on the rare occasion that a catastrophe occurred in which a support vessel sank or lost possession of macroalgae platform array components under tow, the Blue Fields Demonstration Project would potentially affect benthic EFH. Deployment and operating specifics for the project consider a high degree of risk management to mitigate any such occurrence. The array is composed largely of inert materials that, in the unlikely event of a catastrophic loss, would not threaten the benthic environment. In addition, Kampachi would carry small quantities of fuel and lubricants.

If any component of the macroalgae platform became detached from the mooring, the Blue Fields Demonstration Project would potentially affect benthic EFH. This would only occur if a detached component reached land, coral reefs or sank in areas containing benthic EFH. GPS units on the array would send a signal to the Kampachi staff if the macroalgae platform array were to drift outside the operating area. The applicant would make every effort to retrieve any detached array component before it made landfall, were it to travel shoreward. The actions that would be taken by the applicant in the event of any component of the array becoming detached from the mooring minimizes the potential for any impacts on EFH benthic habitat. The mooring concept is reliably used to moor ocean-going tankers, and as such minimizes risks for detachment. Therefore, the Blue Fields Demonstration Project is not likely to result in substantial adverse impacts on benthic EFH shoreward of the project site.

The Blue Fields Demonstration Project would not likely damage precious coral EFH. The nearest precious coral beds are located off Keāhole Point located about 6 nm north of the proposed project site. The Keāhole Point coral bed supports gold coral from 1,148-1,693 ft and pink coral from 1,076- 1,883 ft (Grigg 2002). There is no precious coral known from or likely to be occurring in the immediate Blue Fields Demonstration Project area. The applicant’s vessels would not transit over areas designated as precious corals EFH or HAPC during any project activity. It would be unlikely for any macroalgae platform array component to become detached from the mooring and drift 6 nm to the north before retrieval by the applicant.

The presence and operation of the macroalgae platform, therefore, would not increase impacts to EFH. As such, Kampachi does not anticipate the proposed Blue Fields Demonstration Project to substantially affect any EFH or HAPC at or near the project site.

Rare, Threatened or Endangered Species -

The following describes the potential effects that the Blue Fields Demonstration Project may have on seabirds, turtles, and marine mammals.

Sharks

The potential impacts to the oceanic whitetip shark would be the same as those described for non-threatened and endangered sharks. There is some limited evidence suggesting that sharks, such as the oceanic whitetip shark, could be vulnerable to impacts associated with entanglement. These instances are typically associated with smaller diameter fishing line, twine, or string and less frequently associated with heavier gauge line such as mooring ropes. Incidences of vessel collisions with sharks have predominately been with larger species and individuals like basking sharks and whale sharks.

Seabirds -

When fishing gear entangles animals, the animals may be injured or die (e.g. drown). The heavy lines the applicant proposes using to attach the macroalgae platform to the mooring would pose no entanglement risk to small animals, like seabirds. During the majority of the project, the macroalgae platform would remain submerged to a depth of 5-10m (15-33 ft) beyond the reach of most seabirds. When the macroalgae platform would be at the surface during construction, the presence of humans would likely discourage most seabird species from approaching the macroalgae platform. The macroalgae platform does not have hooked or barbed protrusions that could potentially ensnare a diving seabird.

The macroalgae platform array would not likely affect ESA-listed seabirds in any way. Staff saw no ESA-listed seabirds during operations for the former research projects (Sims 2014). The applicant would halt all activities in the presence of ESA-listed seabird species. The short-tailed albatross occasionally visits the MHI. This species cannot dive more than a few meters below the surface (USFWS 2008), and would not become entangled in the submerged macroalgae platform array. While the ESA-listed Newell's shearwater (threatened) and the Hawaiian petrel (endangered) do occur in the proposed project area, the presence of the macroalgae platform array would not present a significant entanglement risk to either of these species. The Newell's shearwater does have the ability to dive down to the submerged macroalgae platform. Because Newell's shearwater does not appear to frequent waters off the Kona Coast, NOAA Fisheries did not anticipate that the applicants former Velella Delta Array would harm this species through entanglements. Hawaiian petrels forage by seizing prey near the surface and do not have great diving capabilities (Simons 1983). The species also does not appear to be attracted to ships (Harrison 1987). This would suggest that the macroalgae platform array would not likely attract Hawaiian petrels, precluding any potential impacts to this species.

The applicant reported the presence of brown boobies (*Sula leucogaster*) visiting the former Velella Beta and Velella Gamma arrays (Sims 2014). Boobies commonly land on vessels and buoys. The applicant reported no injuries or mortalities to boobies during the previous Velella trials due to gear entanglements. Boobies are plunge divers that capture prey on the wing or by plunge diving a few meters below the surface (Shealer 2002). They would not likely reach the macroalgae platform during these dives.

Marine Mammals and Sea Turtles -
The applicant monitored marine mammal occurrence during the Velella Beta trial. They found no substantial difference between marine mammal densities near the array and those found during control surveys (Sims 2014). During the Velella Gamma trial, the applicant sighted marine mammals only eight times, all rough-toothed dolphins. Staff saw no monk seals or sea turtles during the previous trials (Sims 2014). There are several types of potential impacts to sea turtles, monk seals, and other marine mammals from the proposed action’s gear and operations.

These include:

- Entanglement in gear including mooring lines, bridles, and netting;
- Collisions with vessels including propellers;
- Impacts of fishing by others around the array;
- Impacts to critical habitat; and
- Impacts to behaviors, including habituation.

Components of the proposed research array (macroalgae growth platform and mooring) will be constructed with lines, which can pose an entanglement risk to marine mammals and sea turtles if not kept taught. The risk of entanglement depends on the material used for the array gear and the behavior of the animals.

Macroalgae Platform **-** The algal lines of the macroalgae platform would be strung across the 40m length of the platform, and kept taught by the current moving down the array. The tension on the algal lines would preclude entangling any large protected species.

Healthy monk seals are nimble swimmers and seem to possess excellent underwater vision under a wide range of light conditions, often foraging at depths of 1,600 ft (Parrish et al 2002). The monk seals are likely to see the macroalgae platform array either at the surface or when submerged and are likely able to avoid entanglement in the algal lines.

Cetacean entanglement in passive fishing gear is a well-documented problem (Reeves et al. 2013). However, there is evidence that noise and lighting help reduce the likelihood of entanglements (Carretta et al. 2008, Carretta and Barlow 2011). Cetaceans tend to actively echolocate in the presence of floating and submerged objects, avoiding direct contact with them. With lighting and some low-level sound (wave action on the buoys) coming from the macroalgae platform array, it is likely that cetaceans, especially odontocetes, would be aware of the presence of the array and avoid becoming entangled.

During the previous Velella trials, Kampachi did not report seeing any sea turtles. Sea turtles are deliberate swimmers, and the taught algal lines on the macroalgae platform would not likely present an entanglement risk for sea turtles.

MAS-Point Mooring - Kampachi does not expect the MAS-point mooring lines to entangle cetaceans, monk seals, or sea turtles because lines would be under constant tension and free of loops. When the currents change, the mooring lines are modelled to remain taut even as the currents shift because of the negative buoyancy of the upper 240m (788 ft) of chain and 110m (361 ft) of rope.

The mooring system at the proposed project site is similar to that used for FADs deployed by the State of Hawaiʻi. Over 25 years, the State has reported no entanglements with protected species with state FADs. Additionally, NMFS PIRO issued an ESA Section 7 opinion stating that similar State mooring systems would not likely adversely affect ESA-listed species (DLNR 2012). Ocean aquaculture facilities located in State waters and moored offshore of the Island of Hawaiʻi, have not reported any incidents of protected species entanglements in a combined 15 years of operation (HF, 2009; KBWF, 2009).

In conclusion, marine mammals and sea turtles are likely to detect the presence of the macroalgae platform array and would be able to avoid the gear. Kampachi has demonstrated that previous Velella trials did not attract marine mammals or sea turtles. The MAS mooring lines on the macroalgae platform array would be under constant tension and free of loops, also precluding entanglements. Therefore, the proposed macroalgae Blue Fields Demonstration Project is not likely to pose a substantial entanglement risk to cetaceans, monk seals, and sea turtles.

Collisions with Support Vessels - Ship strikes also have potential to kill or injure cetaceans including false killer whales. False killer whales in waters surrounding Hawaiʻi ride the bow or stern wake of vessels and may come into proximity of propellers (Oleson et al. 2010). A propeller strike from a small support vessel may cause disfigurement of the dorsal fin or other parts of the body without killing the whale (Wells et al. 2008); however, a strike could also seriously injure or kill smaller protected species (e.g. dolphins, monk seals, sea turtles). No documented ship-strike related injuries or deaths of false killer whales or humpback whales exist for Hawaiian waters. However, Baird (2009) reported a fresh head wound on one MHI insular DPS false killer whale photographed off Oahu in September 2009 that a propeller strike may have caused. Observations of monk seals with propeller wounds exist, and there have been reports of sea turtles killed or injured by propellers in waters around the State.

Collisions between cetaceans and vessels are relatively rare events based on data from Marine Mammal Stock Assessments for the Pacific (available from https://www.fisheries.noaa.gov/national/marine-mammal-protection/draft-marine-mammal-stock-assessment-reports). The majority of vessel operators usually sight protected species and avoid them. Detection of sea turtles by vessel operators may be more difficult, but NMFS in past biological opinions has determined that the rate of vessels collisions between sea turtles and vessels was negligible (NMFS 2008), and NMFS does not expect turtle vessel strikes to occur.

Vessels towing the macroalgae platform array and mooring materials to and from the project site and Honokōhau Harbor would not have to transit through the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS), thus avoiding the potential for encountering humpback whales in the sanctuary during transit. Routine daily activity would involve only two trips with a small research vessel (similar to a ~20ft Boston Whaler), and would not be notably different or more intense than typical maritime traffic already occurring in the area. The harbor is 3.5 nm south of the southern sanctuary boundary of the HIHWNMS for the Island of Hawaiʻi. Vessel strikes on sea turtles or marine mammals are not likely to occur, due to the slow speeds involved when towing the array equipment to and from the project site. The maximum speed of the macroalgae platform array under tow would be about 2 kts. NOAA's general guidance for vessels transiting areas where there are known populations of whales indicates that collisions between marine mammals and vessels are minimized when vessel's travel at less than 10 kts (HIHWNMS, 2011).

During weekly maintenance, the Kampachi staff navigating support vessels to the macroalgae platform array would remain vigilant during transits to avoid collisions with marine mammals and other protected species. Support vessels, either inflatable or small recreational craft, would have a maximum operating speed of 24 kts; however, in the open ocean conditions around the array, the support vessels for the project are likely to be operated at speeds of less than 15 kts (Sims 2013b), reducing the risk of collisions with marine wildlife. The support craft operator and other staff would watch for sea turtles and marine mammals, thus reducing the risk of collisions. If a collision between a support vessel and a protected species occurred, the vessel operator would file a report with NMFS. There were no support vessel-related interactions with protected species during previous Velella Beta, Gamma, (Sims 2014) or Delta trials. The macroalgae Blue Fields Demonstration Project would not substantially increase vessel traffic near the project site and therefore not increase the risk of vessel collision with marine mammals and sea turtles.

The following Best Management Practices, in accordance with ESA stipulations would be followed:

"BMPs required for activity types that may result in collision with vessels:
(a) Vessel operators shall alter course to remain at least 100 yards from whales, and at least 50 yards from other marine mammals and sea turtles.
(b) Vessel operators shall reduce vessel speed to 10 knots or less when piloting vessels in the proximity of marine mammals, and to 5 knots or less when piloting vessels in areas of known or suspected turtle activity.
(c) If approached by a marine mammal or turtle, the vessel operator shall put the engine in neutral and allow the animal to pass.
(d) Vessel operators shall not encircle or trap marine mammals or sea turtles between multiple vessels or between vessels and the shore."

7.2.3 Recreation

Kampachi does not anticipate the proposed Blue Fields Demonstration Project would have substantial negative impacts to the local fishing community and ocean users. The macroalgae platform array would likely act as a FAD, attracting baitfish and pelagic fishes like any other floating object in the open ocean. During the 2011-2012 Velella Beta trial, yellowfin tuna, mahimahi, and sharks aggregated under the cage. The towed array became popular with local fishermen. Sims and Key (2012) reported more than six recreational vessels around the towed array on Veterans' Day 2011. Recreational fishermen caught tuna and other pelagic species when fishing near the array. The applicant reported up to 30 vessels fishing near the Velella Gamma Array (Sims 2014) at a single time.

Based on previous experience, Kampachi staff expects that community fishermen (both recreational and commercial charter vessels) will fish around the macroalgae platform array. As in the previous trials, vessels are expected to remain a safe operating distance from the gear. The macroalgae platform array would not interfere with existing FADs. Locally, the F buoy has been replaced on March 29, 2018 and the VV Buoy was replaced in May 10, 2016. There are no other FADs within a 30-mile range of Honokōhau Harbor (the main fishing port on the Kona Coast). Permitting the macroalgae platform array would not grant Kampachi special rights, exclusive use from fishing vessel traffic, or special rights to any fish attracted to the array. The entire Blue Fields Demonstration Project area would remain open to vessel fishing activities. The Blue

Fields Demonstration Project would not affect commercial fishing communities described in Section 6.3. The location of the proposed macroalgae platform array would not likely affect recreational fishing activities or reduce catches. There were no instances of conflicts with local fishermen during the operation of the Velella Beta, Gamma, or Delta trials. Local fishermen were supportive of the presence of the arrays. Fishermen generally remained a safe distance from the arrays as trolling too close to the arrays could have resulted in the loss of expensive fishing lures and other gear.

With respect to safety and boat operations, the risk of gear entanglements or collisions with the submerged macroalgae platform array or mooring lines are not expected based on the fact that there were no such entanglements in the gear of past Velella trials, and the fact that fishing vessels do not normally become entangled or collide when fishing around other FADs. The USCG would note the array's position, as appropriate, through a USCG Notice to Mariners and the gear would be lit at night to prevent collisions at sea. For these reasons, Kampachi does not anticipate that Blue Fields Demonstration Project would substantially affect fishermen and other ocean users.

7.2.4 Noise and Air Quality

The macroalgae platform array will not contribute measurably to ambient noise levels. Boat engines used by Kampachi staff will generate some minor noise during the Blue Fields Demonstration Project maintenance operations, but this will be insignificant.

The support vessels would result in minimal emissions, and these emissions would not exceed the general level of vessel air emissions that occur in the area on a regular basis and would not individually or cumulatively result in degradation to air quality. Winds at sea are expected to disperse the small amount of emissions quickly. Based on the limited operation of the small outboard boat engines, distance from shore, and production of sound similar to ambient levels, the Blue Fields Demonstration Project activities are not likely to substantially impact ambient noise or air quality in the project area.

7.2.5 Aesthetics

Potential impacts on the regional area aesthetics (view-plane) from the project site include changes to what one can see from land, and what one may see from vessels at sea. One may see the flashing light that would be attached to the macroalgae platform array's mooring buoy (located above the center swivel of the array). A variety of vessels are visible in the Blue Fields Demonstration Project area both at day and at night. The macroalgae platform array would light three components of the array in accordance with required navigational lighting. These components would include the mooring buoy and the ends of the float bars on the macroalgae platform. The macroalgae platform array would be lit in compliance with applicable USCG lighting requirements. During general operations, the macroalgae platform array would remain submerged and generally not visible from shore. Considering the small size of the macroalgae platform array (10m x 40m) and the distance from shore, the array would be relatively insignificant in the vista and would not alter daytime views from shore. The support barge would be visible to other fishing vessels when they approach the array at sea both by day and by night. This view to fishing vessels would be similar to encountering other fishing vessels.

The navigational lights from the array would not be brighter than other fishing vessels in the project area. Kampachi proposes using for obstruction lights the SeaLite M650, which has a visible range of up to 3 nm. Because the array would not be closer than 1.5 nm from shore, Kampachi staff would not expect that the lights on the array would significantly change nighttime views from shore. Kampachi staff would remove the macroalgae platform array at the end of 3 years, so lighting impacts to the view-plane would be temporary. This would not significantly add to night-time lighting on the Kona Coast where the State has placed FADs. Fishermen and other vessels also frequent the area at night.

Based on the location and size of the macroalgae platform array and support barge, on current fishing vessel activity, and on the proposed lighting, the Blue Fields Demonstration Project should not substantially impact the regional area aesthetics (view-plane).

7.2.6 Cultural Practices and Traditional Resources

The proposed Blue Fields Demonstration Project site is too deep for free-diving, and for any significant SCUBA diving activity. There are no significant benthic plant or animal populations, and there are virtually no benthic or pelagic fishing activities in this depth range. Kona crab (*Ranina ranina*) and nabeta (*Iniistius pavo*) are the only benthic resources that occur on sand bottom near this depth. However, it is unlikely Kona crab will be present at the site location, as there needs to be contiguous sandy habitat from 20 fathoms to 60 fathoms (the proposed site region has non-contiguous sand across this depth range, therefore, it is unlikely Kona crab will exist at the proposed site depth of 60-70 fathoms). Based on fishing community consultation, no one crabs for Kona crab in the proposed area. Nabeta should exist in the proposed area, but fishermen report larger and more suitable fishing grounds for this species both several miles north and south of the site. Thus, the proposed Blue Fields Demonstration Project site is not a significant fishing area for nabeta.

The only potentially-impacted cultural resource that was cited during extensive discussions with community and kupuna groups was the koʻa ʻōpelu (ʻholes' or schooling places for mackerel scad – *Decapterus macarellus*) that occur in the general region. The locations of these koʻa are considered to be part of the traditional marine lore, and are considered inappropriate for publication, or for sharing outside of the families or community groups who have traditionally fished these koʻa. An important aspect of the koʻa ʻōpelu tradition is the maintenance of these koʻa by feeding of the school. To keep fish attracted to a koʻa, a fisherman will regularly drop bags of palu - grated vegetable matter - to the school (daily, or every second day). The knowledge of the names and locations of the koʻa is considered of historical significance, and is a tradition that the kupuna would like to see preserved and passed on to future generations.

ʻŌpelu aggregations usually occur in water around 120 ft deep, close to reef drop-offs, and the cultural contacts for the preparation of this assessment indicated that the koʻa ʻōpelu in this area occurs in the "same general direction" to Keahuolū ahupuaʻa from the proposed Blue Fields Demonstration Project site, "but closer towards shore." The koʻa ʻōpelu along the QLT coastline is currently fished by commercial and recreational/artisanal fishermen. A local ʻōpelu fisherman of multigenerational fishing experience over the proposed Blue Fields Demonstration Project site region was consulted in preparation of this environmental assessment, who indicated that they did not anticipate any impact to the location of the koʻa ʻōpelu in the shoreward direction, but that if the proposed site were to be moved closer to shore, they would have concern of potential impact. Additionally, our cultural consultation process did not return any accounts of cultural significance occurring over the proposed Blue Fields Demonstration Project site.

7.2.7 Land Use and Environmental Compatibility

Current Usage -

Local commercial and recreational fisherpeople and fishing charter boat operators were consulted in determining the final proposed siting location. The proposed site presently offers no special environmental or public benefit to the community, beyond the relatively rare instance of use by recreational boats. The site is clear of the heavily-used direct line of transit from Honokōhau Harbor to a well-known FAD to the South ("F Buoy"), and well outside of the 40 fathom isobar trolled for ono (*Acanthocybium solandri*). The boating-accessible area between Kaiwi Point and Kailua Bay was described as an area of little fishing interest outside of the ko'a 'ōpelu described in 6.6. The proposed project site is also clear of the charted cruise ship channel where passenger ships transit and anchor.

It is a primary concern to the fishing stakeholder groups that were consulted (as well as to Kampachi Farms) that the array be well marked and lit because of the high recreational watercraft use of Kailua Bay. The Coast Guard is responsible for setting standards of navigational markings, and Kampachi Farms is currently in contact with the Coast Guard to complete their Private Aid to Navigation (PATON) process through the Coast Guard District 14 Waterways office.

Local fisherpeople support allowing boating and fishing from vessels within the project area. Kampachi Farms is not seeking exclusivity (open to fishing, but no snorkeling or diving will be permitted for safety), and prefers to keep the area open to the passage of recreational fisherpeople within safe modes of operation and distances from the surface structures. The Coast Guard consultation process will determine the marking of the area and potential for passage of boat traffic within the watch circle.

Submerged Lands Issues and the Public Trust -

The proposed Blue Fields Demonstration Project site constitutes part of the ceded lands trust, since all submerged lands are ceded lands. The 1999 amendments to the Ocean and Submerged Lands Leasing law (Chapter 190D HRS) directly addressed the issue of Office of Hawaiian Affairs' share of the lease revenues, by stipulating that the designated 20% of lease payments should be due to OHA. As the proposed project is research, and not for-profit, the applicant would ask that the lease fees be waived.

The public trust is also supported through this project, and the public interest is upheld and enhanced, by two unique aspects of the proposed project: commercial scale macroalgae development and greater private and public research funding. This project offers strong potential for environmental and economic benefits. By establishing the economic incentive of commercial culture of macroalgae species, the project increases the profile and the potential funding for research and development into large-scale growout methods for these high-value species.

The proposed demonstration will validate technologies that could be later used at a commercial scale. The successful application of wave-powered pumping technology to provide deeper water nutrients to the array (and for the algae to successfully grow on the very low concentrations of nutrients in the offshore environment) is the key component that will be validated through the demonstration.

Successful demonstration of offshore macroalgae growth using the proposed system could also result in greater research funds – both public and private – for commercializing this technology. More offshore culture of macroalgae might then become established in the islands, which will provide the infrastructure and the technology to initiate large-scale efforts towards the production of renewable biofuel energy.

7.2.8 Cumulative Impacts

Cumulative effects result from the incremental impacts of the proposed Blue Fields Demonstration Project in addition to past, present, and reasonably foreseeable future actions. The proposed action is a small-scale Blue Fields Demonstration Project that would have minimal impacts to air or water quality, noise, marine species, the ecosystem, or other uses in the area.

One other aquaculture farm operates in State waters, but is located at approximately 4.5 nm from the proposed Blue Fields Demonstration Project site. The three prior culture and harvest projects permitted by NMFS, (Velella Beta, Gamma, and Delta) are complete and do not set a precedent for the proposed project. The previous Velella projects' potential effects that may also occur under the proposed project include impacts associated with mooring FAD effects and chain impacts on the ocean bottom.

The macroalgae platform array is not likely to change past and current fishing gear type use at the Blue Fields Demonstration Project site. The MHI Longline Fishing Prohibited Area excludes the Hawaiʻi longline fisheries from the proposed project area. Current fisheries in the proposed project area include pelagic troll, palu-ahi, and ika-shibi. Fish and fishermen already use the F Buoy and the VV Buoy in the general vicinity of the proposed project site as FADs. It is unlikely that changes in fishing effort at the project site would occur that would result in increased fishing mortality or affect fish landings in Hawaiʻi.

In summary, the proposed macroalgae Blue Fields Demonstration Project is not expected to result in large adverse effects on marine resources individually or in combination with other actions that are ongoing or reasonably foreseeable.

7.2.9 Irreversible and Irretrievable Commitment of Resources

The proposed Blue Fields Demonstration Project requires the commitment of a three-year lease of submerged lands, the water column, and the surface for the establishment of the macroalgae Blue Fields Demonstration Project. This is neither irreversible nor irretrievable. Chapter 190 D HRS, as amended, specifically addresses the requirement for any lessee vacating an ocean lease to remove all equipment and to restore the site to its original condition. Kampachi Farms would expect such conditions to also be imposed upon any lease that would be granted for any other aquaculture lease in Hawaiian State waters.

As such, issuance of the required permits associated with this macroalgae Blue Fields Demonstration Project would not result in the irretrievable or irreversible loss of resources. As described above, the potential environmental effects of the macroalgae Blue Fields

Demonstration Project activities would have limited and temporary effects because of gear and program designs, and best management practices designed into the project. All potential impacts on the benthos or water quality will be temporary, and reversible. In areas of soft sediments and strong currents, such as are found in the proposed project area, the habitat could be expected to recover very rapidly from any perturbation that might occur due to anchor placement.

A decision to issue the associated permits would not automatically result in the approval of future projects. Future permit applications, if any, would be subject to independent environmental evaluation, coordination with others, and compliance with all applicable laws, including NEPA.

7.2.10 Summary of Operating Constraints

Operating constraints discussed in the above sections are summarized in Table 7-1.

Table 7-1: Summary of Operating Constraints

TOPIC	ISSUE OR IMPACT	OPERATING CONSTRAINT OR MITIGATING CIRCUMSTANCE
Water Quality	Change in water quality surrounding the project.	DSW accumulators receive, diffuse, and distribute the DSW from the passive, wave driven pump across the algal growth platform. The piping reticulation design for nutrient distribution has been optimized for maximum efficiency of nutrient dispersal. The nutrient pulse of the wave and current driven pump was designed to optimize biomass production and nutrient uptake, while minimizing nutrient loss to the surrounding waters. Water quality is high in the project area. The nitrogen (nitrate + nitrite) concentrations of the DSW from the 300-meter depth are estimated to be approximately 12 µmol/kg, compared to estimated nitrogen (nitrate + nitrite) concentrations of SSW to be approximately 0.5 µmol/kg. The concentration of water at the proposed location will not exceed 1% DSW to 99% surrounding waters (surface sea water; SSW). Growth of *limu* uptakes carbon from the surrounding SSW and would locally mitigate ocean acidification, thus improving water quality.
Terrestrial Flora / Fauna	There are no terrestrial flora or marine macroflora in the proposed Blue Fields	None. No significant bird use of the area.

Table 7-1: Summary of Operating Constraints

	Demonstration Project area. The project area is not considered important for birdlife. No significant impacts on terrestrial flora or fauna.	
Marine Biota	Negligible short-term impacts on benthic community.	None. Depauperate benthic community on deep sand substrates.
	There may be an increase in the amount of marine fauna (via settlement) on the mooring lines. Fouling on mooring lines would probably include macroalgae, bivalves, corals, sea urchins, nudibranchs, and sponges.	None. This recruitment will not result in any measurable decrease in recruitment to the reef areas around Kailua-Kona.
	Attraction of reef fish or pelagic fishes (including sharks) to the platform array due to aggregation (FAD) tendencies.	None. It is not anticipated that reef fish would abandon their typical reef habitats to take up residence on such an exotic structure located off shore which wouldn't offer adequate food resources or nocturnal shelter. Reef fish are also unlikely to move extensively over open water. It is likely that pelagic fish will aggregate around the demonstration, but not cause any significant impact on overall fishing pressure to those species. None. Sharks may be aggregated to the structures, but the number of sharks in the overall area will not increase.
	If any component of the macroalgae platform became detached from the mooring, the Blue Fields Demonstration Project would potentially affect benthic EFH.	There is no precious coral known from or likely to be occurring in the immediate Blue Fields Demonstration Project area. GPS units on array would send a signal to the Kampachi staff if the macroalgae platform array were to drift outside the operating area. The mooring concept is reliably used to moor ocean-going tankers, and as such minimizes risks for detachment.

Table 7-1: Summary of Operating Constraints

Rare, Threatened or Endangered Species	Interaction with ESA-listed seabirds in the area.	Staff saw no ESA-listed seabirds during operations for the former research projects. The applicant would halt all activities in the presence of ESA-listed seabird species.
	Components of the macroalgae platform array may pose an entanglement risk to or obstruct movement in the area for the oceanic whitetip shark, marine mammals, and sea turtles.	None. Taut line moorings, and algal growth lines held taught by the current will eliminate risk of entanglement. The macroalgae platform array and moorings will not present an obstruction to movements.
	Potential for ship strike by vessels towing the macroalgae platform array and mooring materials to and from the project site.	The maximum speed of the macroalgae platform array under tow would be about 2 kts. Vessel strikes on sea turtles or marine mammals are not likely to occur. Support craft operators and other staff would watch for sea turtles and marine mammals thus reducing the risk of collisions.
Recreation	The macroalgae platform array would likely act as a FAD, and community fishermen (both recreational and commercial charter vessels) will fish around the macroalgae platform array.	None. The entire Blue Fields Demonstration Project area would remain open to all ocean activities.
Noise and Air Quality	The macroalgae platform array construction and operation will not contribute measurably to ambient noise levels or air quality emissions.	None.
Aesthetics	The flashing light that would be attached to the macroalgae platform array's mooring buoy for the support barge may be visible from shore.	None. During general operations, the macroalgae platform array would remain submerged and generally not visible from shore. The navigational lights from the array would not be brighter than other fishing vessels in the project area.

Table 7-1: Summary of Operating Constraints

Cultural Practices and Traditional Resources	Activities would inhibit or restrict Kona crab (*Ranina ranina*) and nabeta (*Iniistius pavo*) fishing.	None. There are virtually no benthic or pelagic fishing activities in this depth range, as the project site is too deep for free-diving, and for any significant SCUBA diving activity.
	Potential impact on traditional ʻōpelu koʻa due to a potential to draw fish away from koʻas.	None. A local ʻōpelu fisherman of multigenerational fishing experience over the proposed Blue Fields Demonstration Project site region was consulted in preparation of this environmental assessment, who indicated that they did not anticipate any impact to the location of the koʻa ʻōpelu in the shoreward direction.
Land Use Compatibility and Environmental Justice	Impacts from restricted use of Blue Fields Demonstration Project.	None. Local commercial and recreational fisherpeople and fishing charter boat operators were consulted in determining the final proposed siting location. The entire Blue Fields Pilot Project area would remain open to fishing activities.
	Community or cultural groups or individuals may object to ceded lands being used for private projects.	The amended 190 D HRS directly addresses the issue of revenue sharing with the Office of Hawaiian Affairs. In this case, the applicant seeks to have the fees waived, since the project is for research purposes only, and not for-profit. The public trust is supported through this project, and the public interest is upheld and enhanced, by two unique aspects of the proposed project: the potential for future commercial macroalgae development and greater private and public research funding.
	There is a constitutional requirement for legislative oversight of any disposition of the public lands trust.	The amended 190 D HRS addresses this issue by requiring an annual report to the legislature by the implementing agency (Aquaculture Development Program, in DOA).
Cumulative	None.	N/A

REFERENCES

Abbott, I.A. 1978. The uses of seaweed as food in Hawai‘i. *Econ. Bot. 32:* 409–412.

Abbott 1996. *Limu: An ethnobotanical study of some Hawaiian Seaweed*, 4th edition. Pacific Tropical Botanical Garden, Lawai. pp. 39.

Abbott, I.A. 1999. *Marine red algae of the Hawaiian Islands*. Bishop Museum Press, Honolulu, Hawai‘i. pp. 477.

Abbott, I.A. and J.M. Huisman. 2004. *Marine green and brown algae of the Hawaiian Islands*. Bishop Museum Press, Honolulu. pp. 259.

Baird, R.W. 2002. False killer whale *Pseudorca crassidens*. *In* Encyclopedia of Marine Mammals (W.F. Perrin, B. Würsig, and J.G.M. Thewissen, Eds.), Pp. 411-412. Academic Press, San Diego.

Baird, R.W. 2009. A review of false killer whales in Hawaiian waters: biology, status, and risk factors. Report prepared for the U.S. Marine Mammal Commission, Order No. E40475499. Available at: [http://www.cascadiaresearch.org/hawaii/HawaiifalsekillerwhalereviewMMC2009.pdf]

Bast, F. 2014. An Illustrated Review on Cultivation and Life History of Agronomically Important Seaplants. *In Seaweed: Mineral Composition, Nutritional and Antioxidant Benefits and Agricultural Uses, Eds Vitor Hugo Pomin, 39-70.*

Bonin, D.R., Hawkes, M. 1987. Systematics and life histories of New Zealand Bonnemaisoniaceae (Bonnemaisoniales, Rhodophyta): I. The genus Asparagopsis, *New Zealand Journal of Botany*, 25:4, 577-590. DOI: 10.1080/0028825X.1987.10410088

Chapman, V.J., Chapman, D.J. 1980. *Seaweeds and their uses.* Accessed 29 Jan 2019 https://books.google.com/books?id=4WQyBwAAQBAJ&pg=PT93&lpg=PT93&dq=limu+fuafua&source=bl&ots=m3saJhqKsx&sig=ACfU3U24XhodFHCYQB-p9TsmvCfJY1Ezew&hl=en&sa=X&ved=2ahUKEwi5q4KIlZTgAhWNHjQIHTNeCOIQ6AEwBHoECAAQAQ#v=onepage&q=limu%20fuafua&f=false

De Leo, F.C., J.C. Drazen, E.W. Vetter, A.A. Rowden and C. R. Smith. 2012. The effects of submarine canyons and the oxygen minimum zone on deep-sea fish assemblages off Hawai’i. Deep-Sea Res. I. 64:54-70.

De Leo, F.C., E.W. Vetter, C.R. Smith, A.A. Rowden and M. McGranaghan. 2013. Spatial scale-dependent habitat heterogeneity influences submarine canyon macrofaunal abundance and diversity off the Main and Northwest Hawaiian Islands. Deep-Sea Res. II, 104:267-290. Available at: [http://dx.doi.org/10.1016/j.dsr2.2013.06.015]

Duce, R.A., J. LaRoche, K. Altieri, K.R. Arrigo, A.R. Baker, D.G. Capone, S. Cornell, F. Dentener, J. Galloway, R.S. Ganeshram, R.J. Geider, T. Jickells, M.M. Kuypers, R. Langlois, P.S. Liss, S.M. Liu, J.J. Middelburg, C.M. Moore, S. Nickovic, A. Oschlies, T. Pedersen, J. Prospero, R. Schlitzer, S. Seitzinger, L.L. Sorensen, M. Uematsu, O. Ulloa, M. Voss, B. Ward and L. Zamora. 2008. Impacts of Atmospheric Anthropogenic Nitrogen on the Open Ocean. Science, 320:893-897.

Gentry, Rebecca & Froehlich, Halley & Grimm, Dietmar & Kareiva, Peter & Parke, Michael & Rust, Michael & Gaines, Steven & Halpern, Benjamin. (2017). Mapping the global potential for marine aquaculture. Nature Ecology & Evolution. 1. 10.1038/s41559-017-0257-9.

Hawaiʻi Department of Agriculture. 2017. Aquaculture in Hawaiʻi, 2011 statistics. hdoa.hawaii.gov

Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS). 2011. Maps, Charts, and GIS Data.

Howard, K. G., J. T. Claisse, T. B. Clark, K. Boyle, and J. D. Parrish. 2013. Home range and movement patterns of the Redlip Parrotfish (*Scarus rubroviolaceus*) in Hawaiʻi. Marine Biology. 160:1583–1595.

Jia, Y., P. H.R. Calil, E.P. Chassignet, E J. Metzger, J.T. Potemra, K.J. Richards, and A.J. Wallcraft. 2011. Generation of mesoscale eddies in the lee of the Hawaiian Islands. J. of Geophys. Res. 16:C1109, 18 pp. Available at: DOI: 10.1029/2011JC007305.

Market Research Report: Commercial Seaweed Market Analysis By Product (Brown Seaweed, Red Seaweed, Green Seaweed), By Form (Liquid, Powdered, Flakes), By Application (Agriculture, Animal Feed, Human Consumption) And Segment Forecasts To 2024. August 2016. Grand View Research. www.grandviewresearch.com/

McDermid, K.J., and Stuercke, B. 2003. Nutritional composition of edible Hawaiian seaweeds. Journal of Applied Phycology. 15: 513-524.

Meyer, C. G., and K. N. Holland. 2005. Movement patterns, home range size and habitat utilization of the bluespine unicornfish, *Naso unicornis* (Acanthuridae) in a Hawaiian marine reserve. Environmental Biology of Fishes. 73:201–210.

Meyer, C. G., Y. P. Papastamatiou, and T. B. Clark. 2010. Differential movement patterns and site fidelity among trophic groups of reef fishes in a Hawaiian marine protected area. Marine Biology. 57:1499–1511.

NMFS. 2014a. Hawaiian Monk Seal (*Monachus schauinslandi*) Stock Assessment Report (2013). 7 pp. Available at: [http://www.fisheries.noaa.gov/pr/sars/species.htm]. Accessed on April 3, 2015.

NMFS. 2018. Oceanic Whitetip Shark (*Carcharhinus longimanus*). Available at: [https://www.fisheries.noaa.gov/species/oceanic-whitetip-shark]. Accessed on March 4, 2019.

Price, C.S. and J.A. Morris, Jr. 2013. Marine Cage Culture and the Environment: Twenty-first Century Science Informing a Sustainable Industry. NOAA-TM-NOS –NCCOS-164. 158 pp.

Seki, M.P., R. Lumpkin, and P. Flament. 2002. Hawai‘i cyclonic eddies and blue marlin catches: the case study of the 1995 Hawaiian International Billfish Tournament. J. Oceanography. 58: 739-745.

Sims, N. and G. Key. 2012. Fish without footprints – beta-test of the first unanchored fish pen and the first marine fish culture in U.S. Federal waters. Final Report for Illinois Soybean Association, International Copper Association, Ocean Farms Technologies, and NOAA. 21 pp.

Sims, N. 2014. Culture and Harvest of a Managed Coral Reef Fish Species (*Seriola rivoliana*) Using a Fixed Mooring and Rigid Mesh Submergible Net Pen in Federal Waters West of the Island of Hawai‘i. Kampachi Farms. Application Project Description. Kampachi Farms, LLC. Kona, Hawai‘i. 29 pp. (Available on request from NMFS PIRO, Honolulu, Hawai‘i).

Skelton, P. A. 2003. Marine plants of American Samoa. Department of Marine and Wildlife Resources, Government of American Samoa. Accessed 29 Jan 2019 http://www.botany.hawaii.edu/basch/uhnpscesu/pdfs/sam/Skelton2003SeaweedsAS.pdf

Smith, J.S. and C.R. Johnson. 1995. Nutrient inputs from seabirds and humans on a populated coral cay. Mar. Ecol. Prog. Ser. 124:189-200.

Tacon, A.G.J., Hasan, M.R., and Metian, M. 2011. Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects. Food and Agriculture Organization of the United Nations. Fisheries and Aquaculture Technical Paper 564. Page 87

Ulloa, O., Canfield, D.E., DeLong, E.F., Letelier, R.M., Stewart, F.J. (2012). Microbial oceanography of anoxic oxygen minimum zones. Proceedings of the National Academy of Sciences of the United States of America. Vol. 109 No. 140 P. 15996-16003.

USFWS (United States Fish and Wildlife Service) and T. Telfer. 1983. The Hawaiian Dark-Rumped Petrel and Newell’s Manx Shearwater Recovery Plan. FWS-1-1196-4. Honolulu, Hawai‘i. 57 pp.

USFWS. 2008. Short-tailed Albatross Recovery Plan. Anchorage, Alaska, 105 pp. Available at: https://www.fws.gov/oregonfwo/documents/RecoveryPlans/ShortTailed_Albatross_RP.pdf.

Vetter, E.W., C.R. Smith and F.C. De Leo. 2010. Hawaiian hotspots: enhanced megafaunal abundance and diversity in submarine canyons on the oceanic islands of Hawai‘i. Mar. Ecol., 31:187-199. Available at: [doi:10.1111/j.1439-0485.2009.00351.x]

Villareal, T.A., S. Woods, J.K. Moore and K. Culver-Rymsza. 1996. Vertical migration of *Rhizosolenia* mats in the North Pacific gyre. J. Plank. Res. 18(7):1103-1121.

Woodworth, P.A., G.S. Schorr, R.W. Baird, D. L. Webster, D.J. McSweeney, M.B. Hanson, R. D. Andrews, and J.J. Polovina. 2011. Eddies as offshore foraging grounds for melon-headed whales. Marine Mammal Science, 28(3):638-647 Available at: DOI: 10.1111/j.1748-7692.2011.00509.x

WPFMC (Western Pacific Fishery Management Council). 2001. Coral Reef Ecosystem Fishery Management Plan. WPFMC, Honolulu, HI. Available at [http://www.wpcouncil.org/hot/].

WPFMC. 2009a. Final Programmatic Environmental Impact Statement, Toward an Ecosystem Approach for the Western Pacific Region: From Species-Based Fishery Management Plans to Place-Based Fishery Ecosystem Plans. NOAA, NMFS, PIRO and WPFMC, Honolulu, HI. 461 pp.+App. Available at [http://www.wpcouncil.org/hot/].

WPFMC. 2009b. Fishery Ecosystem Plan for the Hawai‘i Archipelago. WPFMC, Honolulu, HI. 266 pp. Available at [http://www.wpcouncil.org/hot/].

WPFMC. 2009c. Fishery Ecosystem Plan for the Pacific Pelagic Fisheries of the Western Pacific Region. WPFMC, Honolulu, HI. Available at [http://www.wpcouncil.org/hot/].

WPFMC. 2014. Pelagic Fisheries of the Western Pacific Region - 2012 Annual Report. 292 pp. Available at: [http://www.wpcouncil.org/managed-fishery-ecosystems/pacificpelagic/data-collection-and-annual-reports-pelagics/]. Accessed on April 3, 2015.

APPENDIX 1 (a)

NELHA Water Monitoring Station 5; Transect 6

2018 - NELHA Annual Report
for the
Comprehensive Environmental Monitoring Program

NELHA Water Quality Laboratory

Transect 6, Station 5

7/26/1993 - 5/24/2018

SITE ID	DATE	TIME	PO_4^{3-}		NO_3^- & NO_2^-		NH_4^+ & NH_3		Si		TDP		TDN		Turbidity	Salinity	Temp.	pH	DO	Chl a
	M/D/Y	(2400)	(µM)	(µg P/L)	(µM)	(µg N/L)	(µM)	(µg N/L)	(µM)	(µg Si/L)	(µM)	(µg P/L)	(µM)	(µg N/L)	(NTU)	(o/oo)	(˚C)		(ppm)	(µg/L)
DOH LIMIT				**5**		**4.5**		**2.5**				**12.5**		**100**	**0.10**					**0.30**
O6-5S-69m	7/26/93	1119	0.08	2.5	0.14	2.0	0.39	5.5	2.1	60					0.08	34.431	26.9			
O6-5S-69m	12/6/93	907	0.06	1.9	0.51	7.1	0.06	0.8	3.9	109					0.08	34.772	25.7			
O6-5S-69m	3/7/94	840	0.22	6.8	0.84	11.8	0.18	2.5	10.6	298					0.08	33.989	24.9			
O6-5S-69m	6/15/94	853	0.20	6.2	0.21	2.9	0.12	1.7	4.1	116					0.10	34.476	25.6			
Geomean	**'93-'94**			**3.7**		***4.7***		**2.1**							**0.08**					
O6-5S-69m	9/9/94	842	0.07	2.2	0.03	0.4	0.04	0.6	2.6	72					0.09	34.598	27.6			
O6-5S-69m	11/14/94	755	0.15	4.6	0.61	8.5	0.55	7.7	8.3	232					0.09	34.473	26.0			
O6-5S-69m	3/22/95	814	0.17	5.3	0.24	3.4	0.34	4.8	4.8	135					0.11	34.152	25.0			
O6-5S-69m	6/20/95	815	0.14	4.3	0.40	5.6	0.09	1.3	5.4	151					0.06	34.342	26.2			
Geomean	**'94-'95**			**3.9**		**2.9**		**2.3**							**0.09**					
O6-5S-69m	9/26/95	1002	0.12	3.7	0.40	5.6	0.47	6.6	9.6	269					0.11	34.363	27.0			
O6-5S-69m	11/14/95	1054	0.12	3.7	0.37	5.2	0.60	8.4	5.3	148					0.12	34.233	26.8			
O6-5S-69m	3/12/96	1115	0.18	5.6	0.21	2.9	0.58	8.1	4.0	113					0.06	34.129	25.5			
O6-5S-69m	5/14/96	1113	0.09	2.8	0.02	0.3	0.11	1.5	2.3	65					0.05	34.317	27.5			
Geomean	**'95-'96**			**3.8**		**2.2**		***5.1***							**0.08**					
O6-5S-69m	7/31/96	1148	0.14	4.3	1.83	25.6	0.55	7.7	24.9	698					0.12	33.672	27.7			
O6-5S-69m	10/2/96	1115	0.09	2.8	0.72	10.1	0.50	7.0	11.1	313					0.15	34.317	28.4			
O6-5S-69m	1/7/97	1120	0.09	2.8	0.55	7.7	0.25	3.5	7.5	210					0.11	34.547	25.6			
O6-5S-69m	4/28/97	1136	0.17	5.3	0.59	8.3	0.55	7.7	8.8	248					0.09	34.222	26.6			
Geomean	**'96-'97**			**3.6**		***11.3***		***6.2***							***0.12***					
O6-5S-69m	8/19/97	1117	0.12	3.7	0.63	8.8	0.24	3.4	11.0	308					0.11	34.358	27.0			
O6-5S-69m	10/7/97	1016	0.10	3.1	0.11	1.5	0.37	5.2	4.4	125					0.13	34.709	27.6			
O6-5S-69m	3/4/98	1149	0.10	3.1	0.47	6.6	0.24	3.4	8.0	226					0.14	34.849	25.2			
O6-5S-69m	5/5/98	1141	0.14	4.3	1.47	20.6	0.31	4.3	16.6	466					0.08	34.647	24.5			
Geomean	**'97-'98**			**3.5**		***6.6***		***4.0***							***0.11***					
O6-5S-69m	7/7/98	1154	0.14	4.3	1.00	14.0	0.07	1.0	13.8	388					0.12	34.664	26.2			
O6-5S-69m	10/6/98	1106	0.13	4.0	0.02	0.3	0.13	1.8	13.6	381					0.09	34.838	27.3			
O6-5S-69m	1/19/99	1148	0.09	2.8	0.67	9.4	0.08	1.1	10.2	285					0.13	34.894	25.0			
O6-5S-69m	4/12/99	1145	0.12	3.7	0.20	2.8	0.14	2.0	6.1	172					0.09	34.614	24.2			
Geomean	**'98-'99**			**3.7**		**3.2**		**1.4**							***0.11***					
O6-5S-69m	7/6/99	1213	0.09	2.8	0.26	3.6	0.08	1.1	5.0	139					0.08	34.854	25.8			
O6-5S-69m	10/4/99	1234	0.10	3.1	0.28	3.9	0.06	0.8	4.1	115					0.11	34.921	26.4			
O6-5S-69m	1/12/00	1140	0.14	4.3	0.96	13.4	0.40	5.6	13.9	389					0.07	34.680	24.9			
O6-5S-69m	4/11/00	1042	0.10	3.1	0.22	3.1	0.06	0.8	6.5	184					0.07	34.726	24.6			
Geomean	**'99-'00**			**3.3**		***4.9***		**1.5**							**0.08**					
O6-5S-69m	7/25/00	1205	0.10	3.1	0.17	2.4	0.05	0.7	5.0	140					0.07	34.789	26.7			
O6-5S-69m	10/31/00	1148	0.12	3.7	0.54	7.6	0.30	4.2	12.9	362					0.12	34.701	27.0			
O6-5S-69m	3/6/01	1134	0.15	4.6	0.18	2.5	0.10	1.4	4.2	117					0.07	34.684	24.8			
O6-5S-69m	5/7/01	1236	0.20	6.2	1.94	27.2	0.35	4.9	30.1	845					0.09	34.257	24.8			
Geomean	**'00-'01**			**4.3**		***5.9***		**2.1**							**0.09**					
O6-5S-69m	8/14/01	1038	0.12	3.7	0.10	1.4	0.25	3.5	3.0	85					0.14	34.852	26.8			
O6-5S-69m	10/30/01	1050	0.14	4.3	0.70	9.8	0.03	0.4	8.1	227					0.08	34.801	26.8			
O6-5S-69m	3/6/02	1057	0.21	6.5	3.43	48.0	0.08	1.1	17.1	480					0.13	34.231	24.3			
O6-5S-69m	4/15/02	1111	0.16	5.0	2.64	37.0	0.04	0.6	18.8	529					0.08	34.516	25.6			
Geomean	**'01-'02**			**4.8**		***12.5***		**1.0**							***0.10***					

NELHA Water Quality Laboratory
Transect 6, Station 5
7/26/1993 - 5/24/2018

SITE ID	DATE	TIME	PO_4^{3-}		NO_3^- & NO_2^-		NH_4^+ & NH_3		Si		TDP		TDN		Turbidity	Salinity	Temp.	pH	DO	Chl a
	M/D/Y	(2400)	(µM)	(µg P/L)	(µM)	(µg N/L)	(µM)	(µg N/L)	(µM)	(µg Si/L)	(µM)	(µg P/L)	(µM)	(µg N/L)	(NTU)	(o/oo)	(˚C)		(ppm)	(µg/L)
DOH LIMIT				**5**		**4.5**		**2.5**				**12.5**		**100**	**0.10**					**0.30**
O6-5S-69m	7/10/02	1101	0.06	1.9	1.74	24.4	0.20	2.8	12.2	342					0.07	34.379	26.2			
O6-5S-69m	10/8/02	1056	0.10	3.1	1.01	14.1	0.09	1.3	6.9	194					0.11	34.774	27.0			
O6-5S-69m	3/12/03	953	0.14	4.3	0.84	11.8	0.03	0.4	10.6	298					0.09	34.480	25.0			
O6-5S-69m	4/23/03	1105	0.14	4.3	1.40	19.6	0.03	0.4	13.9	391					0.10	34.578	24.9			
Geomean	**'02-'03**			**3.2**		***16.8***		**0.9**							**0.09**					
O6-5S-69m	8/21/03	1030	0.09	2.8	0.04	0.6	0.10	1.4	4.3	122					0.07	34.748	28.3			
O6-5S-69m	11/3/03	1000	0.10	3.1	0.01	0.1	0.14	2.0	2.5	71					0.08	34.651	26.8			
O6-5S-69m	3/18/04	1027	0.19	5.9	1.82	25.5	0.37	5.2	17.3	485					n/a	34.859	25.8			
O6-5S-69m	5/24/04	1043	0.15	4.6	0.42	5.9	0.23	3.2	5.8	163					n/a	33.31	26.8			
Geomean	**'03-'04**			**3.9**		**1.9**		***2.6***							**0.07**					
O6-5S-69m	9/22/04	1119	0.07	2.2	0.07	1.0	0.31	4.3	5.1	144					0.05	33.69	27.7			
O6-5S-69m	11/29/04	1026	0.09	2.8	0.34	4.8	0.17	2.4	4.6	129					0.05	33.63	27.0			
O6-5S-69m	1/24/05	1102	0.05	1.5	0.01	0.1	0.16	2.2	2.4	67					0.08	34.834	25.7			
O6-5S-69m	4/13/05	1108	0.14	4.3	0.34	4.8	0.16	2.2	8.6	242					0.07	34.333	25.0			
Geomean	**'04-'05**			**2.5**		**1.3**		***2.7***							**0.06**					
O6-5S-69m	7/21/05	1041	0.06	1.9	0.26	3.6	0.39	5.5	6.0	169					0.08	34.364	27.4			
O6-5S-69m	10/13/05	1015	0.06	1.9	0.14	2.0	0.20	2.8	3.6	101					0.11	34.817	27.5			
O6-5S-69m	3/15/06	939	0.12	3.7	0.64	9.0	0.40	5.6	8.6	242					0.09	34.659	24.5			
O6-5S-69m	5/17/06	1023	0.09	2.8	0.07	1.0	0.17	2.4	3.0	84					0.07	34.662	24.7			
Geomean	**'05-'06**			**2.4**		**2.8**		***3.8***							**0.09**					
O6-5S-69m	8/16/06	1028	0.13	4.0	0.50	7.0	0.37	5.2	4.4	123					0.14	34.580	26.8			
O6-5S-69m	11/20/06	1023	0.14	4.3	0.65	9.1	0.52	7.3	6.8	192					0.12	34.660	26.7			
O6-5S-69m	2/12/07	1122	0.13	4.0	0.30	4.2	0.38	5.3	2.1	60					0.33	34.407	24.8			
O6-5S-69m	4/16/07	1105	0.16	5.0	1.03	14.4	0.41	5.7	12.9	362					0.13	34.021	26.5			
Geomean	**'06-'07**			**4.3**		***7.9***		***5.8***							***0.16***					
T6-500m	9/27/07	945	0.14	4.4	0.01	0.1	0.13	1.8	5.4	151	0.35	10.8	7.8	110	0.15	34.905	26.7	8.08	6.28	0.06
T6-500m	12/14/07	1038	0.09	2.9	0.01	0.1	0.00		2.0	55	0.35	10.8	6.2	87	0.08	34.727	25.7	8.16	6.52	0.12
T6-500m	3/11/08	1048	0.07	2.3	0.05	0.7	0.06	0.8	3.4	97	0.18	5.5	6.5	91	0.19	34.909	24.8	8.12	6.62	0.23
T6-500m	6/9/08	1114	0.05	1.6	0.05	0.7	0.16	2.2	14.8	416	0.23	7.2	8.9	124	0.09	34.7104	25.8	8.11	5.58	0.33
Geomean	**'07-'08**			**2.6**		**0.3**		**1.5**				**8.2**		***102***	***0.12***					**0.15**
T6-500m	9/23/08	1219	0.11	3.4	0.04	0.6	0.28	3.9	2.3	66	0.47	14.6	4.5	63	0.06	34.802	26.8	8.07	5.75	0.15
T6-500m	12/8/08	1121	0.16	5.1	0.40	5.6	0.33	4.6	4.2	119	0.34	10.6	5.6	78	0.07	34.889	26.4	8.29	5.59	0.02
T6-500m	2/10/09	1009	0.06	2	0.10	1.4	0.18	2.5	1.3	37	0.48	14.9	7.9	110	0.06	35.107	24.7	8.06	5.97	0.03
T6-500m	6/30/09	1102	0.27	8.3	0.45	6.3	0.12	1.7	6.2	173	0.49	15.3	4.8	67	0.14	34.917	27.0	8.20	5.92	0.09
Geomean	**'08-'09**			**4.1**		**2.3**		***3.0***				***13.7***		**78**	**0.08**					**0.05**
T6-500m	9/10/09	1123	0.17	5.3	0.09	1.3	0.56	7.8	5.0	139	0.54	16.8	5.3	74	0.06	35.21	27.4	8.18	5.22	0.32
T6-500m	11/24/09	1035	0.02	0.766	0.02	0.3	0.12	1.7	4.8	136	0.34	10.4	4.7	65	0.03	35.27	25.2	8.25	6.38	0.12
T6-500m	2/24/10	1104	0.11	3.3	0.03	0.4	0.40	5.6	2.2	62	0.43	13.2	6.9	97	0.11	34.68	24.6	8.20	5.44	0.24
T6-500m	5/26/10	1025	0.01	0.2	0.04	0.5	0.15	2.1	2.5	70	0.19	6	4.2	60	0.05	34.85	25.1	8.27	6.71	0.09
Geomean	**'09-'10**			**1.3**		**0.5**		***3.5***				**10.8**		**73**	**0.06**					**0.17**
T6-500m	8/11/10	1042	0.02	0.6	0.16	2.2	0.07	1	2.7	75	0.30	9.4	2.7	38	0.04	34.99	26.10	8.22	6.55	0.15
T6-500m	11/9/10	1037	0.03	0.8	0.13	1.8	0.15	2.1	2.5	71	0.38	11.9	4.1	57	0.08	34.94	26.50	8.29	6.13	0.03
T6-500m	1/11/11	1302	0.11	3.4	0.01	0.2	0.09	1.3	4.1	114	0.42	13.1	3.0	43	0.08	35.03	25.13	8.25	6.39	0.05
T6-500m	4/27/11	1034	0.14	4.4	0.12	1.7	0.06	0.8	6.1	171	0.41	12.7	4.0	56	0.11	34.87	24.89	8.22	6.22	0.20
Geomean	**'10-'11**			**1.6**		**1.1**		**1.2**				**11.7**		**48**	**0.07**					**0.08**

NELHA Water Quality Laboratory

Transect 6, Station 5

7/26/1993 - 5/24/2018

SITE ID	DATE	TIME	PO_4^{3-}		NO_3^- & NO_2^-		NH_4^+ & NH_3		Si		TDP		TDN		Turbidity	Salinity	Temp.	pH	DO	Chl a
	M/D/Y	(2400)	(µM)	(µg P/L)	(µM)	(µg N/L)	(µM)	(µg N/L)	(µM)	(µg Si/L)	(µM)	(µg P/L)	(µM)	(µg N/L)	(NTU)	(o/oo)	(˚C)		(ppm)	(µg/L)
DOH LIMIT				**5**		**4.5**		**2.5**				**12.5**		**100**	**0.10**					**0.30**
T6-500m	7/27/11	1120	0.17	5.3	0.02	0.23	0.05	0.7	0.2	5	0.46	14.2	2.9	41	0.03	34.86	26.31	8.23	6.36	0.09
T6-500m	10/19/11	1104	0.04	1.2	0.06	0.9	0.05	0.7	2.9	82	0.39	12	3.5	49	0.05	35.09	26.71	8.26	6.98	0.15
T6-500m	1/26/12	1030	0.05	1.6	0.04	0.6	0.06	0.8	1.1	31	0.35	10.9	3.2	45	0.09	35.06	24.49	8.22	6.66	0.15
T6-500m	4/25/12	1042	0.17	5.4	0.15	2.1	0.36	5.1	3.2	89	0.44	13.6	3.8	54	0.10	34.91	24.88	8.19	6.69	0.04
Geomean	**'11-'12**			**2.7**		**0.7**		**1.2**				***12.6***		**47**	**0.06**					**0.09**
T6-500m	7/25/12	1049	0.01	0.2	0.03	0.4	0.34	4.7	1.5	41	0.35	10.9	3.1	43	0.06	35.11	26.50	8.24	7.21	0.16
T6-500m	11/28/12	1041	0.12	3.6	1.06	14.9	0.31	4.4	7.4	209	0.55	16.9	4.8	67	0.03	34.96	25.23	8.20	6.59	0.15
T6-500m	1/24/13	1035	0.07	2.2	0.01	0.1	0.04	0.6	1.1	30	0.43	13.3	3.8	53	0.05	35.13	24.87	8.23	6.30	0.05
T6-500m	4/24/13	1000	0.15	4.75	0.01	0.1	0.13	1.85	3.2	89	0.55	17.15	3.6	51	0.03	35.15	25.17	8.22	6.80	0.05
Geomean	**'12-'13**			**1.7**		**0.5**		**2.2**				***14.3***		**53**	**0.04**					**0.09**
T6-500m	8/6/13	1118	0.06	1.8	0.02	0.3	0.16	2.3	2.1	59	0.33	10.2	4.4	62	0.02	35.24	26.8	8.20	6.85	0.10
T6-500m	10/30/13	1027	0.13	4.1	0.17	2.4	0.06	0.8	2.0	57	0.53	16.4	5.3	75	0.02	34.90	27.1	8.22	5.84	0.11
T6-500m	2/5/14	1051	0.13	4.0	0.14	2.0	0.21	3.0	2.4	68	0.46	14.3	3.7	52	0.02	34.94	25.2	8.21	6.27	0.20
T6-500m	5/7/14	1049	0.13	3.9	0.31	4.4	0.11	1.5	2.8	78	0.45	13.9	5.4	75	0.06	34.75	25.8	8.20	5.36	0.15
Geomean	**'13-'14**			**3.3**		**1.6**		**1.7**				***13.5***		**65**	**0.03**					**0.13**
T6-500m	8/6/14	1040	0.16	4.9	0.01	0.2	0.24	3.4	0.6	16	0.48	14.9	3.6	51	0.07	34.98	27.1	8.22	5.97	0.08
T6-500m	12/4/14	1120	0.13	4.6	0.09	12.6	0.19	7.8	0.4	155	0.39	15.3	2.5	73	0.06	35.10	26.3	8.26	6.15	0.20
T6-500m	3/5/15	1137					0.17	2.4							0.10	34.70	25.5	8.29	6.60	0.11
T6-500m	6/18/15	1058	0.10	3.2	0.02	0.3	0.29	4.0	1.5	42	0.35	10.7	6.4	90	0.06	34.48	27.1	8.21	6.50	0.14
Geomean	**'14-'15**			**4.2**		**0.9**		***4.0***				***13.5***		**69**	**0.07**					**0.13**
T6-500m	8/27/15	1054	0.14	4.2	0.06	0.8	0.18	2.5	2.7	77	0.19	5.9	4.7	67	0.03	34.69	28.6	8.28	5.99	0.03
T6-500m	11/18/15	1128	0.15	4.5	0.45	6.3	0.16	2.3	3.6	102	0.54	16.8	7.3	103	0.06	34.58	27.4	8.30	6.68	0.10
T6-500m	3/2/16	1005	0.11	3.3	0.06	0.8	0.39	5.5	1.1	31	0.46	14.4	6.1	85	0.08	34.81	25.4	8.26	5.71	0.09
T6-500m	5/4/16	1106	0.12	3.6	0.09	1.2	0.21	3.0	1.5	42	0.27	8.4	4.1	58	0.08	34.69	26.0	8.19	6.01	0.28
Geomean	**'15-'16**			**3.9**		**1.5**		***3.1***				**10.5**		**76**	**0.06**					**0.09**
T6-500m	7/7/16	1106	0.07	2.1	1.06	14.8	0.49	6.8	0.4	12	0.41	12.8	2.1	29	0.10	34.68	27.1	8.33	6.70	0.22
T6-500m	12/21/16	1147	0.04	1.1	0.16	2.3	0.04	0.5	1.6	45	0.35	10.9	4.4	62	0.03	34.67	25.6	8.28	5.76	0.19
T6-500m	3/1/17	1215	0.01	0.3	0.01	0.1	0.07	1.0	0.2	5	0.30	9.2	3.6	51	0.09	34.78	24.6	8.25	5.61	0.17
T6-500m	5/10/17	1201	0.05	1.7	0.01	0.2	0.05	0.7	0.1	3	0.22	6.9	3.3	46	0.08	34.87	25.6	8.22	4.11	0.07
Geomean	**'16-'17**			**1.0**		**0.9**		**1.2**				**9.7**		**45**	**0.07**					**0.15**
T6-500m	9/28/17	1059	0.13	4.0	0.09	1.3	0.19	2.6	0.4	12	0.39	12.1	2.5	36	0.05	34.86	28.1	8.19	4.64	0.07
T6-500m	11/30/17	1039	0.09	2.7	0.10	1.4	0.51	7.2	1.2	33	0.36	11.2	3.6	51	0.04	35.23	26.5	8.25	5.50	0.13
T6-500m	2/6/18	1135	0.06	1.9	0.06	0.9	0.36	5.1	1.0	27.5	0.33	10.2	2.0	27.8	0.09	34.90	25.0	8.16	5.71	0.14
T6-500m	5/17/18	1051	0.08	2.5	0.13	1.8	0.17	2.4	3.3	93	0.36	11.2	3.1	43	0.05	34.81	26.2	8.16	6.31	0.12
Geomean	**'17-'18**			**2.7**		**1.3**		***3.9***				**11.2**		**38**	**0.05**					**0.11**

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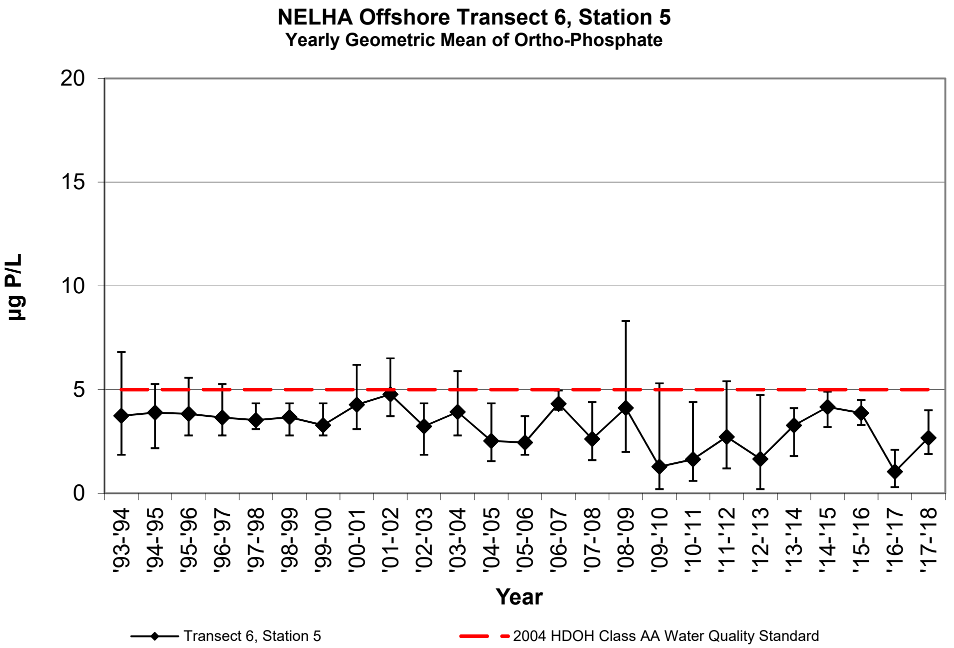

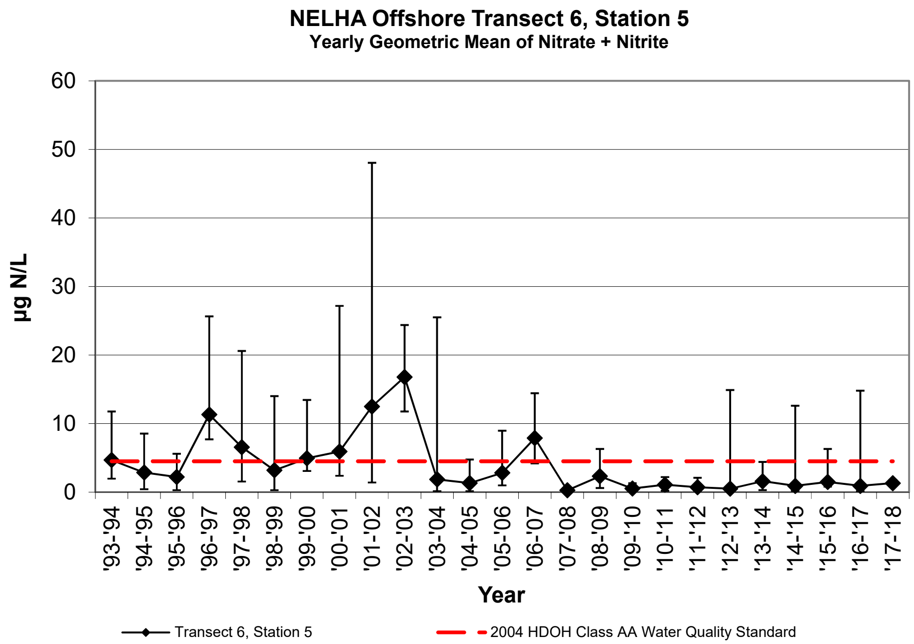

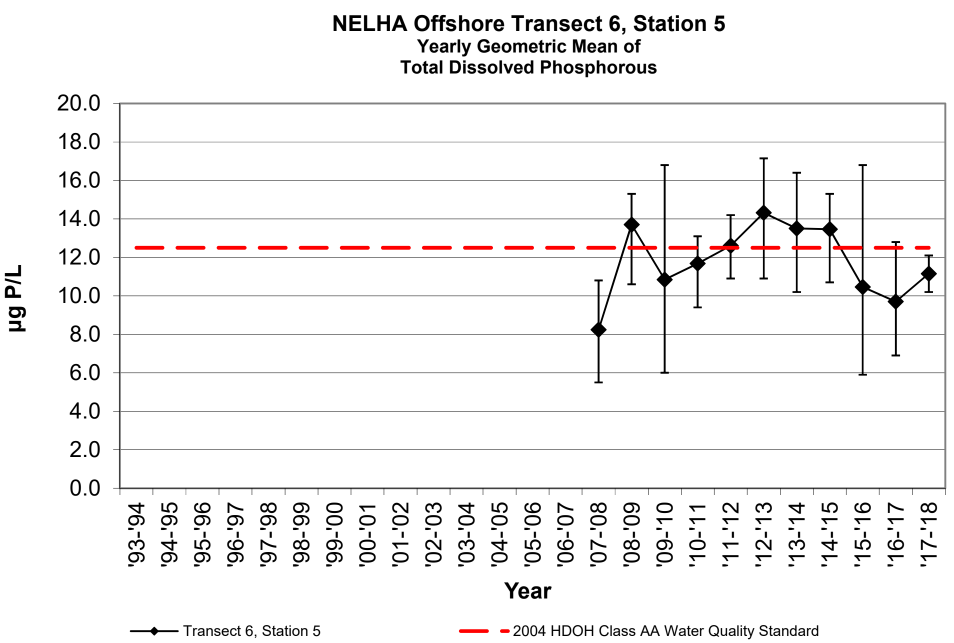

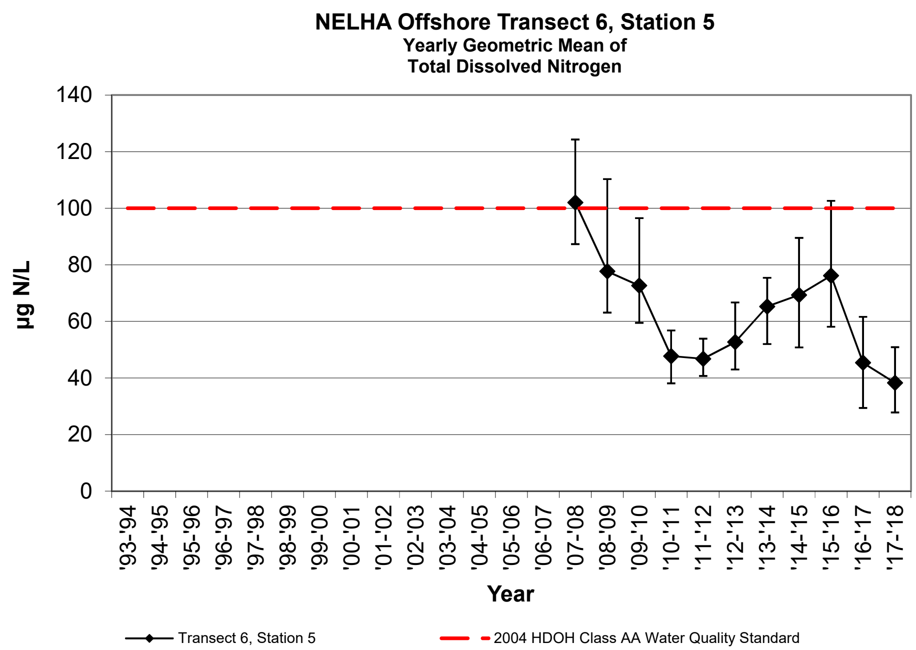

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