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Sustain seafood resources in the U.S. affiliated Pacific islands- status and strategies

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Abstract: Seafood plays important crucial socio-economic roles in daily life of the U.S.-affiliated Pacific Islands (USAPI). USAPI includes American Samoa, the Republic of the Marshall Islands (RMI), the Federated States of Micronesia (FSM), the Commonwealth of the Northern Mariana Islands (CNMl), Guam, and the Republic of Palau (Palau). With less than 2,558 km^2 in total land mass but extended Exclusive Economic Zone (EEZ), the primary source of dietary protein for Pacific islanders has to come from the Ocean. The per capita seafood consumption exceeded global average. In 2015, per capita seafood consumption in Oceania was 25.0 kg/year vs 15.5 kg/year worldwide (FAO, 2018).

Seafood comes from capture fisheries and aquaculture but capture fisheries are the main seafood source for the USAPI. Increasing threats from climate change and overfishing have diminished the sustainability of yield from capture fisheries. Although there were optimistic reports on status of tuna stocks (key species in capture fisheries) in the Pacific, foreign fishing companies have exported majority of their catch to consumers outside the islands. Islanders have relied on subsistence catch to meet their demand. As the harvest from nearshore fishery declined, they have to consider secure their seafood supplies from other means such as aquaculture.

USAPI can take the advantages of their superior natural resources, such as pristine water, year-round warm weather, and isolated condition for disease prevention to sustain their seafood sources via fish farming. However, they have to overcome constraints to aquaculture development such as small land area, natural hazards for some islands, insufficient knowledge base, shortage of available capital, distant markets, and poor transportation systems. Except natural hazards for some islands, the other constraints are solvable. A good strategic development plan is essential to reveal aquaculture potential in the region.

This report discuss the potential threat of climate change to fishery, review the current status and challenges of aquaculture, and finally present some suggestions on future development.

Key words: seafood, aquaculture, sustainability, climate change, US affiliated Pacific Islands, food security

Introduction

Seafood comes from both capture fisheries and aquaculture. In 2016, capture fisheries and aquaculture contributed equally to the total global seafood production. For the U.S.-affiliated Pacific Islands (USAPI), capture fisheries remains the main source of seafood supplies. Seafood plays a key important role in supporting livelihood of the USAPI. USAPI include American Samoa, the Republic of Marshall Islands (RMI), the Federated States of Micronesia (FSM), the Commonwealth of the Northern Mariana Islands (CNMl), Guam, and the Republic of Palau (Palau). This region, composed of thousands of tiny islands spread between the latitudes of 15° N to 14° S and the longitudes of 134° E to 170° W, has less than 2,558 km^2 in total landmass. With their Exclusive Economic Zone

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(EEZ), it extends across an area as large as the continental United States. This extended EEZ is their primary nature resource for living and economic development. Their ancestors have relied on their surrounding water to support their daily living and recreations. Seafood was their primary source of dietary protein until strong influences from western countries. However, the per capita seafood consumption still exceeded global average. In 2015, per capita seafood consumption in Oceania was 25.0 kg/year vs 15.5 kg/year worldwide (FAO, 2018). Within Oceania, Pacific Small Island Countries (PICs) had an average national fish consumption ranging from 55 kg to 110 kg per person per year (Bell *et al*., 2009).

Climate change and overfishing have threatened the sustainability of yield from capture fisheries in USAPI. Although there were some optimistic reports on future status of tuna stocks in the Pacific, foreign fishing companies have exported majority of their catch to consumers outside the islands. Islanders have relied on subsistence catch to meet their demand. As the harvest from nearshore fishery declined due to overfishing and pollutions, they have to consider secure their seafood supplies via aquaculture. In 2016, per capita seafood supply for Oceania was down to 24.3 kg while worldwide per capita supply increase to 19.7 kg (FAO, 2019).

USAPI has superior natural resources for aquaculture development, such as pristine water, year-round warm weather, and isolated condition for disease prevention. However, they have to overcome constraints to aquaculture development such as small land area, natural hazards for some islands, insufficient knowledge base, shortage of available capital, distant markets, and poor transportation systems. Other than natural hazards for some islands, the remaining constraints are solvable. Currently, the Pacific islands is still the least developed region in terms of aquaculture production worldwide with annual production around 24,091 tonnes or less than 0.022% of the total worldwide aquaculture production (FAO, 2019, www.fao.org/fishery/statistics/software/fishstati/en). A good strategic development plan is essential to reveal aquaculture potential in the region. With the complex political systems in the region, each island's entities must have their own development plan. In this region, there are two territories, one commonwealth and three independent countries.

This report will discuss the potential threat of climate change to fishery, review the status and challenges of aquaculture, and finally present some suggestions on future development.

Food Sources

Fish plays an important role in food security in USAPI. Traditionally, nearshore fishery is the main source of seafood for local consumption. Inhabitants were able to survive on the catch plus limited agriculture farming products from land. As distant fishery advanced, government leases out offshore fishing ground to foreign countries to harvest and export to outside of the countries. The fishing right leasing income played significant portion of total GDP in RMI and FSM (**Table 1**). Aids from foreign governments were another major income for the government (**Table 2**). As a result, communities have made a shift from eating traditional seafood items to importing cheap, processed foods. Consequently, many residents have suffered widespread health

Table 1. Fisheries Contribution

	FSM	Marshall	Palau	American Samoa	Guam	CNMI
FY2014 GDP						
Total$	318.1	186.7	249.08	711		
$	31.8	26.3	5.46	1.6	1.36	2.12
% of GDP	10.0	14.1	2.2	0.2		
200 mi EEZ (KM^2)	2,978,000	2,131,000	629,000	390,000	218,000	1,823,000
Per Capita Consumption (kg)	72.0–142.0	38.9–59.0	84.0–135.0	15.5	20.4–27.2	23.0

Table 2. Comparison of Top Donor Countries' and Organizations' Total Aid Spent in the Freely Associated States (2011–2018) (cited from Grossman *et al*., 2019).

	United States	China	Australia	Japan	Taiwan	Multilateral Organizations
Federated States of Micronesia (FSM)	532.86	86.23	27.8	61.08		14.97 (World Bank)
Republic of the Marshall Islands (RMI)	313.6		31.23	48.9	51.99	16.7 (Asian Development Bank)
Palau	48.77		24.20	57.26	4.92	10.94 (Asian Development Bank)

Note: All figures are in U.S. dollars (million).

problems. Diabetes, cardiovascular diseases or hypertension significantly downgraded their quality of life (Carlin *et al*., 2016; Charlton *et al*., 2016). It is essential to revert their daily food diagram back to their tradition to regain their quality life. Increasing seafood supply via fish farming is one of the solutions to make seafood affordable and sustainable. Reliance on capture fishery as seafood supply is facing the challenge of climate change. Climate change may cause the migration of main tuna fisheries to other location (Bell *et al*., 2016), thus, small island countries may lose both revenue and seafood. Losing seafood may mean more dependence on less healthy processed foods from abroad and increases medical expenses.

Climate Change and Fishery

USAPI has three main physiographical types: high volcanic islands, raised limestone islands, and low coral atolls and is the most vulnerable to climate change (Bell *et al*., 2011). A few high islands in the region are large enough to influence local weather. The majorities are the small atolls and are at the mercy of sporadic rainfall for their fresh water. With the islands at or below sea level, rising sea level from global warming definitely imposes negative impacts on the livelihood of island habitants. The rising water temperature might also alter the distribution of tuna stock eastward from western part of the Pacific Ocean (**Fig. 1**; Bell *et al*., 2016). Besides the redistribution of tropical tuna, global warming and ocean acidification can also cause damages to coral reef and other habitats for many aquatic species (Bell *et al*., 2018). Bell *et al*. (2016) further predicted that the abundances of tuna would decrease due to the decline in richness of food web. To increase the resilience of USAPI to climate change, agencies such as US Agency for International Development (USAID) has created a Pacific-American Climate Fund to civil society organizations to reduce long-term vulnerabilities associated with climate change. Since the vulnerability is a function of potential impacts and adaptive capacity. Islanders have to strengthen their adaptive capacity to modify or change actual or expected climate stress to reduce the vulnerability and to stay at their islands.

USAID's Pacific-American Climate Fund has supported three aquaculture projects in Marshall Islands and Federal State of Micronesia to train local residents to produce seafood and aquatic products in their water and to generate income (Ellis *et al*., 2018; Hicks and Murashige, 2018; Zackhras *et al*., 2018). Although the scale is still small and not significant, it has potential to expand to a large scale and ultimately enhance the nature fish stocks via aquaculture.

Status of Aquaculture

Adam *et al*. (2001) presented the status of aquaculture in the Pacific islands. Now, the total production still did not show any noticeable increase after about twenty years. In 2017, the total aquaculture production worldwide reached 112 million metric tonnes (including aquatic plants) but

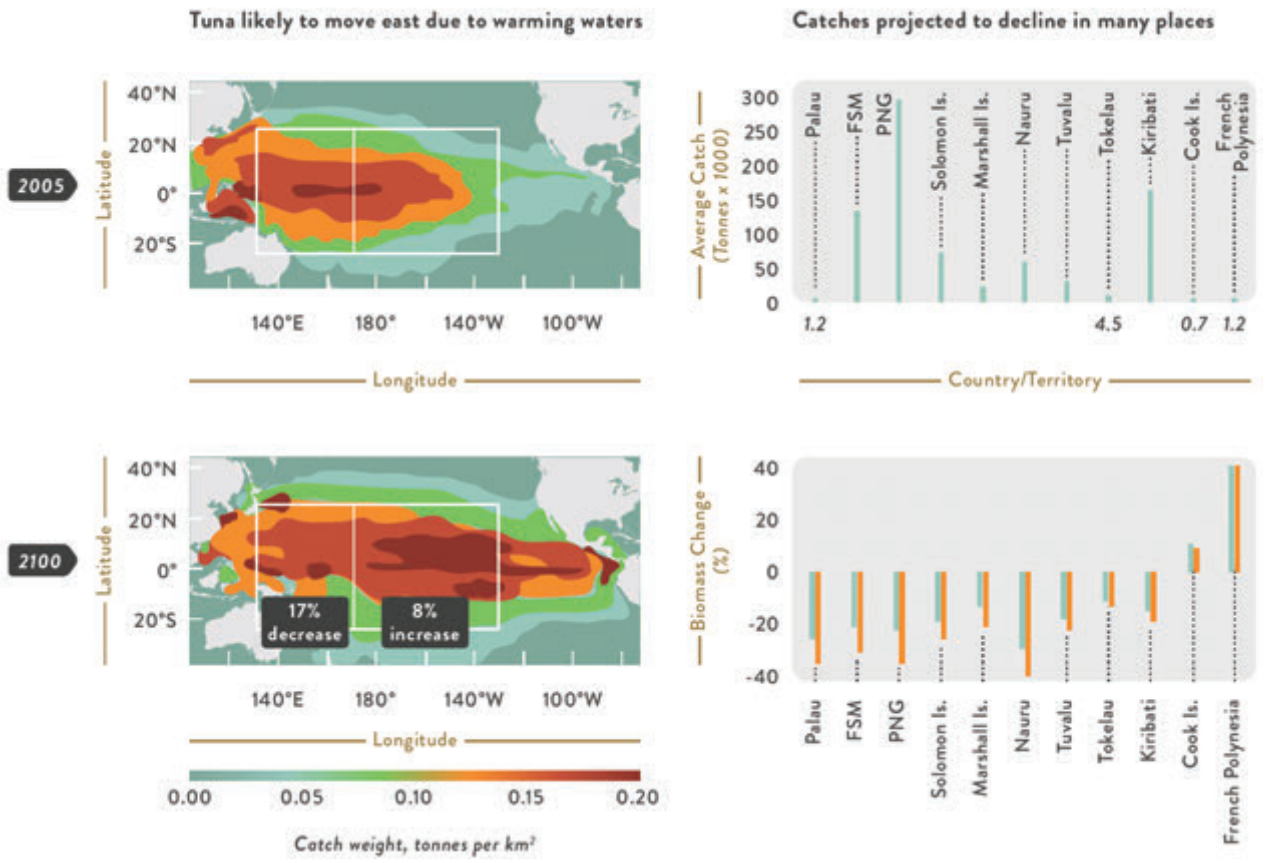

Fig. 1. Climate change and predict tuna distribution. From Bell *et al.* (2016).

the estimated contribution from USAIP was only at 201 metric tonnes (FAO, 2018). In spite of the lower productivity from aquaculture, aquaculture has been the focus of technical and development attention throughout the region. Numerous documents, reports and reviews on the accomplishments are available (Adams *et al.*, 2001). It shows the intention of developing aquaculture remains strong. Almost all island entities have their aquaculture development plan but did not completely implement for various reasons. Most of previous or on-going aquaculture projects led by outsiders have focused on technology transfer and capacity building. Projects have shown impressed outputs but not in actual production. Until now, the total aquaculture yield from USAPI was still insignificant and could not meet the daily domestic food demand. The followings are the highlight of regional aquaculture status.

Farming species- There are several target farming species in the region, which includes but not limit to giant clams, several hard and soft corals, marine ornamental fish, black pearl oyster, bath sponge, sea cucumber, Pacific threadfin (Moi), milkfish, rabbitfish, tilapia, groupers, marine shrimp, and mangrove crab, etc. (**Table 3**). Out of those farming species, giant clams, various coral species, ornamental fish, and processed bath sponge are export items currently. Sea cucumber and black pearl oysters are next two items with high export potential.

Research Facilities- There are aquaculture research facilities at University of Guam and community colleges throughout the region for research and training purpose. The following is a list of available facilities throughout the region.

1) Palau- Palau Mariculture and Demonstration Center (PMDC or giant clam hatchery) under Palau Marine Resources Bureau may be the most impressive governmental facility in the region. At junction to PMDC, Palau Aquaculture Center funded by Taiwan government is an upgraded marine finfish hatchery. Palau Community College runs a multi-species hatchery located at Ngermetengel Village, Ngeremlengui State. Biota Palau at Airai Old Dock Ordomel is a private operation and a branch of Biota

Table 3. List of Species Produced in U.S.-Affiliated Pacific Islands (USAPI)

Commonwealth of the Northern Mariana Islands (CNMI)	Tilapia, Marine shrimp, Rabbitfish
Guam	Tilapia, Marine shrimp, Milkfish, Freshwater prawn
Palau	Corals, Giant clams, Tilapia, Milkfish, Rabbitfish, Marine shrimp, Marine ornamental fish, Grouper
Federated States of Micronesia (FSM)	Corals, Sponges, Giant clams, Sandfish, Black pearl oyster
Republic of the Marshall Islands (RMI)	Corals, Giant clams, Pacific threadfin, Marine ornamental fish, Grouper
American Samoa	Tilapia, Giant clams

Florida. The company focuses on marine ornamental fish, coral, clams and other finfish species.

2) Guam- Guam Aquaculture Development and Training Center (GADTC), also known as the Fadian Hatchery, is under the care of the University of Guam (UOG) from 2001 until 2019. Now, a private company has established a lease agreement with UOG to operate the hatchery. The UOG Marine Laboratory can conduct basic and applied research on the biology of tropical marine organisms. Instead of aquaculture, the laboratory's research focuses on the conservation and development of marine resources of the near-shore waters of Guam and Micronesia.

3) FSM- In Pohnpei, College of Micronesia Land Grant Program has operated Nett Point hatchery since August 2001 for black pearl oyster and sea cucumber. This hatchery was installed in an old warehouse space next to water. At the east side of the island, a non-profit organization established Marine and Environmental Research Institute of Pohnpei works on several coral species, bath sponge, giant clam and ornamental species. In Kosrae, the Federated States of Micronesia National Aquaculture Center established in 1991 at Lelu produces giant clam, mangrove crab and others. In Chuuk, the Korea-South Pacific Ocean Research Center (KSORC) was established on 30 May 2000 on a small island, Weno Island, located within the Chuuk Lagoon with the long-term goal of promoting ocean research and related marine industries.

4) CNMI- College of North Mariana had a small aquaculture research facility but was destroyed by a recent hurricane in 2017. They have budget to rebuild another one.

5) RMI- College of Marshall Islands has one science station with facility for aquaculture research. Another finfish hatchery build by Rongelap Atoll local government under a grant from USAID has been used for research purpose as well.

Skilled workforce- USAPI has relied on foreign technicians to take full charge of farm operation and train local workers. College education and on-site training at funded aquaculture projects are two key sources for local aquaculture technicians. Local trained technicians have shown their abilities to operate black pearl oyster and sea cucumber hatcheries, for example. However, it seemed to be a challenge to assist those skillful workers to apply their technique in production. With less working opportunities, it has been a difficult task for them to find a good job. Often time those well-trained technicians had to find another different job after the funded projects ended.

Commercial farms- Because of the limitation of land area, over one hectare land-based grow-out farms only located in CNMI, Guam and Palau so far. Cage culture at open water so far only took place in Majuro, and Palau. Cage culture has great potential to expand to other islands where do not have natural hazards, such as hurricanes.

There were several commercial ventures taken place in USAPI. Currently, only a few operations remain. A hopeful commercial marine shrimp farm at CNMI was permanently stopped operation after strong hurricanes damaged the facilities in 2017. Marshall Islands mariculture farm with the strong support from parent company Ocean, Reef and Aquarium (ORA) in Florida is doing well in

ornamental fish and giant clams. The marine finfish cage farm by Rongelap Atoll local government in Majuro is progressing toward to be a commercial operation. In Palau, milkfish, rabbitfish and mangrove crabs are cultured for commercial purpose. Up to now, investors from outside have expressed interested in starting fish farming in USAPI but yet to be seen.

Path for the Future

Accepting USAPI is the most vulnerable to climate change and knowing coastal fisheries and staple food crops will decline due to climate change, skillful management of the harsh environment condition and nature resources is the only way to continually inhabit in USAPI for years to come. View the success or failure of aquaculture in the region while we review the status, we can conclude the pathway to the future success. USAPI has unique situation different from other countries in their social culture background. It indicates the essential need of community engagement in any aquaculture development. The initial aquaculture practice has to be simple technique and accessible to all required components. Any new practice should respect their traditional rural lifestyles and become a part of community social activities.

To utilize fully and sustainably the most valuable resource, *i.e.* EEZ, for food production, skillful workforce is the fundamental and essential base. Capacity building has been the center of all previous and on-going aquaculture projects. It seemed to be not an issue to find talents and train them. The big challenges are to retain skillful workforce. It is a fruitless effort of having skillful workforce but no established business ventures to receive them. After establishment of skillful workforce, appropriate farming technology can be developed and applied in food production. The appropriate farming technology should also consider the adaptation to the climate change (Wijkström, 2012). And, it is important to have a business mindset to implement any farming technology. We need the entrepreneurs connect all the above dots together, furthermore to the markets and attract capital for operation. Investors will be not interested unless they are able to determine which islands have friendly investment environments. A true partnership between private and public sectors is essential to make sure the sustainability of the development. Finally, everyone involved must have the "will" to overcome any threats in front of aquaculture development before we will be able to success (Lee and Awaya, 2003). The sustainable utilization of the unique natural resource at EEZ for fisheries development will have benefits to the people and economies of the Pacific region and extend far beyond their economic returns at every level.

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In the book "Aquaculture in the Third Millennium", this chapter "Current status of aquaculture in the Pacific Islands" gave an overview the status of aquaculture in the Pacific Islands at the turn of 20th century. It served as the base to assess any new development in 21st century. Through the new wave of international cooperation, it is expect to increase sustainable use of aquatic resources to meet the goal of food security. Food and Agriculture Organization of the UN (FAO) and Network of Aquaculture Centres in Asia-Pacific (NACA) co-organized this conference in 2000.

(2) Lee C. S., and Awaya K., 2003: Viable aquaculture development in the U.S. affiliated islands - lessons from giant clam and sponge farming. *Aquaculture Economics & Management*, **7(1&2)**, 125-135.

This paper reviewed the farming technology for giant clam and bath sponges. Then, it used giant clam and bath sponges as an example to

discuss the challenges of technology transfer, which include biological, technological, environmental, and socioeconomic, to Pacific Islands. Finally, some recommendation was made for the successful technology transfer.

(3) FAO, 2018: The State of World Fisheries and Aquaculture 2018 – Meeting the sustainable development goals, FAO, Rome, 227pp.

An important of aquaculture and fisheries status report published by FAO every two years. It highlights the critical importance of fisheries and aquaculture for the food, nutrition and employment of millions of people, many of whom struggle to maintain reasonable livelihoods. Data and graphics presented in this publication are widely used by research groups to assess the progress and to propose future works.

(4) Bell J. D., Johnson E. J., Ganachaud A. S., Gehrke P. C., Hobday A. J., Hoegh-Guldberg O., Le Borgne R., Lehodey P., Lough J. M., Pickering T., Pratchett M. S., and Waycott M., 2011: Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change: Summary for Pacific Island Countries and Territories, Secretariat of the Pacific Community, Noumea, New Caledonia, 386pp.

The book entitled *Vulnerability of Tropical Pacifc Fisheries and Aquaculture to Climate change* provides the region with the understanding needed, and the adaptations, policies and investments recommended to reduce the likely impacts of climate change on fisheries and aquaculture. It also gives the sector a roadmap for capitalising on the opportunities expected to arise from the changing climate. This book is the product of a partnership that started between the Australian Agency for International Development (AusAID) and the Secretariat of the the Pacific Community (SPC), and then grew to embrace contributions from 36 institutions. This summary, which is a companion to the book, provides this vital information in an accessible form for each Pacific Island country and territory. It is a quick access to understand projected changes to surface climate and the ocean, to oceanic fisheries, to coastal fisheries, to freshwater and estuarine fisheries, to aquaculture, economic and social implications, and adaptations and suggested policies. It is a valuable document to have a quick overview of potential climate change impacts and suggested remedy policy.

(5) Charlton K. E., Russell J., Gorman E., Hanich Q., Delisle A., Campbell B., and Bell J., 2016: Fish, food security and health in Pacific Island countries and territories: a systematic literature review. *BMC Public Health*, **16**, 285. (doi: 10.1186/s12889-016-2953-9)

This paper discussed the importance of fish to Pacific Island Countries and territories (PICTs) in both food security and health related concerns based on the review of 29 studies. However, there is a paucity of research aimed at assessing how maintaining and/or improving fish consumption benefits the diets and health of Pacific Islanders. Instead of fresh seafood, there is an increasing demand for packaged imported foods, such as canned meats, instant noodles, cereals, rice, and sugar-sweetened beverages, with subsequent decreased consumption of locally-produced plants and animals.

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This paper discusses the important species, the status of the resources, and the fisheries management under offshore fishing and coastal (or nearshore) fishing. This report also provides information on the fisheries in each of the 14 independent Pacific Island countries (including Federated States of Micronesia, Marshall Islands, and Palau) in the following categories:

- Overview and main indicators
- Production sector
- Post-harvest sector
- Socio-economic contribution of the fishery sector
- Trends, issues and development
- Institutional framework
- Legal framework