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State of the plate: Assessing present and future contribution of fisheries and aquaculture to Hawai'i's food security

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ABSTRACT

Seafood provides the most important source of protein on the planet, and millions in coastal communities depend on this sector for nutrition, livelihoods, and cultural values. Despite seafood's important role, in many locations the contributions of fisheries and aquaculture to local food security have not been accurately assessed. An overview is provided of current and future contributions of seafood to food security in Hawai'i through metrics using a supply chain approach from hook-to-plate, encompassing production and consumption. Hawai'i's local seafood production is nearly 21,000 metric tons per year, with ~90% sourced from pelagic fisheries, and 6% from reef fisheries. Seafood is a bright spot in the overall Hawai'i food system, providing a relatively higher degree of self-sufficiency than other food sources. Annual local production of seafood in Hawai'i is estimated at 20,424,243 ± 1,958,488 kg (μ ± SD). Accounting for imports and exports, the total locally available seafood (32,450,820 kg ± 1,571,905 kg) accounts for about 134 ± 6.5 million meals available every year. Wild-capture fisheries (pelagic and nearshore) in Hawai'i are modeled to be able to meet 45% or less of the growing seafood demand in Hawai'i by 2040, compared to an estimated 55% in 2015. A projected 20% increase in total seafood demand by 2040 would exceed current average annual local production by up to 37%. Improvement in sustainable fisheries, aquaculture, and innovations in value and supply chains are critical if Hawai'i is to improve its seafood security and the food provisioning functions of ocean and coastal environments.

1. Introduction

Human activities in coastal environments have resulted in significant impacts to ocean health and diminishing returns to society from these ecosystems [1–4]. Critical ocean ecosystem services such as fisheries, coastal protection, and cultural values are essential to the health and wellbeing of coastal communities and are diminishing globally [5,6]. Fisheries contribute 20% of the protein for 3.1 billion people's diets and 17% of global protein consumed, representing a crucial contribution to global food security [1,7–11]. The ocean is the biggest source of protein for humanity, and aligning food self-sufficiency goals in seafood with natural resource management goals can lead to effectively achieving Sustainable Development Goals (SDGs). Yet, this benefit to humanity from the oceans is tenuous because about 31% of all assessed fish stocks are overfished, and 58% are fished at full capacity [11].

Nowhere are coastal fisheries more important for seafood self-sufficiency than in the developing economies and communities of Pacific Island Countries and Territories. Many coastal fisheries in this region have significant capacity gaps in management, threatening the food and livelihood security that these fisheries provide to communities [7,12–14]. In most areas, rural coastal communities are witnessing increasing fishing effort and resource depletion as they become integrated into market systems that supply growing demand in urban centers [7]. These changes are coincident with dietary shifts to processed, imported foods and erosion of cultural fishing practices [15], which result in declines in fishing pressure in some regions [16]. Across the region, local stressors such as overfishing and pollution as well as global threats such as climate change are causing major impacts to coastal ecosystems [17–23], with consequences for food security in resource-dependent communities [7,10,24,25].

In Hawai'i, public interest in food security and the potential for self-sufficiency has increased in recent decades as locally sourced food and seafood has declined in its contribution to meeting local food demand. Attitudes in Hawai'i towards food security and food self-sufficiency have been summarized in the past as "local production for local

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consumption, under local control" [26]. Seafood is an integral part of society – a reflection of the Hawaiian archipelago's unique geography, culture, and history. Seafood comprises > 20% of all animal protein consumed in Hawai'i – the highest of any other food category – and is a particularly important source of protein for low-income households in Hawai'i (< $35,000 USD per year) [27]. Fishing and providing local seafood towards household food self-sufficiency and security is of high cultural and nutritional value in Hawai'i, underscoring the need for sustainable management [28]. Demand for seafood is expected to increase in the future due to projected population growth. However, Hawai'i's nearshore fisheries are threatened by local stressors such as overfishing, land-based pollution and invasive species, as well as global threats such as climate change, which are impacting the food security benefits of these food systems [7,8,10,24],

Despite the importance of coastal fisheries to Hawai'i's economy, communities, and culture, little is understood about the functional role these fisheries play in food security for the archipelago. Recent work has shown that small-scale coral reef fisheries in Hawai'i provide large-scale benefits to the economy, food security, and cultural practices, contributing millions of meals per year to households [28]. But little is known about the full scope of all fisheries' contributions to food security and food self-sufficiency in Hawai'i.

Food security is broadly defined as including 'physical, social, and economic access to safe and nutritious food that meets the local needs [29]. Food self-sufficiency refers to a region's ability to produce all the food necessary to satisfy the local demand and need for that food [26,30,31]. For seafood, this requires us to understand the total production from fisheries and aquaculture, the total demand for seafood, dependency on local versus imported seafood sources, and how these trends are expected to change in the future under projected demand growth and climate change.

A clearer picture of the current state and the critical factors that influence seafood security and seafood self-sufficiency can help inform a range of interventions to improve management of local fisheries and seafood supply chains. This includes informing market-based interventions and policy and governance reform to protect the role of local fisheries and aquaculture production in food security, the economy, and community resilience [7].

Here, based upon recent evaluations of total nearshore fisheries production and a value chain assessment for Hawai'i [28], the current and future state of seafood security are evaluated. The objective is to (1) refine metrics for seafood production's role in food self-sufficiency at a local/regional scale, using the Hawaiian Archipelago as a case study, (2) offer novel metrics that forecast future seafood consumption and potential changes in capacity for seafood self-sufficiency by 2040, (3) identify economic challenges that a growing gap could pose for people in Hawai'i, and (4) propose pathways to sustainable production in coastal fisheries. The overarching goal is to inform conservation practitioners, community-level resource stewards, fisheries managers, fishers, seafood consumers, and decision-makers with practical information that would help enhance food security and sustainable production - in Hawai'i and beyond.

2. Methods

2.1. Overview

A supply chain approach is used here in the examination of the current status of seafood security and seafood self-sufficiency, using the primary supply chain components of production, distribution, and consumption (Fig. 1) [28,32–34]. Each of the three primary components of seafood security is dependent upon the proper functioning of its corresponding link in the supply chain. Specifically, physical availability of seafood is dependent upon sufficient *production*, economic access to seafood is dependent upon fair and equitable *distribution*, and shifts in demand and socioeconomic and cultural factors affect seafood *consumption*.

To assess the status of seafood security, a set of indicators, focusing on production and consumption functions was developed. Here, 9 indicators in total were defined, 5 in production and 4 in consumption, based on reviewing food policy and food self-sufficiency research relevant to Hawai'i [11,26,31], as well as available research in our target geography and sector [35–37] (Table 1). The 4 forward-looking consumption indicators are novel and developed here for Hawai'i based on criteria considered by the authors to be important for the future, including 1) increased total seafood demand, 2) increasing fish protein gap between what can be locally produced and what is needed to meet the local seafood demand; 3) increasing seafood prices linked to preferences and price elasticity in a growing population, 4) changes in household expenses. These factors are critical to illuminate if Hawai'i is to preserve large-scale food, income, and livelihood benefits from local fisheries.

Distribution pathways for food are crucial for access and food security, and production modes for seafood can vary due to a number of complex factors, with impacts on benefits from seafood production systems [38,39]. Due to the complexity of distribution pathways, and the lack of detailed data on seafood distribution networks in Hawai'i, this study focuses the indicators on the key production and consumption aspects of seafood systems.

2.2. Indicators

Indicators for are summarized in Table 1 and data sources and calculations are further described below.

2.2.1. Production indicators (PI)

2.2.1.1. Local production (PI#1). *Local Production* refers to the total seafood that is *produced* in Hawai'i. Existing data were synthesized to estimate the total seafood production from the primary fisheries, including nearshore coastal, bottom, reef, and pelagic fisheries, as well as aquaculture. These represent the primary fisheries in the archipelago and together with aquaculture, comprise the major production sources for local seafood. Due to data limitations, this research purposefully excludes other smaller fisheries such as periodic seasonal fisheries, or fisheries for specific products limited to certain geographies, noting that such fisheries can represent significant sources of food as well as cultural practices in communities [40]. On-land aquaculture including freshwater aquaculture, is also excluded, restricting the focus here to marine finfish, invertebrates, seaweed and other marine products harvested from wild-capture fisheries or produced in aquaculture in coastal aquatic environments. The aquaculture production estimates come from the latest available data, 2008–2011 [41]. Aquaculture reports were not available for recent years; therefore, the authors in this study made the assumption that average annual finfish and shellfish annual aquaculture production is similar in recent years to averages from 2008 to 2011.

Commercial bottomfish production is an average of 2006–2010 Hawai'i Department of Land and Natural Resources – Division of Aquatic Resources, available through NOAA's Pacific Islands Fisheries Science Center [42]. The non-commercial bottomfish production is an average of 2006–2010 data, from two model scenarios of the Deep 7 complex (*Lehi*, Silverjaw Snapper, *Aphareus rutilans*; *Ehu*, Squirrelfish Snapper, *Etelis carbunculus*; *Onaga*, Longtail Snapper, *Etelis coruscans*; *Opakapaka*, Pink Snapper, *Pristipomoides filamentosus*; *Kalekale*, Von Siebold's Snapper, *Pristipomoides sieboldii*; *Gindai*, Brigham's Snapper, *Pristipomoides zonatus*; *Hapu'upu'u*, Hawaiian Seabass, *Hyporthodus quemus*) [37]. Non-commercial pelagic catch data (including albacore, yellowfin tuna, big-eye tuna, giant trevally, blue marlin, striped marlin, skipjack tuna) for 2009–2013 were collected by the NOAA Marine Recreational Information Program [43]. Non-commercial reef production estimates come from recent analyses [28].