Seafood Consumption and Supply Sources in Hawaii, 2000–2009

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Introduction

As an isolated chain of islands in the central Pacific Ocean, Hawaii is striving to redevelop a viable regional food system in the face of rising fuel prices and global climate changes. Naturally, an increasingly robust food system will ensure that Hawaii's food sources are more resilient to global supply disruptions, and seafood from the surrounding ocean is an important component of this effort. While Honolulu ranks consistently in the top 10 U.S. ports for commercial fisheries value, its ranking for equivalent fisheries volume is much lower (NMFS, 2011). Honolulu ranked 8th in U.S. ports in landing value of $71.6 million while ranking only 30th in landings amount of 23.5 million pounds (NMFS, 2011).

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U.S. residents collectively spent an estimated $23.8 billion on seafood products for home consumption and another $50.3 billion at food service establishments, including restaurants, carry-outs, and caterers, thereby contributing to an aggregate total expenditure of $74.1 billion in 2009 (Hedlund[1]). Although similar information is not available for Hawaii in that same year, relevant information from the 2004–05 Consumer Expenditures Survey (CES), West Table 3031 (BLS, 2008a) can be utilized to arrive at the approximate seafood consumption by dollar value.

Hawaii's remote location in the central Pacific Ocean, combined with a diverse cultural population, contributes to a significantly higher home consumption of seafood than the national average. The 2004–05 CES (BLS, 2008a) shows an annual per capita, at-home seafood expenditure of $104.29 per resident for Honolulu[2], more than double the comparable national measure of $45.20 per resident for the United States (BLS, 2008b). This spending level is also higher than the $53.46 per resident spending in the U.S. western region.

If we assume that residents in Honolulu eat out in similar proportion as the national average, annual per capita expenditure on seafood at food-service establishments would amount to $226.39. If we further assume that similar expenditure patterns hold across the entire state, as in Honolulu, then Hawaii residents would have spent about $133 million on seafood for home consumption and $275 million at food service establishments in 2004–05[3]; when combined they equal over 11% of the total food expenditures.

Additionally, the above estimated seafood expenditure of $408 million represents only the portion spent by Hawaii residents. In 2005, Hawaii visitors spent an estimated $2.3 billion in food and beverage (DBEDT, 2005). If we further assume that approximately 11% of this

[1] Hedlund, S. 2010. U.S. seafood consumption drops in 2009. Seafood Source.com. Available online at http://www.seafoodsource.com/news-articledetail.aspx?id=4294998771, accessed 12 Jan. 2012. It reported that Americans spent $50.3 billion at foodservice and $23.8 billion at retail, and hence summing up to $74.1 billion in 2009.

[2] Honolulu serves as a proxy for Hawaii because the BLS publishes only consumption expenditures for the City of Honolulu and not the State of Hawaii.

[3] 2004–05 is the latest available information for Honolulu and considered statistically valid by the BLS.

ABSTRACT – Measures of consumption and supply sources of seafood can provide valuable input to research and policy planning of a viable food system. This article fills a gap in the existing literature by mapping the existing seafood supply flows from various sources (local, domestic U.S., and foreign) in Hawaii. The authors trace the seafood transshipment of foreign origin via the continental United States to Hawaii and update total and per capita consumption of seafood more accurately by including noncommercial catches into the analysis.

*Per capita seafood consumption in Hawaii from all commercial sources is estimated at an annual average of 29 edible pounds during the 10-year period from 2000 to 2009. This is significantly more than the 16 edible pounds for all U.S consumption in 2009. Including noncommercial catch, the same measure increases to 37 edible pounds. The eight-pound differential suggests that noncommercial fishing is an important source of seafood supply in Hawaii. Overall, fresh tuna (*Thunnus *spp.) is the single largest species group consumed, followed by Pacific and Atlantic salmon (Salmonidae).*

By edible weight, the majority of Hawaii's commercial seafood supply comes from foreign sources (57%) vs. local sources (37%), and U.S. domestic sources (6%). The leading sources for Hawaii's direct seafood imports from 2000 to 2009, were Taiwan, Japan, New Zealand, the Philippines, and the Marshall Islands. Local supply becomes the majority source once noncommercial catch is included with 51% of the total supply.

Table 1. —Hawaii apparent seafood consumption data components and sources.

	Hawaii production			+ Imports		– Exports	
	Commercial landings	Aqua culture	Noncommercial catch	Continental United States	Foreign	Continental United States	Foreign
Data source	Hawaii DLNR-DAR + NMFS	NASS	NMFS	*US Army Corps of Engineers (waterborne only) + Dealer Survey*	FAS + *Dealer Survey* (continental United States *transshipments)*	*Dealer Survey (waterborne and airborne)*	FAS

Note: Italicized data sources indicate the corresponding data component requires an estimate from multiple sets of information vs. a single authoritative published data source. The acronyms used are defined in the text.

$2.3 billion is spent on seafood, as with the Hawaii residents, it would amount to $256 million. Total expenditures on seafood by Hawaii residents and visitors together would then amount to $664 million annually. It is evident from the above that Hawaii residents and visitors spent significantly more on seafood relative to the nation as a whole.

With Honolulu fisheries landings valued at $71.6 million in 2010 (NMFS, 2011), it is apparent that locally produced seafood cannot meet the market demand in Hawaii, where seafood expenditures had already reached $664 million in 2005. Hence, we seek to quantify, analyze, and understand how much of the seafood consumed in Hawaii is imported. Unfortunately, the information is not readily available due to the difficulties in reconciling the various data sources on imports, seafood expenditures, and local production.

For example, while customs data provide fairly disaggregated imports of various seafood items from foreign sources, interstate trade flow data are rather crude, and not comparable with the customs data. Furthermore, it is a difficult task to convert data consistently from the various sources to a common point in the supply chain. To illustrate the point, much of the seafood expenditure data are presented at retail value, the import data are valued either at Freight On Board (FOB) or Cost, Insurance, and Freight (CIF), and the production data are commonly valued at ex-vessel.

In 2005, an estimated $72 million (ex-vessel value) of seafood offered to the Hawaii market came from local commercial fisheries and aquaculture operations. If we were to assume a 30% share of the retail value for the producers (fishermen and aqua-farmers), the $72 million would translate to about $240 million in actual retail value. This would mean that 64% of seafood by dollar value in Hawaii would have been imported.

Materials and Methods

To assess the different seafood supply sources, total and per capita consumption, species caught, and forms of seafood consumed, it is necessary to first define, establish, and measure the various flows in the Hawaii seafood supply chain. Our initial effort was focused on the consumption of commercial fish and shellfish in the state (Hudgins, 1980). Shortly thereafter, a study surveying seafood wholesalers and retailers was conducted (SMS Research[4]). At that time, 45% of seafood was produced locally, while 30% was imported from the continental United States, and the remaining 25% was imported from foreign sources (Shomura, 1983). Since then, no additional work on this subject matter has appeared.

This article serves to fill that gap in the existing literature and to enhance the overall seafood consumption measure by including the contribution of noncommercial catch. The primary objectives are to identify and outline the data sources, assess data completeness and integrity, utilize appropriate methodologies to estimate the latest seafood consumption, and to map the supply flow of seafood in Hawaii. These estimates are then compared to the U.S. per capita, other global per capita, and historical consumption estimates.

Consumption in our analysis is represented by apparent consumption, which is defined as production plus imports minus exports. Seafood production is further defined as the sum of commercial landings, aquaculture production, and noncommercial catch. Noncommercial catch includes recreational and sport fishing but excludes illegal or unreported fishing. The greater part of this article discusses seafood consumption in edible weight[5], and with some mention of live weight (as indicated). Weight is converted between edible and live by using Food and Agricultural Organization (FAO) conversion factors (unpublished). The data components and corresponding sources used to calculate Hawaii's apparent consumption are listed in Table 1.

Table 2.—Hawaii commercial seafood landings, edible pounds, 2000–09.[1]

Species category	Annual average (1,000 lb)	% Total
Bigeye tuna	6,608	37.8%
Yellowfin tuna	2,347	13.4%
Other pelagic	1,803	10.3%
Other tuna	1,656	9.5%
Billfish	1,551	8.9%
Swordfish	1,455	8.3%
Mahimahi	877	5.0%
Other fish	827	4.7%
Snapper	307	1.8%
Mollusks, crustaceans, and aquatic invertebrates	42	0.2%
Seaweed	11	0.1%
Flatfish and tilapia	1	0.0%
Total	17,485	100.0%

[1]Source: DLNR-DAR (2012).

Data on commercial landings are published by the Hawaii Department of Land and Natural Resources-Division of Aquatic Resources (DLNR-DAR) in cooperation with the NMFS. DLNR-DAR (2012) reported 138 edible species for the years 2000–2009. Table 2 shows the 10-year, average annual edible weight for Hawaii commercial seafood land-

[4]SMS Research. 1983. Survey of the broker and retail sectors of the fish markets in Hawaii. Final Rep., 45 p., submitted to Honolulu Laboratory, Natl. Mar. Fish. Serv., NOAA.

[5]Edible weight refers to the portion of seafood that is readily consumed. For example, it includes the dressed up portion of fish or the edible portion of shellfish.

ings by species from 2000 to 2009. In total, the average annual weight for the 10-year period was 17.5 million edible pounds, and the two leading species caught were bigeye tuna, *Thunnus obesus*, and yellowfin tuna, *Thunnus albacares*.

The commercial landings data are a compilation of all seafood caught for commercial purposes in Hawaii. Any individual or vessel engaged in taking, selling, or offering for sale any seafood for commercial purposes must possess a Hawaii commercial marine license. Additionally, all licensees are required by law (HRS-189-3) to report their marine catch to DLNR-DAR on a monthly basis.

Aquaculture data are collected as a complete enumeration by the National Agricultural Statistics Service (NASS). The data published shows only shellfish and finfish. Shellfish includes marine shrimp, freshwater prawns, crayfish, lobsters, oysters, clams, snails, and abalone. Finfish produced includes Japanese flounder, Chinese catfish, tilapia, carp, mullet, moi (Pacific threadfin), awa (milkfish), and amberjack (DOA[6]). The average annual weight of aquaculture production for the 10-year period (2000–09) was 623,000 edible pounds. Finfish represents 58.5% of all aquaculture products raised in Hawaii.

NASS also reports algae, but only in farmgate value, not volume. Algae is Hawaii's most valuable aquaculture crop. It consists primarily of the species *Arthrospira* and *Haematococcus* which are used for aquaculture feed additives and human nutritional supplements; and limu ogo *Gracilaria* sp. for human consumption (DOA[6]). In 2009, algae production was valued at $17 million or 53% of total aquaculture production in Hawaii. Production of finfish was valued at $4.5 million and shellfish at $420,000 in the same year (NASS, 2011).

Noncommercial catch data are primarily recreational landings published by the National Marine Fisheries Service (NMFS) under the Marine Recreational Information Program (MRIP). Noncommercial catches are often ignored when measuring seafood consumption for a geographic area. However, in the case of Hawaii, it adds a significant portion to available supply, especially for yellowfin tuna and inshore marine species (Hospital et al.[7]). The average annual weight for noncommercial catch in Hawaii was estimated at 11.5 million edible pounds.[8]

Data for foreign direct imports and exports are available from the Global Agricultural Trade System (GATS) online, which is administered by the Foreign Agricultural Service (FAS). GATS Online contains statistics for available U.S. customs district by country of origin and destination, and by commodity at the 10-digit level of the Harmonized Tariff Schedule (Harmonized System), established by the World Customs Organizations (FAS[9]). For the years 2000–09, the GATS reported 326 different seafood commodities for Hawaii imports, and 62 different seafood commodities for Hawaii exports. The average annual weight for foreign direct seafood imports for the 10-year period was 14.8 million edible pounds. Similarly, some 600,000 edible pounds of Hawaii seafood products were available for foreign exports.

In the absence of robust data on the volume of seafood imports and exports between Hawaii and the continental United States, we utilized 10 years of waterborne commerce data from the U.S. Army Corp of Engineers, Waterborne Commerce Statistics Center (ACE-WCSC[10]) to estimate annual waterborne flows of seafood. To estimate the complementary airborne shipment of imports, we surveyed key Hawaii-based commercial seafood dealers, identified in collaboration with the Hawaii Seafood Council (HSC). Likewise, we surveyed the corresponding airborne shipment of exports. We also utilized the survey to estimate the proportion of foreign seafood imports to Hawaii via transshipments passing through the continental U.S. ports.

The survey instrument to each dealer focused on seafood species by sales value, weight, and product form (fresh/frozen or fillet/whole). For each species listed, they were asked the proportion of airborne shipments (imports and exports), and the proportion of foreign transshipments. To improve the confidence level of the aggregate estimates of Hawaii's apparent seafood consumption, we applied sensitivity analyses to evaluate possible variations in the various components such as: 1) airborne imports from the continental United States; 2) seaborne and airborne exports to the continental United States; 3) foreign transshipments via the continental United States; and 4) waterborne imports from the continental United States. The methodology above begins to define Hawaii's seafood supply chain by estimating how much seafood enters and exits the state.

Results

The findings from the commercial seafood dealers' survey[11] revealed that 100% of local seafood exports to the continental United States were shipped airborne. Hence, the waterborne data from the ACE-WCSC were utilized solely to estimate Hawaii seafood imports from the continental United States.

[6]DOA. 2009. Aquaculture development outlook. Dep. Agric. Hawaii, Honolulu. Available online at http://Hawaii.gov/hdoa/adp/outlook, accessed 6 Sept. 2011.

[7]Hospital, J., S. S. Bruce, and M. Pan. 2011. Economic and social characteristics of the Hawaii small boat pelagic fishery. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Pac. Isl. Fish. Sci. Cent., Admin Rep. H-11-01, p. 38.

[8]Some industry analysts believe the original MRIP figure may have been overestimated. This number represents an internal revised estimate, 17% lower from that originally published by NOAA-NMFS in 2011 (personal commun.). The original estimate was deemed too high by the NRC and NMFS was tasked with revising it.

[9]FAS. 2011. Global agricultural trade system (GATS) online. Foreign Agric. Serv., Wash., D.C. Available online at http://www.fas.usda.gov/gats/default.aspx, accessed 28 Nov. 2011.

[10]ACE-WCSC. 2010. Cargo by ports part 4 tons_year/direction_ports calendar years 2009–2005. U.S. Army Corp. Eng., Waterborne Commer. Stat. Cent. Available online at http://www.ndc.iwr.usace.army.mil/wcsc/webpub09/webpubpart-4.htm, accessed Sept. 6, 2011.

[11]The survey fielded 49 questionnaires to key Hawaii-based commercial seafood dealers, identified in collaboration with the Hawaii Seafood Council. Responses were received from 13 dealers but 4 were tossed out due to incomplete filing, leading to a survey response rate of 18.4%.

Table 3. —Hawaii total and per capita apparent seafood consumption, edible pounds, annual average for 2000–2009.

	Hawaii Production (1,000 lb)			+	Imports (1,000 lb)		–	Exports (1,000 lb)		=	Consumption	
Item	Landings	Aquaculture	Noncommercial		U.S.	Foreign		U.S.	Foreign		Total (1,000 lb)	Per capita (lb)
Commercial Consumption	17,485	623			2467	22,075		3128	599		38,922	28.5
% Total	44.9%	1.6%			6.3%	56.7%		–8.0%	–1.5%		100.0%	
Commercial Consumption + Noncommercial Catch	17,485	623	11,465		2467	22,075		3128	599		50,387	36.9
% Total	34.7%	1.2%	22.8%		4.9%	43.8%		–6.2%	–1.2%		100.0%	

Note: Above values represent edible pounds. Italicized data indicate the corresponding data component requires an estimate from multiple sets of information versus a single authoritative published data source.

A closer analysis of this waterborne dataset indicated a high degree of variability from one year to the next. From the 10 years (2000–09) of waterborne import data utilized, we arrived at an average annual estimate of 3.4 million edible pounds.

The commercial seafood dealers' survey also allowed us to estimate the proportion of airborne imports and waterborne imports at 65% and 35%, respectively, for all Hawaii seafood imports from the continental United States. These proportions when applied to the annual 3.4 million edible pounds for waterborne imports, allowed us to estimate total seafood imports from the continental United States at 9.7 million edible pounds annually. Likewise, an annual estimate of 6.3 million edible pounds of Hawaii seafood imports from the continental United States were shipped airborne.

The seafood dealers' survey further allowed us to estimate the amount of foreign transshipments via the continental United States at 75% of edible weight imported. This means that roughly 7.2 million edible pounds of Hawaii annual imports from the continental United States are of foreign origin. For the purposes of analysis, we categorized the transshipments as foreign imports rather than imports from the continental United States.

Finally, survey responses enumerated the annual seafood exports to the continental United States at 1.25 million edible pounds. Combined with the expert opinions of the two leading seafood exporters surveyed, and their 40% market share, we estimated the Hawaii annual seafood exports to the continental United States at 3.1 million edible pounds.

Table 4. —Hawaii net available seafood consumption by source, edible pounds, and annual average for 2000–09.[1]

Source	Net available from source without noncommercial catch (1,000 lb)	% without noncommercial catch	Net available with noncommercial catch (1,000 lb)	% with noncommercial catch
Local	14,380	37%	25,845	51%
Foreign imports	22,075	57%	22,075	44%
Continental U.S.	2,467	6%	2,467	5%
Total available for local consumption	38,922	100%	50,387	100%

[1]Net available seafood volume from local sources is derived by subtracting foreign and continental United States exports from the aggregate of local production sources.

Since estimates for apparent seafood consumption do not generally include noncommercial catch, the estimates in this article are presented generally in edible weight, without and with noncommercial catch. Table 3 shows the estimates of Hawaii total apparent seafood consumption on an annual average and the various components for the 10-year period from 2000 to 2009. Excluding noncommercial catch, the apparent seafood consumption on an annual average in Hawaii is 38.9 million edible pounds. With the inclusion of noncommercial catch, the estimate increases to 50.4 million pounds. To estimate per capita apparent consumption, the total estimate is divided by the de facto population in Hawaii, which takes into account military personnel stationed and tourists visiting the state.

The per capita apparent seafood consumption on an annual average in Hawaii is 29 edible pounds without including noncommercial catch, and 37 edible pounds with the inclusion of noncommercial catch. The 22% contribution of noncommercial catch is significant to the total availability of seafood in Hawaii.

Table 4 shows the proportion of net available seafood consumption by source in Hawaii, without and with noncommercial catch. Excluding noncommercial catch, foreign imports account for 57% of all seafood available for consumption in Hawaii. Local commercial landings account for 37% of available seafood consumption while the remaining 6% is satisfied by imports from the continental United States. With the inclusion of noncommercial catch, available seafood for consumption in Hawaii shifts to 51% of the total from local sources. The proportion of foreign imports drop to 44%, and imports for the continental United States fill the remaining 5%.

While airborne trade flow and foreign transshipment figures via the continental United States are derived from local seafood dealers, the estimates may not be sufficiently precise, given the low survey response rate of 18.4%. In the seafood dealers' survey, three component measures of supply flows were estimated: 1) airborne imports from the continental United States (using an estimated 65% total imports from the continental United States); 2) airborne exports to the continental United States (using an estimated 40% of total exports as reflected in the survey); and 3) foreign transshipments via the continental United States (using an estimated 75% of total imports from the continental United States, that is transshipped from foreign countries).

Table 5.—Sensitivity analysis of varying waterborne imports from continental United States.

Catch source	Apparent seafood consumption			
	Excluding noncommercial		Including noncommercial	
% change in waterborne imports from the continental U.S.	Total (1,000 lb)	Per capita (lb)	Total (1,000 lb)	Per capita (lb)
–100%	29,209	21.4	43,090	31.5
–50%	34,065	24.9	47,946	35.1
–10%	37,960	27.8	51,831	37.9
Baseline	38,922	28.5	50,387	36.9
10%	39,893	29.2	53,774	39.3
50%	43,779	32.0	57,659	42.2
100%	48,635	35.6	62,516	45.7

Table 6.—Sensitivity analysis of varying all parameters.

Catch source	Apparent seafood consumption			
	Excluding noncommercial		Including noncommercial	
% change in all parameters	Total (1,000 lb)	Per capita (lb)	Total (1,000 lb)	Per capita (lb)
–20%	34,082	24.9	47,962	35.1
–10%	36,226	26.5	60,106	36.6
Baseline	38,922	28.5	50,387	36.9
10%	42,636	31.2	56,517	41.3
20%	48,353	35.4	62,234	45.5

The third estimate, foreign transshipments, does not affect the overall per capita consumption estimate, but it does affect the percentage of available supply from foreign sources.

As mentioned, the ACE-WCSC dataset utilized to estimate waterborne imports exhibited a high degree of variability for the 10-year period (2000–09). Hence, we conducted sensitivity analyses to evaluate the possible variations of the three estimates from the dealers' survey, and the volatile waterborne imports data from the continental United States. As the total seafood volume reported in the dealers' survey already amounted to 2.7 million edible pounds, we sense the estimated waterborne imports from the continental United States of 3.4 million edible pounds may be somewhat underestimated.

Table 5 shows the estimated total and per capita seafood consumption if the waterborne continental United States imports were off the mark by 10%, 20%, 50%, and 100%, assuming that all other parameters are at their baseline levels. As shown in Table 4, the swing of the estimated per capita annual consumption can be as high as 7.1 edible pounds. In other words, the estimated per capita annual consumption would have been 35.6 edible pounds (excluding noncommercial catch) and 45.7 edible pounds (including noncommercial catch), if we underestimated the waterborne U.S. continental imports by 100%.

We also investigated the effects on the estimated apparent consumption when all the parameters were off the mark simultaneously by 10% and 20% respectively. As shown in Table 6, the swing is larger at 6.9 edible pounds if we underestimated all the parameters by 20% as opposed to only 3.5 edible pounds if we overestimated all the parameters by 20%. Together with the results from the above sensitivity analysis, we may be off the mark to the fullest extent, by 7 edible pounds.

Table 7.—Hawaii vs. U.S., 1970's and 2000's: per capita seafood consumption, edible pounds.

Item	1970–1977[1]			2000–2009[2]		
	Hawaii	U.S.	Hawaii: U.S.	Hawaii	U.S.	Hawaii: U.S.
Consumption	20.9	12.4	1.7: 1	28.5	15.9	1.8: 1
Change				36.4%	28.4%	5.9%

[1]Figures for 1970–1977 from Hudgins (1980).
[2]Data is average from 2000 to 2009 of U.S. per capita consumption of commercial fish and shellfish from NMFS, 2011.

Discussion

One notable inference in our analysis is the significant contribution of noncommercial catch to Hawaii's seafood consumption. It accounts for 39% of total local production when measured in edible pounds, and it further translates into per capita seafood consumption of 8 pounds. Collectively, local landings, aquaculture, and noncommercial catch make up 51% of total available seafood supply in Hawaii. Yellowfin tuna emerged as the single largest species consumed in edible pounds when all local sources are considered.

Despite the collective contribution of local production sources, almost half (49%) of all seafood consumed in Hawaii is imported. Seafood imports from foreign countries account for 44% of total seafood consumption by edible weight, while the remaining 5% originates from the continental United States. Excluding noncommercial catch, foreign imports are the largest source of available seafood in Hawaii, contributing 57% of total supply for local consumption in edible pounds (Table 4).

Likewise, about 80% of commercial landings remain in Hawaii, 18% are exported to the continental United States, and 2% are exported to foreign countries. For aquaculture products, 85% remains in Hawaii, about 15% are exported to foreign countries, and a fractional percentage is exported to the continental United States.

The first study of Hawaii's apparent seafood consumption by Hudgins (1980), covering 8 years from 1970 to 1977, found that per capita apparent seafood consumption in Hawaii was 1.7 times higher than that in the U.S. As shown in Table 7, we estimate the per capita apparent seafood consumption in Hawaii at a marginally higher, 1.8 times than that in the U.S., based on the average annual consumption from 2000 to 2009.

The per capita seafood consumption from the 1970's to the 2000's grew by 36.4% in Hawaii as compared to 28.4% for the United States. The higher growth rate in Hawaii can be attributed to two factors during the period reviewed: 1) higher visitor counts to Hawaii, and 2) higher immigrant counts from countries with high seafood consumption.

From 1977 to 2009, the number of visitors to Hawaii nearly doubled from 3.4 million in 1977 to 6.4 million in

2009[12], with the majority coming from the continental United States. Given Hawaii's geographic location, these visitors were exposed to seafood that was not usually available to them in restaurant offerings at home. Japanese visitors comprised the next largest market share. Well known for their high consumption of seafood, the increasing Japanese visitor count since 1977, has influenced the higher rate of seafood consumption in Hawaii.

At the height of its plantation economy, Hawaii received immigrant workers from countries with high seafood consumption, including China, Japan, Korea, the Philippines, and Portugal. Subsequently, the U.S. immigration policy provided favorable preferences to close relatives, which encouraged additional immigrants from these countries to Hawaii in the past three decades. A sizable population of Micronesians has also migrated to Hawaii under provision of the Compact of Free Association[13] in the past two decades. Most of these countries have substantially higher fish consumption rates than the United States. Table 8 shows the per capita (in live weight) seafood consumption in 1977 and 2007, comparing Hawaii and select countries with large immigrant descendent populations in Hawaii.

The 2007 live weight consumption for Hawaii, without including noncommercial catch is 55.5 live pounds per person. Similarly, the FAO[14] report specifies the U.S. seafood consumption at 53.1 live pounds per person in 2007. In comparing the per capita seafood consumption between Hawaii and the U.S., the ratio is 1.8: 1 in edible weight. In contrast, the live weight ratio is much smaller at 1.05: 1.

This contrast can be explained by the different seafood consumption patterns (behaviors) in Hawaii and in the United States. In our analysis, we find Hawaii residents consume much more fresh and frozen finfish, led by tuna and salmon, than do other U.S. citizens. Table 9 shows that eight of the top 10 species consumed in Hawaii (per capita basis) are fresh or frozen finfish. In contrast, the United States generally consumes more shellfish and processed seafood, led by shrimp and canned tuna. Only six of the top 10 species consumed are fresh or frozen finfish. Our analysis also indicates that fresh and frozen products account for 77%, and processed products account for 23% of total seafood consumed in Hawaii by edible weight. In comparison, fresh and frozen products account for 72%, and processed products for 28% of total seafood consumed in the United States.

Additionally, finfish and shellfish represent 80% and 20%, respectively, of total seafood consumed in Hawaii by edible weight. The comparable proportions for the United States are 64% finfish and 36% shellfish, respectively. Beyond that, both processed seafood and shellfish have higher edible-to-live conversion factors and translate into higher live weight for any given edible weight. For example, the FAO uses a factor of 3.0 in converting the edible weight of canned fish to live weight.[15] Shellfish have conversion factors rang-

Table 8.—Global comparison of per capita seafood consumption, live pounds, 1977 and 2007.

Place	1977	2007[1]	% Change
Hawaii	N.A.	55.5[2]	N.A.
U.S.	33.8	53.1	57.7%
World	25.3	36.8	45.5%
Countries with large immigrant descendent populations in Hawaii			
Micronesia	137.4	164.5	19.7%
Japan	143.4	134.0	–6.6%
Portugal	83.5	120.9	44.8%
South Korea	80.0	116.2	45.3%
Samoa	74.2	102.1	37.6%
Philippines	73.9	71.4	–3.4%
China	12.8	58.4	356.3%

[1]Data for worldwide live weight per capita consumption is from the FAO (see text footnote 14); 2007 is the most current available data. Global edible weight figures are not available.

[2]This is the 2007 per capita estimate in live pounds per person using the methodology presented in this article and, excludes noncommercial catch, which would otherwise raise the 2007 estimate to 66.1 live pounds per capita.

[12]DBEDT. 2011 State of Hawaii data book. Dep. Bus. Econ. Develop. Tourism, Hawaii. Table 07.03 Visitor arrivals and average daily census: 1921–2011, Honolulu. Available online at http://hawaii.gov/dbedt/info/economic/databook/db2011/section07.pdf , accessed 18 Dec. 2012.

[13]This is included in U.S. Pub. Law 99-239, Compact of Free Assoc. Act of 1985, 48 USC 1681 note. 59 Stat. 1031. Available online at www.fsmlaw.org/compact/, accessed 18 Dec. 2012.

[14]FAO. 2011. FAOSTAT. Rome, Italy. Available online at http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368#ancor, accessed 6 Sept. 2011.

[15]FAO. Conversion Factors EW to LW (average). Food Agric. Org., Rome, Italy. Unpubl. notes.

Table 9.—Top 10 Hawaii[1] and U.S.[2] per capita seafood consumption by species, edible pounds.

Rank	Hawaii with noncommercial catch	Edible lb	Hawaii without noncommercial catch	Edible lb	U.S.	Edible lb
1	Tunas (yellowfin, bigeye, other)	12.72	Tuna (yellowfin, bigeye, other)	7.36	Shrimp	4.08
2	Salmon	4.23	Salmon	4.23	Canned tuna	2.80
3	Mollusks, crustaceans, aquatic invertebrates	3.92	Mollusks, crustaceans, & aquatic invertebrates	3.92	Salmon	2.12
4	Mahimahi	1.93	Shrimp	1.85	Pollock	1.48
5	Shrimp	1.85	Billfish	1.01	Catfish	0.97
6	Billfish	1.58	Swordfish	0.80	Tilapia	0.93
7	Swordfish	0.80	Mahimahi	0.79	Crab	0.62
8	Cod/Pollock	0.53	Cod/Pollock	0.53	Cod	0.49
9	Snapper	0.51	Catfish	0.46	Clams	0.45
10	Catfish	0.46	Tilapia	0.37	Pangasius[3]	0.38
	Total Top 10	28.53	Total Top 10	21.32	Total Top 10	14.32
	Total	36.85	Total	28.46	Total	16.14

[1]Annual average for 2000–09.

[2]Annual average for 2002–10.

[3]For Hawaii, *Pangasius* is included in catfish.

ing from 2.8 to 9.1. Furthermore, for a specific species such as salmon, the conversion factor ranges from 1.13 for frozen salmon, to 1.5 for salted salmon, and to 2.0 for fresh or chilled salmon fillets. These differences in the patterns of consumption between Hawaii and the United States help to explain why the former consumes 1.8 times more seafood than the latter in edible weight, yet remains so similar when measured in live weight.

Hawaii receives a substantial amount of its commercial seafood supply from foreign sources. While the countries of origin for foreign transshipments via the continental United States are not documented, direct imports by country of origin are well recorded. The leading direct import sources for Hawaii's seafood as reported by the USDA Foreign Agricultural Service (FAS) were Taiwan, Japan, New Zealand, the Philippines, and the Marshall Islands. Figure 1 shows the distribution of direct seafood imports by country of origin.

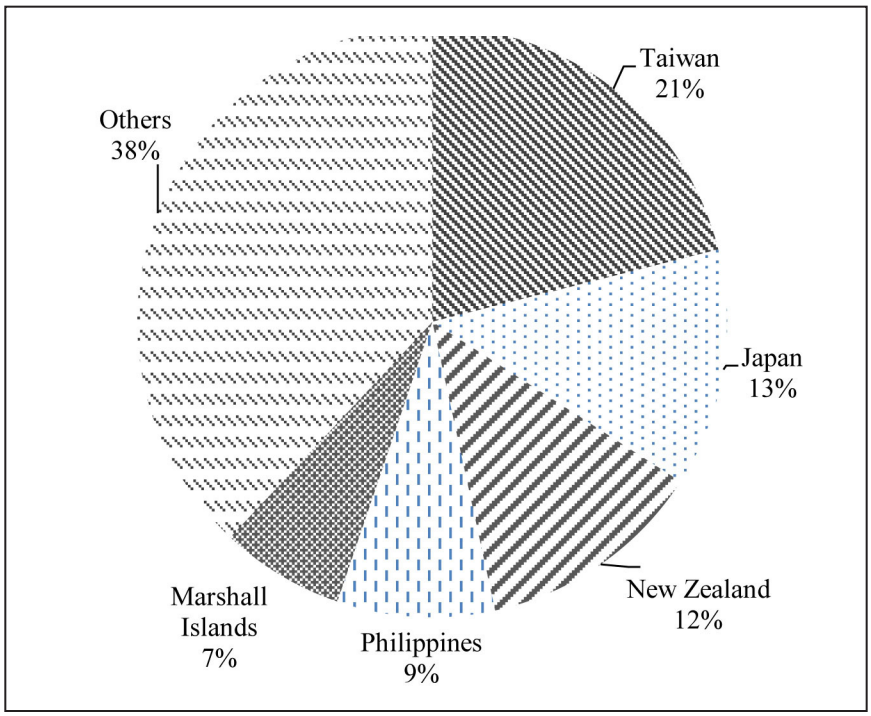

Figure 1.—Hawaii direct seafood imports by country of origin, 2000–09. (Source: FAS. 2011. Global agricultural trade system (GATS) online. Foreign Agric. Serv., Wash., D.C. Available online at http://www.fas.usda.gov/gats/default.aspx, accessed 28 Nov. 2011).

While we discuss seafood consumption in edible weight extensively in this article, most measures at the international level are collected and published in live weight. By utilizing FAO conversion factors, we were able to present Hawaii seafood production in live weight. In the same 10-year period analyzed (2000–09), the average annual estimate for commercial landings is 25.4 million live pounds. Similarly, the total contribution from aquaculture is 1.3 million live pounds, and 17.2 million live pounds from noncommercial catch in the same period. An additional 26.4 million live pounds of foreign seafood are imported annually. Likewise, 1.2 million live pounds of Hawaii seafood are exported to foreign countries.

Excluding noncommercial catch, the seafood consumption on an annual average (2000–09) in Hawaii is 68.8 million live pounds. With the inclusion of noncommercial catch, the estimate increases to 85.6 million live pounds. On a per capita basis, the seafood consumption on an annual average in Hawaii is 50 live pounds, without including noncommercial catch; and 63 live pounds, with the inclusion of the noncommercial catch.

Conclusions

This article assesses multiple dimensions of seafood activity in Hawaii, including expenditures, supply sources, consumption, species, and forms of seafood consumed. Specifically, it updates the total and per capita consumption of seafood in Hawaii, introduces noncommercial catch, and foreign transshipments via the continental United States into the analysis. Hawaii per capita seafood consumption is estimated at 29 edible pounds, significantly more than the 16 edible pounds for the United States. With the inclusion of noncommercial catch, the same measure increases to 37 edible pounds. The eight-pound per capita differential shows the significant contribution of noncommercial catch to Hawaii's seafood supply chain.

While we find that per capita seafood consumption in Hawaii has increased over time (36.4% between 1970–1977 and 2000–2009), the ratio of consumption between Hawaii and the rest of the United States has not changed much during the same period (ratio of 1.7 in 1970–1977 to 1.8 in 2000–2009), simply because the United States has been increasing its consumption of seafood. However, we did find a contrast in the variety and form of seafood eaten by each population. Hawaii consumes more fresh and frozen finfish, whereas the rest of the United States consumes more shellfish and processed seafood.

On seafood imports, we find that Hawaii receives 57% of its commercial supply from foreign sources and another 6% from the continental United States (Table 4). When noncommercial catch is included in the total seafood supply, the proportion from foreign sources falls to 44% and 5% from the continental United States. Future reliance on foreign sources may decline as exporting countries must satisfy their increasing domestic consumer demands for sea-

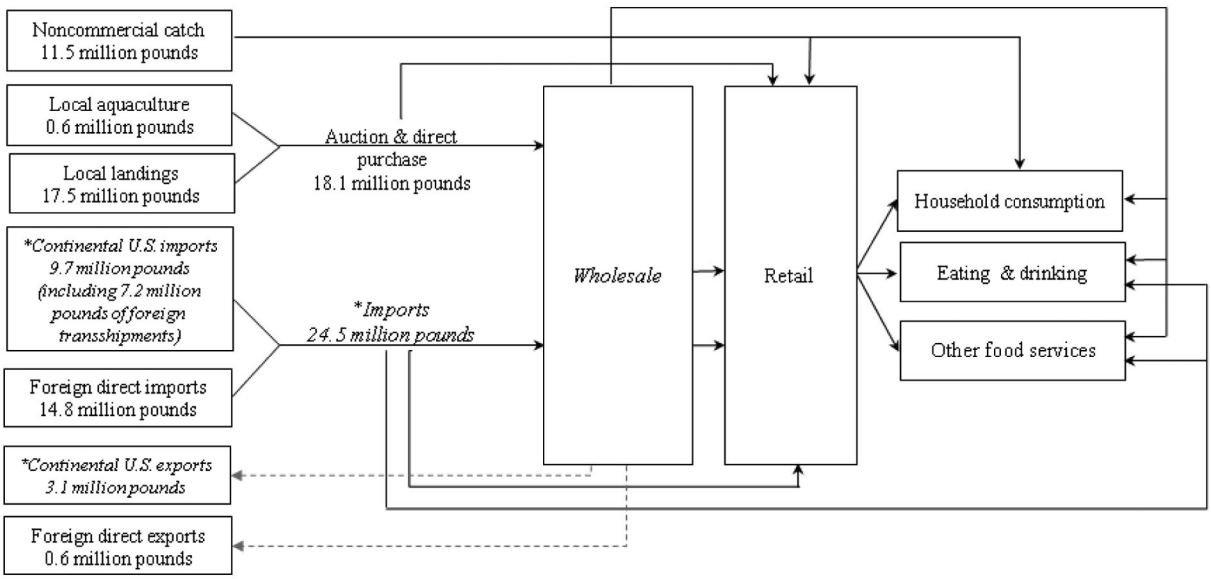

Figure 2.— Hawaii's seafood supply chain, annual average for 2000–2009. Italicized components refer to estimates based on multiple sources of information versus an officially published data source.

food, driven in part by population and income growth, while simultaneously confronting depletion pressures in their ocean resources and rising costs of production, which is driven to a large extent by higher fuel costs.

Estimates of per capita consumption and measurements of supply sources for seafood in Hawaii are essential to assessing the market competitiveness of local vs. imported seafood. These measures also provide valuable input to research and policy planning for Hawaii's efforts to redevelop a viable regional food system. The collection of primary data and the volatility of secondary data relating to Hawaii seafood imports from the continental United States imposed serious challenges to this research effort. Many responses in the dealers' survey were incomplete, and follow-up efforts, including emails and phone calls were equally elusive. Likewise, individual interviews with wholesalers (arranged by the HSC) were partially successful. In general, local seafood enterprises were polite but reluctant to disclose their import levels (sales, weight, and species). Similarly, the volatility of yearly import data imposed costly, multi-year analysis to arrive at more consistent measure estimates.

Figure 2 illustrates a pathway for continuing research in the seafood supply chain in Hawaii. It is important to assess the seafood supply flows from the wholesale sector to the retail sector and beyond to households, eating and drinking establishments (restaurants), and other food service establishments (food catering). The retail sector includes primarily supermarkets, grocery stores, club stores, and mass merchandisers. Likewise, it is useful to measure import flows directly to commercial retail, eating and drinking establishments, and other food service establishments. Finally, while noncommercial catch is intended for household consumption, it is also useful to assess its contribution (supply flow) to the retail sector in Hawaii.

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