Report to the Thirtieth Legislature
2015 Regular Session

Report on the Findings and Recommendations of Effectiveness of the West Hawai'i Regional Fishery Management Area

Prepared by

Department of Land and Natural Resources
State of Hawai'i

in response to

Section 188F-5, Hawai`i Revised Statutes

December 2014

PURPOSE OF THIS REPORT

This report is submitted in compliance with Act 306, SLH 1998, "Relating to the West Hawai′i Regional Fishery Management Area" and subsequently established as Chapter 188F, Hawaii Revised Statutes (HRS). This Statute requires a review of the effectiveness of the West Hawai′i Regional Fishery Management Area be conducted every five years by the Department of Land and Natural Resources (DLNR), in cooperation with the University of Hawai′i (§188F-5 HRS).

SUMMARY OF FINDINGS

The West Hawai′i Regional Fishery Management Area (WHRFMA) was created by Legislative Act 306 (1998) largely in response to longstanding and widespread conflict surrounding commercial aquarium collecting. The Act's requirement for 'substantive' community input in management decisions has been described as 'revolutionary.'

In order to accomplish the mandates of Act 306, a community advisory group, the West Hawai′i Fishery Council (WHFC) was convened by the Division of Aquatic Resources (DAR) in 1998. The first accomplishment of the WHFC was the designation of a network of nine no aquarium collecting- Fish Replenishment Areas (FRAs), comprising 35.2% of the coastline.

In addition to the development of the FRA network the WHFC has been successful in achieving a number of other notable management actions including lay gill net rules, species of special concern (e.g. sharks/rays) protection, a ban on SCUBA spearfishing and further comprehensive management of the aquarium fishery.

Several other West Hawai′i initiatives are in the works including no-take Fish Reserves and establishment of a limited entry commercial aquarium fishery. Based on over a decade and a half of experience, the WHFC has been found to be a model system for the resolution of issues surrounding reef fisheries resources.

The Hawai′i marine aquarium fishery is currently the most economically valuable commercial inshore fishery in the State with FY 2014 reported landings greater than $2.3 million.

The West Hawai′i aquarium fishery has undergone substantial and sustained expansion over the past 38 years. Total catch and value have increased by 22% and 45% respectively since FY 2000. Approximately 70% of the fish caught in the State and 67% of value presently comes from West Hawai′i.

Concerns over continued expansion of the aquarium fishery and harvesting effects in the open areas prompted DLNR to establish in 2013 a 'White List' of 40 species which can be taken by aquarium fishers. All other species of fish and invertebrates are off limits.

Of the 40 collected aquarium species, Yellow Tang comprise 84.3% of the total and Kole 8.3%. Since the FRAs were established the value of Yellow Tang has increased 79% while Kole have increased 10%.

2010 and 2014 Hawai'i Island aquarium catch report validation did not indicate substantial underreporting of catch by aquarium collectors. Dealer reports of purchases from collectors were

11% and 40% lower than the number reported sold due to the lack of a Hawaii Administrative Rule requiring dealer reports.

The West Hawaiʻi Aquarium Project (WHAP) has been monitoring West Hawaiʻi reefs since 1999 and a number of long-term studies extend over multiple decades. Over 16 years of monitoring, a total of 70 survey divers have conducted over 6,700 transects for the WHAP project in addition to hundreds of other surveys for related projects. This information is utilized to monitor the condition of the West Hawaiʻi's reefs and the impact of aquarium collecting.

The no-aquarium collecting Fish Replenishment Areas (FRAs), implemented in 1999, have been very successful in increasing populations of Yellow Tang (*Zebrasoma flavescens*) which is the most heavily targeted aquarium fish accounting for 84% of the total catch. Fifteen years after closure, the population of Yellow Tang has increased 64.5% in the FRAs while its abundance in the Open Areas has not declined significantly.

Overall Yellow Tang abundance in the 30'-60' depth range over the entire West Hawaiʻi coast has increased 58% (over 1.3 million fish) from 1999/2000 to 2012-2013 to a current population of 3.6 million fish.

Two of three sites at long-term studies in South Kohala and South Kona have found Yellow Tang populations have increased to levels found over three decades ago before the expansion of aquarium collecting.

Outward movement of adult Yellow Tang from protected areas into surrounding areas ('spillover') augments adult stocks in Open Areas up to a kilometer or more away.

There are no significant differences in the abundance of adult Yellow Tang in Open vs. closed areas in shallow water (10'-20' depths). Total estimated coastwise population of adult Yellow Tang in this depth range was estimated to be >2.5 million individuals.

West Hawaiʻi had a significantly greater percent change in Yellow Tang density within its networked MPAs (and Open Areas) as compared to the non-networked sites on Maui. Five of the 10 most collected aquarium fish in West Hawaiʻi were significantly more abundant in West Hawaiʻi's Open Areas as compared to Maui MPA closed areas.

The FRAs have also been very successful in increasing Kole (*Ctenochaetus strigosus*) populations. This species is the second most aquarium collected species, representing 8% of the total catch. The number of Kole increased significantly in all management areas, including Open Areas, from 1999/2000 to 2012/2013. Overall Kole abundance in 30'-60' depth range over the entire West Hawaiʻi coast increased 49% (over 2.1 million fish) during this time period with a current population of about 6.5 million fish.

Long-term West Hawaiʻi studies have found Kole populations to have decreased from 31% in South Kona to 71% in South Kohala. Given the length of protection at these sites and the overall decline in habitat quality and fish populations in South Kohala it seems unlikely that the declines are due primarily to aquarium collecting.

Comparative surveys utilizing DAR and NOAA data indicate Kole are substantially more abundant in West Hawaiʻi over most size ranges than in any of the other islands in the Main Hawaiian Islands or the Northwest Hawaiian Islands.

Commercial aquarium landings of Achilles Tang (*Acanthurus achilles*), the third most aquarium collected species, have declined in West Hawai'i over the past two decades in association with a recent dramatic increase in its value. This is strongly suggestive of declining availaility (i.e. abundance).

Achilles Tang have declined in FRAs and Open Areas over the last 15 years tempered somewhat by a slight increase in the last year or two. A similar declining trend is apparent within MPAs except for the last four years when their numbers have increased. Open Area populations are higher than FRA (albeit both being low).

Achilles Tang has had low levels of recruitment over the past decade and substantial numbers of larger fish (i.e. 'breeders') are taken for human consumption.

Achilles Tang is the only species on the 'White List' which is listed as an "Ecologically Unsustainable Species" by the Sustainable Aquarium Industry Association (SAIA) and monitoring data suggest there should be concern for the sustained abundance of this species.

Attempts to institute 'Adaptive Management' (i.e. a catch moratorium) both administratively and legislatively to address such situations as with Achilles Tang have not been successful.

Of the other top 10 collected aquarium species, two species (Forcepsfish – *Forcipiger flavissimus* and Potter's Angelfish – *Centropyge potteri*) increased in one or more of the management areas while two species (Ornate Wrasse – *Halichoeres ornatissimus* and Fourspot Butterflyfish – *Chaetodon quadrimaculatus*) declined. While the latter two species declined in the Open Areas, they also declined in one or the other of the protected areas (FRA or MPA) suggesting that factors other than aquarium collecting were also affecting their populations.

For 24 other species on the White List, five showed a significant population increase in one or more of the management areas while 11 decreased. Of the species which declined, only a single one - Bird Wrasse (*Gomphosus varius*) declined exclusively in the Open Areas indicating that factors other than aquarium collecting were also affecting the populations of the other species.

For the Bird Wrasse, reported annual take is so low and such a minimal percentage of the total Open Area population (< 0.5%) it's difficult to see how collecting alone could be the cause of this species' population decline in the Open Areas.

For most of the species on the White List, collecting impact, in terms of the percentage of the population being removed annually, is relatively low with eight species having single digit percent catch and 23 species having catch values <1%.

In terms of the yearly differences in a species' abundance between the Open Areas and the FRAs six species have been consistently more abundant in the FRAs than in the Open Areas. Eleven species showed no consistent pattern and 17 species were consistently more abundant in the Open Areas.

Besides harvest impacts, species abundances change over time due to both extrinsic and intrinsic factors. This is exemplified by the Saddle Wrasse which underwent significant declines in all management areas since 1999/2000. This species is consistently more abundant in the Open Areas than in the FRAs or MPAs.

Of the 40 species on the White List, 11 (27.5%) are considered endemic to Hawaiʻi. This is just slightly above the overall average (25%) of Hawaiʻi marine fish endemism. All but one of the endemic species (Psychedelic Wrasse - *Anampses chrysocephalus*) also occurs at Johnston Atoll.

Endemic fishes are often the most abundant in their genera or families presumably because they have had ample opportunity to become fully adapted to the local environment. A number of Hawaiian endemics are important food species and are harvested in substantial numbers both commercially and non-commercially.

Six of 11 endemic species on the White List are common in suitable habitat. Collecting pressure on 8 of these species takes <9% of their Open Area population annually. Seven of the 8 species have <1% of their population collected annually.

Survey data is lacking for six species which typically occur in deep water. Meaningful trends in catch report data for these species aren't readily apparent although there is some indication of a downward trend in catch for Tinker's Butterfly (*Chaetodon tinkeri*). Value isn't increasing, however, as would be expected if scarcity was affecting prices. It is clear that collection of Hawaii Longfin Anthias (*Pseudanthias hawaiiensis*) is a relatively recent development.

Based on deep diver observations, Tinker's Butterflyfish and Psychedelic Wrasse are substantially more common in the long term protected areas (MPAs) while Flame Wrasse and Hawaiian Longfin Anthias are more abundant in the FRAs. Sightings for all these species did not exceed 25% of observational dives.

Herbivore biomass is significantly higher (1.8X) in the West Hawaiʻi MPAs than in the FRAs or the Open areas, both of which are declining. Herbivore biomass is slightly but significantly greater in the FRAs than in the Open areas. Other types of fishing (i.e. food fishing) are likely responsible for observed differences between these areas and the more protected MPAs.

In West Hawaiʻi the aquarium fishery takes 1.8X the number of reef fishes taken by recreational and other commercial fishers combined. If Yellow Tang, which is primarily harvested at small sizes and not targeted by other fishers, is excluded, the recreational and commercial fisheries combine to take 3X the number of reef fishes caught by aquarium collectors.

In terms of reef fish biomass caught by the different fisheries in West Hawaiʻi, considerably more biomass is taken by the combined recreational and commercial fisheries either including Yellow Tang (2.8X) or excluding it (8.6X).

The total take of reef fish by commercial and non-commercial fishers on other Main Hawaii Islands greatly exceeds the numbers and biomass of the fish taken by aquarium collectors.

RECOMMENDATIONS

Based on the results of this review and evaluation, the following recommendations are proposed:

1. Biological and fishery results to date indicate the FRAs are clearly working and are expected to increase in importance as time progresses. Since the recent inclusion of a new FRA at Kaʻohe (Pebble Beach), South Kona, there are no compelling reasons at present to alter the makeup of the existing network of protected areas.

2. As monitoring and evaluation of the FRAs is required by law and necessary to further understand the dynamics of our coral reef ecosystem, a dedicated monitoring program similar to WHAP needs to be continued and financially supported by the State of Hawai′i. As of now the monitoring program is wholly dependent on extramural funds (i.e. NOAA) for its continued existence.

3. Community input and co-management responsibility has proven to be critical in the establishment and legitimacy of the FRA network. Community advisory groups such as the West Hawai′i Fishery Council should be encouraged and supported by DLNR.

4. Maintain and continue support and implement co-management efforts at Ka′ūpūlehu, Ho′okena, Puakō, Miloli′i, and other interested communities.

5. Experienced facilitators preferably with training in environmental dispute resolution need to work with community advisory groups when addressing complex and contentious marine resource issues. This would also be desirable for DAR when holding particularly contentious community meetings and public hearings.

6. While FRAs are an excellent strategy to manage the most abundant and heavily collected aquarium species, uncommon, rare or ecologically important species require species-specific harvesting limitations in open areas.

7. Legislative authority for the BLNR to adopt 'Adaptive Management' is essential for real time response to emerging resource issues. This will become increasing important as the effects of global climate change become manifest.

8. A limited entry aquarium fishery should be established in West Hawai′i to curtail possible unsustainable expansion in the future. Clear legislative authority for such a limited entry program is desirable and possibly necessary.

9. DLNR should prioritize the adoption of a Hawaiian Administrative rule required a marine dealer report. This would allow for a comprehensive verification of aquarium dealer and collector catch reports to determine reporting accuracy.

10. An effective DOCARE enforcement "presence" on the water and along coastal areas is essential for long term sustainability of our marine resources. Legislative authority permitting DOCARE to inspect catch/fish boxes/coolers is imperative for effective enforcement.

11. The effectiveness of the West Hawai′i FRAs for aquarium fish suggests it would be prudent to establish MPAs for other resource species throughout Hawai′i as a precautionary measure against overfishing and for restoration of marine resources. Currently, less than 1% of the Main Hawaiian Islands is fully protected by MPAs.

12. MPAs should be large enough for self-recruitment of short distance dispersing propagules and spaced far enough apart that long distance dispersing propagules released from one reserve can settle in adjacent reserves.

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BACKGROUND

The West Hawai'i Regional Fishery Management Area (WHRFMA) was conceived and established primarily in response to the activities of aquarium collectors along the West Hawai'i coastline.

The aquarium collecting industry in Hawai'i and especially in West Hawai'i has long been a subject of controversy. Walsh et al. 2003 provides an historical overview of the commercial aquarium fishery in Hawai'i. This controversy continues to this day with repeated efforts by anti-aquarium advocates to shut down the fishery by one stratagem or another. A recent Hawai′i County Council initiative (West Hawaii Today 2014) and an anticipated proposed legislative ban (Evans, pers. Comm.) attest to this ongoing controversy. As such, particular emphasis is placed in this report on the West Hawai′i aquarium fishery and related findings of coral reef monitoring on West Hawai′i reefs.

In contrast to other areas in the State, in West Hawai'i, the aquarium fishery has undergone substantial and sustained expansion over the past 30 years (Figure 1). In FY 2014 there were 51 commercial West Hawai′i aquarium permits. Of the issued permits, 41 reported some aquarium catch with 19 reporting substantial catch (>10K) of Yellow Tang, the prime species in the fishery.

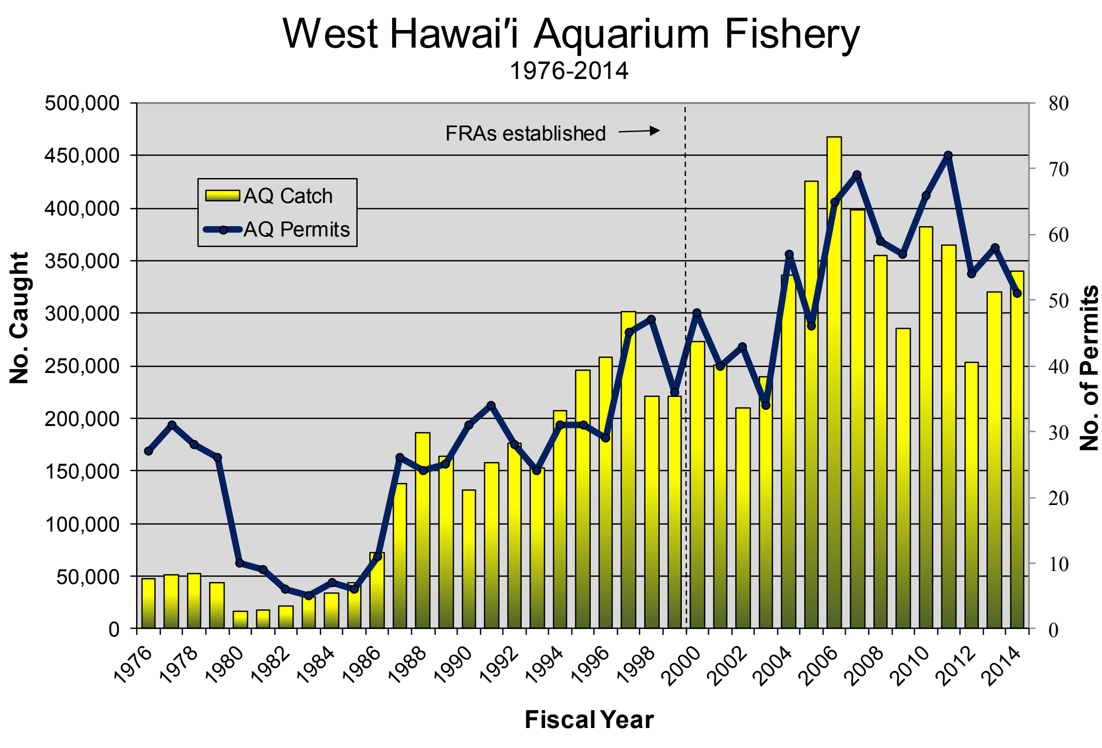


Figure 1. Number of aquarium animals collected and number of commercial aquarium permits in West Hawai′i for Fiscal years (FY) 1976-2014.

As the number of collectors in West Hawai'i began to rise in the 1980s and the numbers of animals collected increased markedly, conflict escalated along the coast, most particularly between dive tour operators and collectors. A short-lived informal "Gentleperson's Agreement" was reached in 1987 whereby aquarium collectors agreed to refrain from collecting in certain areas. In return, charter operators agreed not to initiate legislation opposing collecting and to cease harassment. In 1991, four of the areas from the Gentleperson's Agreement were established as the Kona Coast Fisheries Management Area (FMA) within which aquarium collecting is prohibited (HAR §13-58).

In spite of these management efforts, controversy and conflict over aquarium collecting continued unabated. Various meetings were held and legislative resolutions and bills were drafted to address the issue. A 1996 House Concurrent Resolution (HCR 184) requested the Department of Land and Natural Resources (DLNR), in conjunction with a citizens' task force, to develop a comprehensive management plan to regulate the collection of aquarium fish. A West Hawai'i Reef Fish Working Group (WHRFWG) involving over 70 members of the West Hawai'i community including aquarium collectors and charter operators and other stakeholders held nine meetings over a 15 month period. The WHRFWG opened a dialog between user groups and community members and provided a forum for the education of its members on social and biological issues involved in resource management.

The WHRFWG identified "hot spots" along the coast where conflict over ocean resources was especially intense and ultimately proposed a wide range of management recommendations, some of which were included in the 1997 DLNR legislative package. Working directly with the people of Ho'okena and Miloli'i, DAR also developed comprehensive FMA rule proposals for each of these communities. To finally begin investigating the biological impact of collecting, DAR commenced a joint research project with the University of Hawai'i-Hilo. Due in part to opposition by O'ahu aquarium collectors and a lack of agency and political support, only two legislative recommendations of the WHRFWG passed; establishing dealer licenses and increasing commercial license fees. Similarly, recommendations involving the DAR FMA rule proposals languished.

Act 306, SLH 1998

In response to the perceived lack of success in adequately dealing with aquarium collecting, a number of citizens, including several members of the WHRFWG formed a grassroots organization, the Lost Fish Coalition (LFC), to push for a total ban on aquarium collecting in West Hawai'i. They collected almost 4,000 signatures on a petition to ban such collecting. In January 1997, Representative (Rep.) Paul Whalen (R-Kona, Ka'u) introduced legislation (House Bill (HB) 3349) which proposed an outright ban on all collecting between Kawaihae and Miloli'i. Shortly thereafter, Rep. David Tarnas (D-N. Kona, S. Kohala) introduced HB 3457. This bill proposed establishing a West Hawai'i Regional Fishery Management Area (WHRFMA) along the entire 147 mile West Hawai'i coast (Upolu Pt. to Ka Lae) to provide for effective management of marine resources. Among several provisions of this bill was a requirement to set aside 50% of the WHRFMA as Fish Replenishment Areas (FRAs) where aquarium collecting was prohibited. In February 1998, HB 3348 was put on hold. During committee hearings on HB 3457, the 50% provision for FRAs was reduced to "a minimum of 30%." Aquarium collectors and other user groups endorsed the bill and it was passed by the Legislature as Act 306, SLH

1998; effective 13 July 1998. It was subsequently codified as Hawaii Revised Statue – HRS 188F.

Given the longstanding and contentious nature of the aquarium issue in West Hawaiʻi, the importance of legislation in finally addressing the issue cannot be underestimated. It was only when organized and concerted community effort was applied directly via the legislative process that the means for resolution was made possible. It seems highly likely that without the direct legislative mandates of Act 306, SLH 1998, little progress would have been made in successfully managing this controversial fishery.

Act 306, SLH 1998 established a West Hawai'i Regional Fishery Management Area along the entire west coast of the Island of Hawai'i (§188F-4, HRS). Overall, the purposes of Act 306 were to:

(1) Effectively manage fishery activities to ensure sustainability;
(2) Enhance nearshore resources;
(3) Minimize conflicts of use in this coastal area.

There were also four specific management objectives to be accomplished by DLNR:

(1) Designate a minimum of 30% of coastal waters as Fish Replenishment Areas (FRAs) where aquarium collecting is prohibited.
(2) Establish a day-use mooring buoy system and designate some high-use areas where no anchoring is allowed.
(3) Establish a portion of the FRAs as fish reserves where no fishing of reef-dwelling fish is allowed.
(4) Designate areas where the use of gill nets is prohibited.

A review of the WHRFMA management plan was to be conducted every five years by DLNR in cooperation with the University of Hawaiʻi.

Additionally, Act 306, SLH 1998, also provided for "substantive involvement of the community in resource management decisions." This mandate was a unique and key aspect of the legislation which allowed the community to actively participate in the development of resource management actions. This approach was at once both innovative and far-reaching. As noted by Maurin and Peck (2008) "The Act's requirement for 'substantive' community input before management decisions can be taken to achieve the goals has been described as 'revolutionary.' It required, explicitly and for the first time, that the state agency regulating ocean use go beyond the standard public hearings which often occur late in the rule-writing process, and engage in active and ongoing consultation with its constituents.

The West Hawai'i Fishery Council (WHFC)

In order to accomplish the mandates of Act 306, SLH 1998, with substantive community input, The West Hawaiʻi Fishery Council (WHFC) was convened June 16, 1998 under the aegis of DLNR and the University of Hawaiʻi Sea Grant. Consisting of 24 voting members and 6 ex-officio agency representatives from DLNR, Sea Grant, and the Governor's Office, the WHFC's members represented diverse geographic areas and various stakeholder, community and user groups in West Hawai'i. Four aquarium representatives (three collectors and one aquarium shop owner) were members of the WHFC, 40% of the WHFC were makaʻāinana and most of the members were previously on the WHRFWG.

The West Hawaiʻi Fishery Council provided the vehicle for stakeholders to participate directly in the development of management recommendations. Such participation has important benefits for increasing legitimacy of decisions in the eyes of stakeholders, as well as increasing compliance with decisions and rules subsequently established (Kessler 2004). More detailed information on the background, activities and membership of the WHFC is available on their website: http://westhawaiifisherycouncil.org.

The first mandate of Act 306 was the establishment the FRAs. FRAs were mandated to address concerns over user conflict and localized resource depletion caused by aquarium fish collectors in West Hawai'i. Working under a punishing deadline, the WHFC, by determination, consensus and vote, developed an FRA plan consisting of nine separate areas along the coast (Figure 2) encompassing a total of 35.2% of the West Hawaiʻi coastline (including already protected areas). Perhaps somewhat surprisingly the areas specifically recommended as FRAs by the aquarium collecting representatives on the Council showed remarkable congruence with those selected by the WHFC as a whole.

The WHFC and the FRA development process have been the focus of a number of in-depth reports and scientific case studies (Walsh 1999, Capitini et al. 2004, Tissot 2005, Maurin and Peck 2008, Tissot et al. 2009, Gregory 2009, Rossiter and Levine 2013) making it one of the most intensively studied community driven management efforts in the State of Hawai'i.

The WHFC's FRA plan was subsequently incorporated by DLNR into administrative rule. The 28 April 1999 public hearing on the FRA Rule (HAR 13-60.3) was the largest public hearing ever conducted by DAR with at least 860 attendees. The draft rule received overwhelming support (93.5% of 876 testimonies) from a wide range of community sectors. The FRA administrative rule was signed by Governor Benjamin Cayetano on 17 December 1999 becoming effective 31 December 1999.

The FRAs prohibit all collecting of aquarium animals within their boundaries as well as non-fishing related fish feeding. The seaward boundaries of the FRAs extend to a depth of 100 fathoms and distinctive signs mark the boundaries on shore.

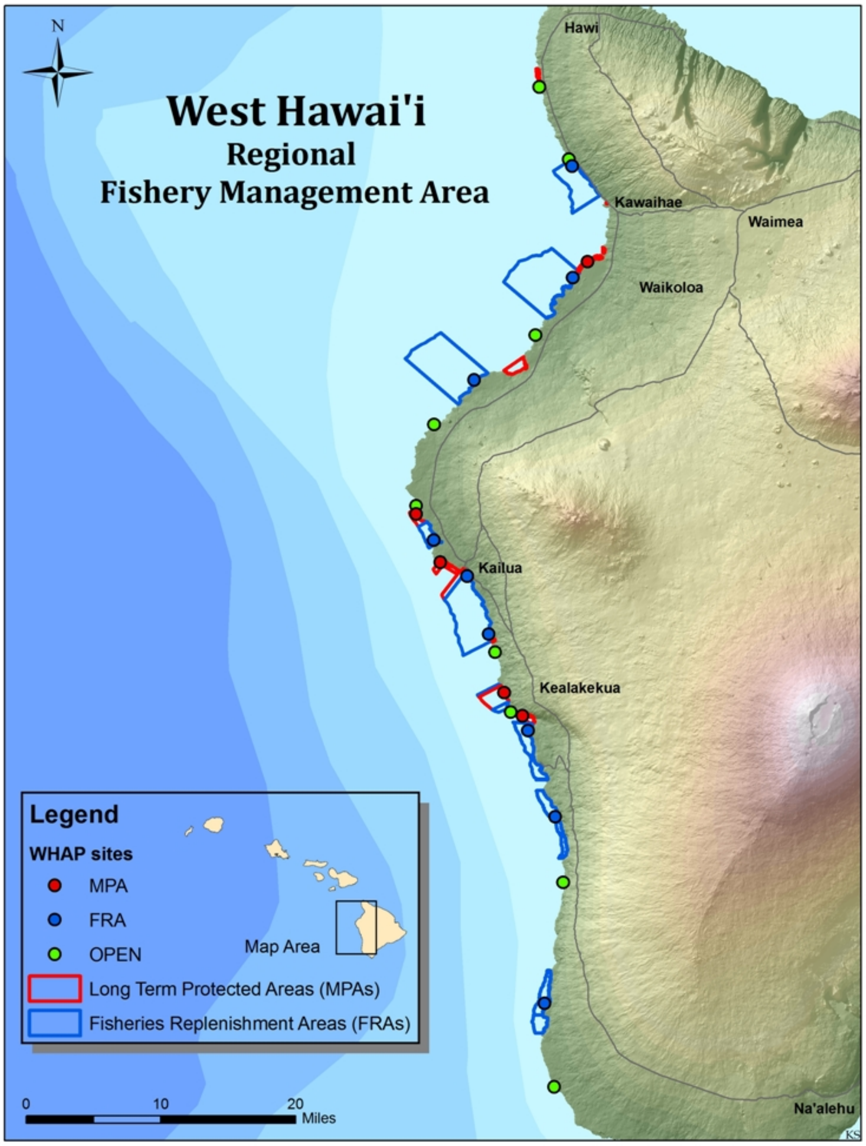


Figure 2. Locations of Fish Replenishment Areas (FRAs) in West Hawai'i and DAR monitoring sites (5 MPAs, 9 FRAs and 9 open sites)

In addition to the development of the FRA network, the WHFC, in conjunction with DAR and UH Sea Grant, has been successful in achieving a number of other accomplishments:

- **Sea Urchin Limited Harvest**: The WHFC developed a management plan permitting the sustainable harvest of *wana* (long-spine/black sea urchin) at Makae'o, the Old Kona Airport Marine Life Conservation District (MLCD). This recommendation was adopted by DLNR as an administrative rule amendment in 2005.
- **The West Hawai'i Youth Fishery Council**: An outreach component of the WHFC, the Youth Fishery Council worked with the Hawai'i County Council to ban smoking at Kahalu'u Beach Park.

- **Gill Net Rules**: The WHFC developed a set of gill net rule recommendations focused on limiting impacts of large-scale commercial netting while providing for subsistence netting. This recommendation was adopted as an administrative rule amendment in 2005 and served as a model for the statewide gill net rule (HAR §13-75-12.4) which was adopted in 2007.
- **Day-Use Mooring Buoys**: In collaboration with the Malama Kai Foundation, the WHFC is a working partner in the site selection process and educates communities on the value of day use moorings to preserve our coral reefs.
- **Kaʻūpūlehu Marine Reserve**: DAR worked with the WHFC and the Kaʻupulehu Marine Life Advisory Committee (KMLAC) to develop draft rules to re-designate the Ka'upulehu Fish Replenishment Area as a Marine Reserve where the take of nearshore marine life will be prohibited for 10 years, with exceptions to allow for the continued harvest of pelagic and deep benthic species using specific fishing gear. The proposal is the initial first step in complying with the statutory mandate of HRS §188F-4(3) to establish a portion of the Fish Replenishment Areas where no fishing of reef-dwelling fish is allowed. In October, 2014 the BLNR approved holding a Public Hearing on this rule amendment. Several other local communities are actively engaged in developing management recommendations which include some form of a highly protected nearshore area.
- **SCUBA Spear Fishing Prohibition**: The WHFC proposed banning SCUBA (and rebreather) spear fishing in West Hawai'i as is the case in most other Pacific island jurisdictions.
- **Pebble Beach User Conflict**: The WHFC drafted recommendations addressing a conflict between aquarium collectors and this South Kona community. It recommended creating a new FRA in the Pebble Beach area and opening up to collecting a similarly sized section of another FRA (by a non-residential area). The latter part of the 'swap' was subsequently rejected by aquarium collectors.
- **Aquarium 'White List'**: Working with commercial aquarium collectors the WHFC established a list of 40 fish species permitted for aquarium take. Only those fish found on the White List can be collected live for aquarium use. All other fishes and all invertebrates are off-limits to collecting. Size and bag limits are also established for three of the species on the White List. (See Table 5 for list of White List species).
- **Species of Special Concern**: Prohibition on the take or possession of nine species of inshore sharks and rays and two invertebrate crown-of-thorns predators (Table 1).

Table 1. List of species for which all take or possession is prohibited within the West Hawaiʻi Regional Fishery Management Area (WHRFMA)

Common Name	Scientific Name	Hawaiian Name
Spotted Eagleray	*Aetobatus narinari*	Hīhīmanu
Broad Stingray	*Dasyatis lata*	Hīhīmanu
Pelagic Stingray	*Pteroplatytrygon violacea*	Hīhīmanu
Hawaiian Stingray	*Dasyatis hawaiiensis*	Hīhīmanu
Tiger Shark	*Galeocerdo cuvier*	Manō/niuhi

Whale Shark	*Rhincodon typus*	Lele wa'a
Whitetip Reef Shark	*Triaenodon obesus*	Manō lālākea
Blacktip Reef Shark	*Carcharhinus melanopterus*	Manō pā'ele
Gray Reef Shark	*Carcharhinus amblyrhynchos*	Manō
Triton's Trumpet	*Charonia tritonis*	'Ōlē
Horned Helmet	*Cassis cornuta*	Pū puhi

The last four bulleted recommendations (above) received overwhelming support during the Hawaii Administrative Rule public hearing process (Figure 3) and were adopted as an new administrative rule (HAR 13-60.4) which became effective December 26, 2013 after being signed by Governor Neil Abercrombie.

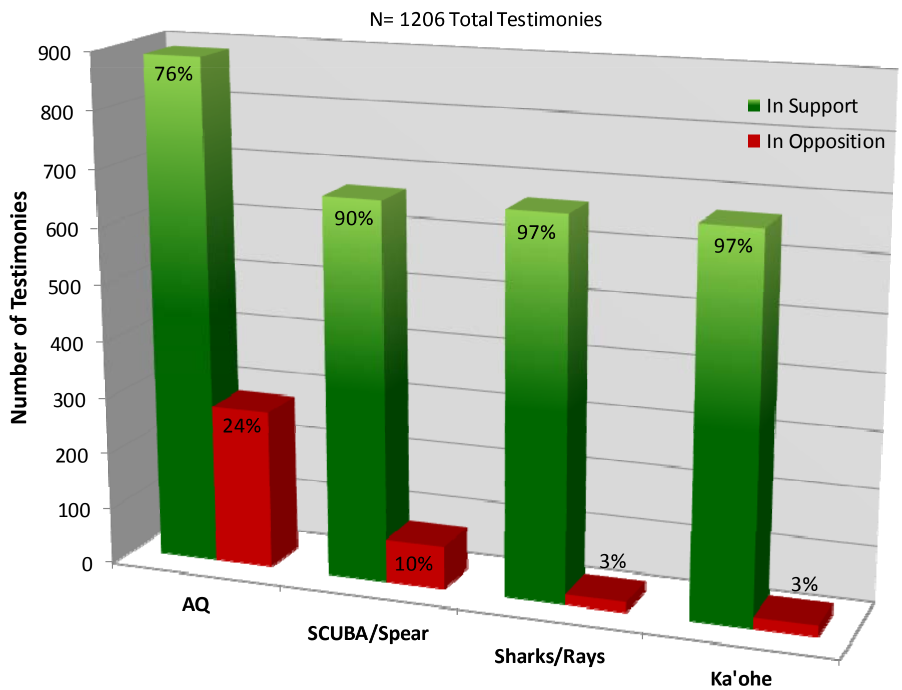


Figure 3. Summary of all public testimonies on WHRFMA rule (HAR 13-60.4)

The creation and functioning of the WHFC is entirely attributable to the volunteer commitment of time, energy and resources of its members. The 70 members of the community who have been members at one time or another of the WHFC have contributed thousands of hours of their own time at no cost to the State. While not directly authorized by state law, this community-based advisory body represents a valuable tool to state government in terms of its approach to and recommendations on marine resource management. These efforts have been assisted by the support of community organizations such as the Hawai'i Community Foundation, The Nature Conservancy, Community Conservation Network, the Malama Kai Foundation and especially the Harold Castle Foundation, all of whom recognize the significance and value of the WHFC and its role in assisting in effective management of our marine resources.

West Hawai`i Aquarium Fishery.

The marine aquarium fishery is currently the most economically valuable commercial inshore fishery in the State of Hawai'i with FY 2014 reported landings greater than $2.3 million (Figure 4). It should be noted that the dollar value of these fisheries represents only the *ex-vessel* value - what the fishers are paid for their catch, and does not include the value which would be generated by additional dealer and retail sales. The actual economic value of the catch is thus substantially greater than the ex-vessel values shown in figure 4.

Although specific export data does not exist for the aquarium fishery, it is clear that most of the aquarium catch is shipped out of the state to dealers on the mainland United States, Europe and Asia (Dierking 2002). This is neither surprising nor atypical for commercial fisheries in Hawai′i. For example, seafood exports of various Hawaiian species exceed 3.7 million pounds annually (Loke et al. 2012).

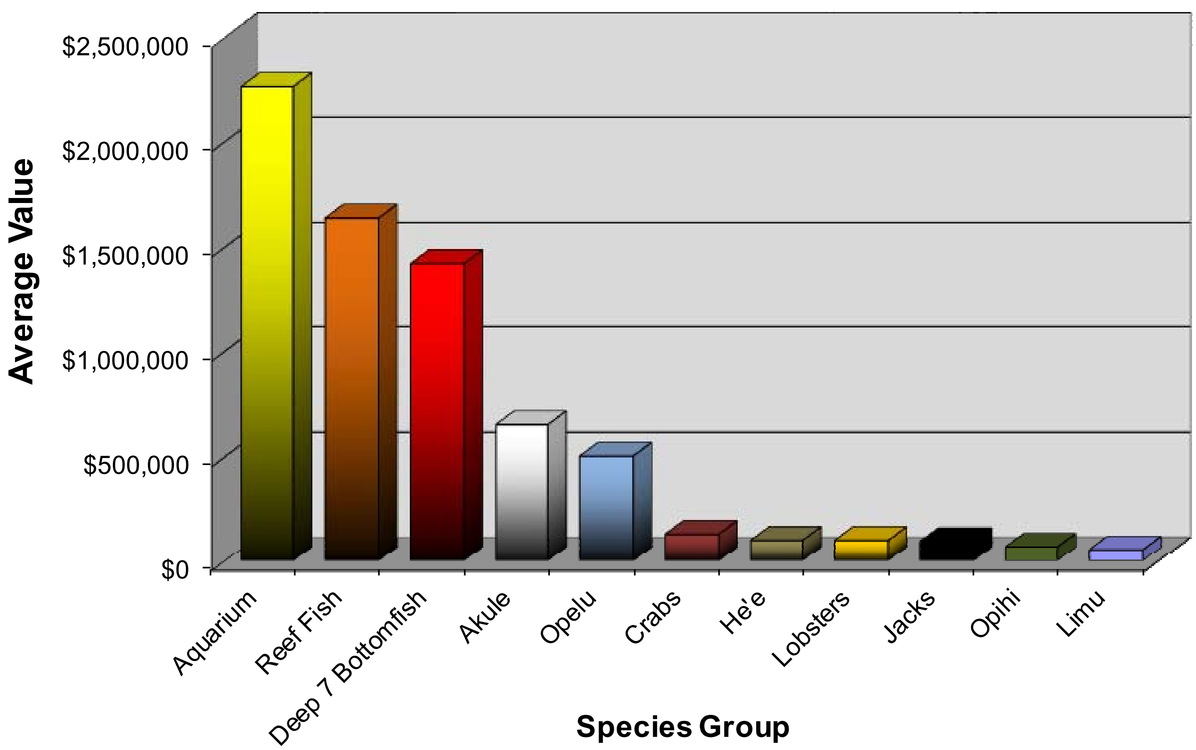


Figure 4. Economic value for various inshore fisheries of the main Hawaiian Islands. Value ($ adjusted for inflation) averaged over FY 2012-2014

Presently 78% of fish caught in the State and 68% of the total aquarium catch value comes from the Big Island and almost exclusively from West Hawai'i (Table 2). The total aquarium catch and its value have continued to increase since the FRAs were established in 2000 while the number of collectors has declined in recent years from a peak in 2005/2006.

Even though initially there was substantial opposition to the implementation of the FRA network by aquarium fishers and their supporters (Walsh 1999, Capitini et al. 2004, Maurin and Peck 2008) it's clear that overall catch has not declined and recent work (Stevenson et al. 2013) has indicated that the economic status of West Hawai'i aquarium collectors has significantly improved since the FRA network was implemented.

Of the 40 fish species which can now be collected in West Hawai'i, two surgeonfishes comprise the overwhelming portion of the catch. Yellow Tang (*Zebrasoma flavescens*) currently constitutes 84.3% of the total catch while the Goldring Surgeonfish – Kole (*Ctenochaetus strigosus*) makes up 8.3%. Since the FRAs were established the ex-vessel value of Yellow Tang has increased 79% (currently $4.04/fish) while Kole has increased 10% ($2.47/fish). It is interesting to note that on a price per pound basis Yellow Tang is easily the most valuable marine organism in Hawai'i which are commercially caught in relatively large numbers. Based on mean size at capture data (6.1cm SL - Stevenson et al. 2011) the ex-vessel price for Yellow Tang exceeds $250/lb. which currently is about the price of silver bullion.

Table 2. Changes in West Hawai'i aquarium fishery since implementation of the FRAs. Dollar value is adjusted for inflation

	FY 2000	FY 2014	Δ
No. Permits	48	51	6% ↑
Total Catch	279,606	339,898	22% ↑
Total Value	$1,081,980	$1,573,078	45% ↑
% of State Fish Catch	70%	78%	8% ↑
% of State Fish Value	67%	71%	4% ↑
% of State Total Catch	55%	58%	3% ↑
% of State Total Value	59%	68%	9% ↑

Earlier studies suggested that the reported aquarium catch may have been underestimated by a factor of approximately 2X to 5X (Cesar et al. 2002, Walsh et al. 2003). However, an analysis of FY 2010 and FY 2014 data comparing Hawai'i Island aquarium catch report data with dealer purchase data from collectors found a good correspondence in reported numbers of animals caught and sold by aquarium collectors. In FY 2010 there was a 3.5% difference between the numbers of animals reported caught and sold and in FY2014 the difference was only 0.4% (Figure 5). These small differences likely represent both live releases and mortality.

Dealer reports of purchases (including retail sales) from Hawai'i collectors were 10.9% *lower* in FY 2010 and 40.1% lower in FY 2014 than the number reported sold by collectors. There are two likely reasons for this discrepancy. First, and most importantly, unlike with aquarium collectors, there currently is no Hawaii Administrative Rule (HAR) requiring dealers to report aquarium purchases (or food species) even though the department has long had statutory authority (HRS §189-10 – last amended in 1997) to adopt such rules.

DAR currently has a commercial marine dealer license and a commercial marine dealer report which clearly states that Commercial Marine Dealers are required to submit monthly reports. However DAR is not enforcing this requirement because of the lack of an applicable HAR and apparently some dealers are aware of this. Thus dealer reporting is essentially on a voluntary basis and a few dealers are not reporting in whole or in part.

Additionally, the catch of aquarium collectors who sell fish to out of state dealers disappears since these dealers have absolutely no requirement (however tenuous) to file dealer reports with DAR. Even with these onerous limitations in catch report validation, the 2010/2014 comparison did not indicate substantial *underreporting* of catch by aquarium collectors.

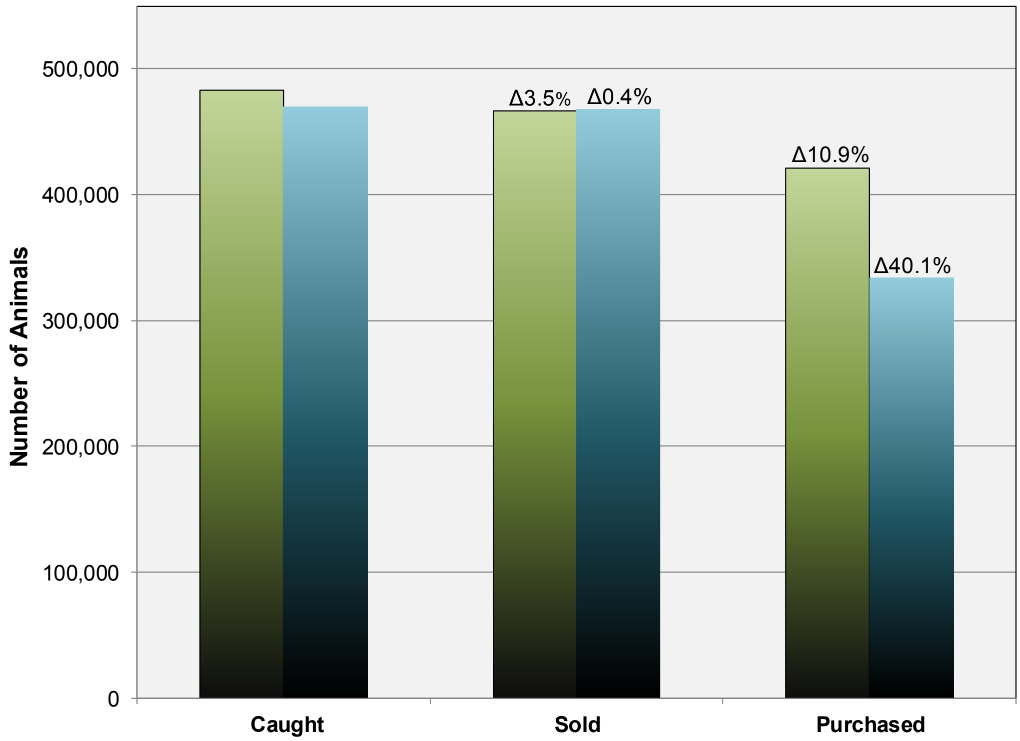


Figure 5. Comparison between Hawai'i Island aquarium collector report data and dealer purchases of aquarium animals from the collectors. Green bars represent FY 2010 data and blue bars FY 2014 data

West Hawai'i Aquarium Project (WHAP)

Although Act 306, SLH 1998, mandated review and evaluation (thus monitoring) of the FRAs in conjunction with UH, no funding was provided to accomplish this. In order to investigate the effectiveness of the FRAs to replenish depleted fish stocks, a consortium of researchers established the West Hawai'i Aquarium Project (WHAP) in early 1999. Funding was secured for the early years of the project through the Hawai'i Coral Reef Initiative Research Program (HCRI-RP), a federal initiative under the aegis of the National Oceanic and Atmospheric Administration (NOAA). Subsequent funding has been provided by Coral Reef Monitoring Grants under NOAA's Coral Reef Conservation Program. The initial project researchers were Dr. William Walsh, DAR/DLNR, Dr. Brian Tissot, Humboldt University, and Dr. Leon Hallacher, University of Hawai'i Hilo. They have been joined in recent years by Dr. Ivor Williams and Dr. Jill Zamzow, National Marine Fisheries Service, Coral Reef Ecosystem Division and on related projects by Dr. Mark Hixon, University of Hawai'i Mānoa and Dr. Helen Fox, Rare org.

WHAP established 23 study sites (Figure 2) along the West Hawai'i coastline in early 1999 at 9 FRA sites, 8 open sites (aquarium fish collection areas) and 6 previously established Marine Protected Areas (MPAs) to collect baseline data both prior to and after the closure of the FRAs. The MPAs are Marine Life Conservation Districts (MLCD) and Fishery Management Areas (FMA), which have been closed to aquarium collecting for at least 9 years and were presumed to have close to "natural" levels of aquarium fish abundances. They serve as a reference or 'control' to compare with the FRAs and open areas. It should be noted that after several years of study and observation, one of the MPA sites (Lapakahi MLCD – subzone B), was found to really not be closed to aquarium collecting due to its remoteness and poorly defined seaward boundaries (i.e. 500 feet offshore). As such the Lapakahi survey site is considered an Open Area for data analysis.

The overall goals of WHAP were two-fold: 1) To evaluate the effectiveness of the FRA network by comparing targeted aquarium fishes in FRAs and open areas relative to adjacent control sites and, 2) To evaluate the impact of the FRA network on the aquarium fishery.

Detailed explanations of the study sites and survey methodology are contained in Tissot et al. 2004 and Walsh et al. 2013. To briefly summarize: Densities of all fish and selected invertebrate species are visually estimated along four 25mX4m strip transects at each of 23 permanent sites in the three types of management areas. All survey divers either have extensive experience in conducting underwater fish surveys in Hawai'i or received training through the UH's Quantitative Underwater Ecological Survey Techniques (QUEST) training course prior to collecting data (Hallacher and Tissot, 1999). In addition to the transect surveys, a 10 minute 'free-swim' survey is also conducted by two divers in the areas surrounding the actual transects. The purpose of this survey is to better census uncommon or rare species and species of particular ecological interest such as Taape, Roi, terminal phase parrotfish, Cleaner Wrasses and Crown-of-Thorns Starfish. All sites are presently surveyed four times a year. As of December 2014, a total of 75 survey rounds of all study sites have been completed (>6,500 transects). Six rounds were conducted prior to FRA closure in 1999.

The scientific information presented in this report represents the cumulative efforts of 70 survey divers (See Acknowledgements) who conducted over 6,700 transects for the WHAP project over the past 15 years in addition to hundreds of other surveys for other related projects.

FINDINGS AND EVALUATION

<u>Fish Replenishment Areas (FRAs)- Aquarium Collecting Impacts</u>

The overall changes in abundance since FRA establishment for the top 10 most collected aquarium fishes are shown in Table 3. The ρ value in the far right column of Table 3 (and reported elsewhere) is a measure of the significance of the difference between populations, in this case the density (i.e. abundance) between the Before and After periods. The ρ-value is a number between 0 and 1 and interpreted in the following way (after Rumsey 2011):

- A small ρ-value (typically ≤ 0.05) indicates strong evidence *against* the hypothesis that there is *no difference* between the populations – in other words, there is a real (i.e. 'significant') difference in the abundance of the two populations.

- A large ρ-value (> 0.05) indicates the opposite; that there is no significant difference in the abundance of the two populations.

These 10 species represent 98.3% of all the fish collected in West Hawaiʻi in FY 2014. The two most heavily collected species, Yellow Tang and Goldring Surgeonfish (aka Kole) alone account for 92.6% of total fish catch and thus are key indicators of the protective value of the FRAs and the sustainability of the aquarium fishery. Since 1999/2000 both of these species have increased markedly (and significantly) in the FRAs and MPAs and in the Open Areas for Kole as well.

Table 3. Changes in abundance of the top ten most collected aquarium fishes in West Hawaiʻi. 'Before' = Mean of 1999-2000; 'After' = Mean of 2012-2013. Shaded cells show statistically significant increases (green) and decreases (red). Young of Year (YOY) not included. Bold = statistically significant t-test

COMMON NAME	SCIENTIFIC NAME		MEAN DENSITY ($NO./100M^2$)		OVERALL % CHANGE IN DENSITY	ρ
			Before	**After**		
Yellow Tang	*Zebrasoma flavescens*	**FRA**	**12.73**	**20.94**	**+64.5%**	**<0.001**
		Open	10.24	9.75	-4.7%	0.08
		MPA	**23.08**	**25.32**	**+9.7%**	**<0.001**
Goldring Surgeonfish	*Ctenochaetus strigosus*	**FRA**	**28.38**	**35.27**	**+24.3%**	**<0.001**
		Open	**21.18**	**26.99**	**+27.5%**	**<0.001**
		MPA	**28.56**	**40.56**	**+42.0%**	**<0.001**
Achilles Tang	*Acanthurus achilles*	**FRA**	**0.26**	**0.09**	**-64.2%**	**0.004**
		Open	0.31	0.20	-35.4%	0.07
		MPA	0.42	0.54	+28.4%	0.33
Orangespine Unicornfish	*Naso lituratus*	FRA	0.81	0.67	-17.6%	0.11
		Open	1.12	1.31	+17.1%	0.16
		MPA	1.59	1.57	-1.4%	0.89
Black Surgeonfish	*Ctenochaetus hawaiiensis*	FRA	0.18	0.28	+57.7%	0.14
		Open	0.17	0.25	+50.8%	0.09
		MPA	0.53	0.48	-11.1%	0.58
Forcepsfish	*Forcipiger flavissimus*	**FRA**	**0.41**	**0.68**	**+67.0%**	**0.002**
		Open	0.41	0.41	+1.0%	0.95
		MPA	0.84	0.71	-15.2%	0.34
Potter's Angelfish	*Centropyge potteri*	**FRA**	**1.38**	**1.75**	**+27.2%**	**0.001**
		Open	**1.65**	**2.21**	**+33.9%**	**<0.001**
		MPA	1.54	1.84	+19.7%	0.09

Ornate Wrasse	*Halichoeres ornatissimus*	**FRA**	**0.94**	**0.65**	**-30.8%**	**0.004**
		Open	**2.20**	**1.79**	**-18.5%**	**0.005**
		MPA	1.24	1.15	-6.9%	0.56
Fourspot Butterflyfish	*Chaetodon quadrimaculatus*	FRA	0.05	0.05	-7.1%	0.93
		Open	**0.54**	**0.20**	**-61.7%**	**<0.001**
		MPA	**0.43**	**0.18**	**-58.3%**	**0.007**
Orangeband Surgeonfish	*Acanthurus olivaceus*	FRA	0.13	0.16	+25.0%	0.63
		Open	0.31	0.24	-22.2%	0.34
		MPA	0.56	0.46	-16.8%	0.49

Yellow Tang

The overall average changes in Yellow Tang abundance in the three management areas are shown in Figure 6. Prior to the year 2000, the areas which would become FRAs were not significantly different than the Open Areas in terms of Yellow Tang abundance. Yellow Tang subsequently exhibited an increase in abundance in all areas following a strong recruitment year in 2002. Relatively low recruitment in six of the following years resulted in subsequent downward trends in all areas. A similar pattern was evident in 2009.

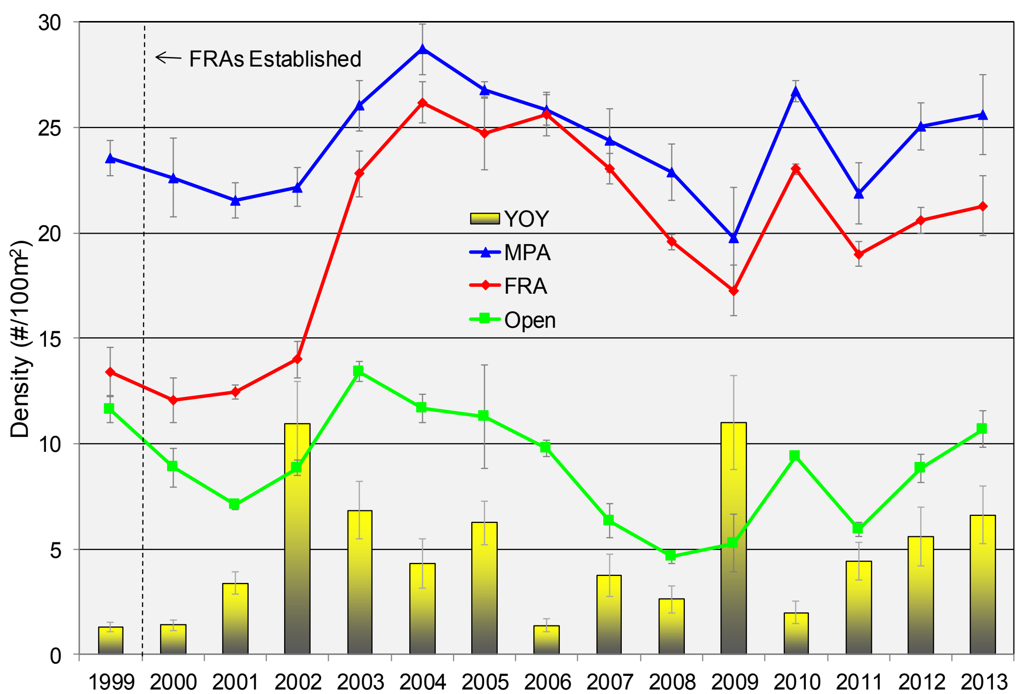


Figure 6. Overall changes in Yellow Tang abundance (Mean ± SE) in FRAs, MPAs and Open areas, 1999-2013. Yellow vertical bars indicate mean density (May -Nov) of Yellow Tang Young-of-Year (YOY). YOY are not included in trend line data

The FRAs have been very successful in increasing Yellow Tang populations. The most recent findings indicate that the number of Yellow Tang, excluding Young of the Year (YOY), increased by 64.5% in the FRAs since they were established almost 15 years ago and 9.7% in the previously protected MPAs (1999/2000 – 2012/2013 comparison). Their slight decrease (4.7%) in the Open Areas over this same time period is not statistically significant thus. Yellow Tang abundance in the Open Areas has thus *not* declined since the FRAs were established. Yellow Tang abundance is however, substantially lower (53.5% for 2012/2013) in the Open Areas relative to the FRAs due to the fact that aquarium collecting occurs in these areas. The difference in Yellow Tang abundance between the Open Areas and FRAs has been less in recent years likely due to decreases in aquarium catch and effort (Figure 7) and reliable recruitment.

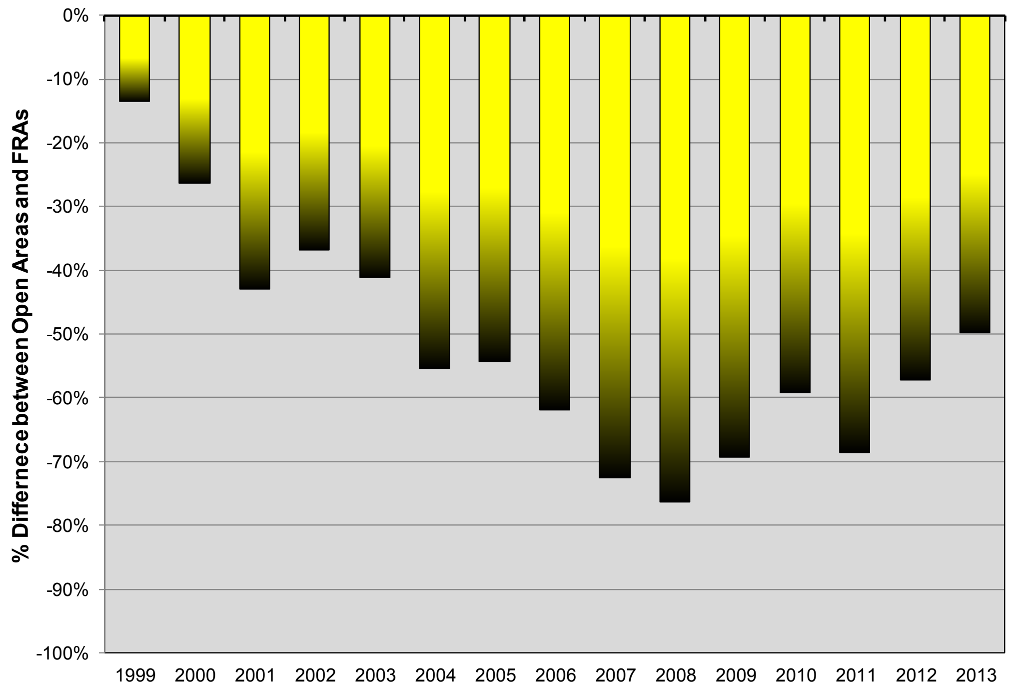


Figure 7. Difference in Yellow Tang abundance in West Hawai'i Fish Replenishment Areas (FRAs, n=9) relative to Open Areas (n=9). Bars represent the % difference in abundance for each year from 1999 to 2013. Bars *below* the x axis indicate greater abundance in the FRAs than the Open areas

Even with lower Yellow Tang abundance in the fished Open Areas, overall Yellow Tang abundance in the 30'-60' depth range over the entire West Hawai'i coast is estimated to have increased 58% (over 1.3 million fish) from 1999/2000 to 2012-2013 to a current population of about 3.6 million fish.

Summer 2014 recruitment in many areas has been very strong and continued upward trends for Yellow Tang are anticipated. Indeed, at a number of locations around the state, summer recruitment has been termed 'biblical' (Talbot 2014). At the most southerly WHAP survey site (Manukā, Ka'u District), the number of Yellow Tang recruits in July was 390% higher than on any other previous survey at the site over the previous 15 years. A few other sites exhibited similar robust recruitment.

In addition to the WHAP surveys, DAR has three long-term studies which provide a more expansive overview on changes in the abundance of aquarium targeted species over several decades. One of the sites at Hōnaunau in South Kona will be resurveyed over the next 4 summers beginning in 2015 and thus is not included in this report. Another of these studies was conducted at two sites in South Kohala. One site is at Puakō which has been a Fishery Management Area (FMA) since 1985 in which the use of all nets, except thrownets, is prohibited (thus no aquarium collecting). The other site is 2.5km to the south at Pauoa Bay which became an FRA in 2000 and was also closed to laynetting in 2005. As can be seen in Figure 1, there was not much aquarium collecting occurring in West Hawai'i during the time period of the original study (by the UH Hawaii Cooperative Fisheries Research Unit) and thus population estimates for Yellow Tang at this time represent a largely unfished state given that they are not a highly desired food fish.

Yellow Tang abundance has declined by 9% at Puakō but has increased by 14% at Pauoa Bay. (Figure 8). Unfortunately, due to how the data was presented in the original study, statistical analysis of this change is not possible. Yellow Tang is one of only a few species which has not undergone substantial declines in both these areas - indeed it increased somewhat at Pauoa. Both the Puakō and Pauoa sites have suffered major habitat degradation and fish declines over the past 3+ decades (Walsh 2013). Aquarium targeted species are not the only ones which have declined but rather major declines were apparent in all trophic levels and most fish families. As noted above, both areas have been off-limits to aquarium collecting for quite some time and thus it is not reasonable to attribute the extensive changes in habitat and fish populations at these sites to aquarium collecting.

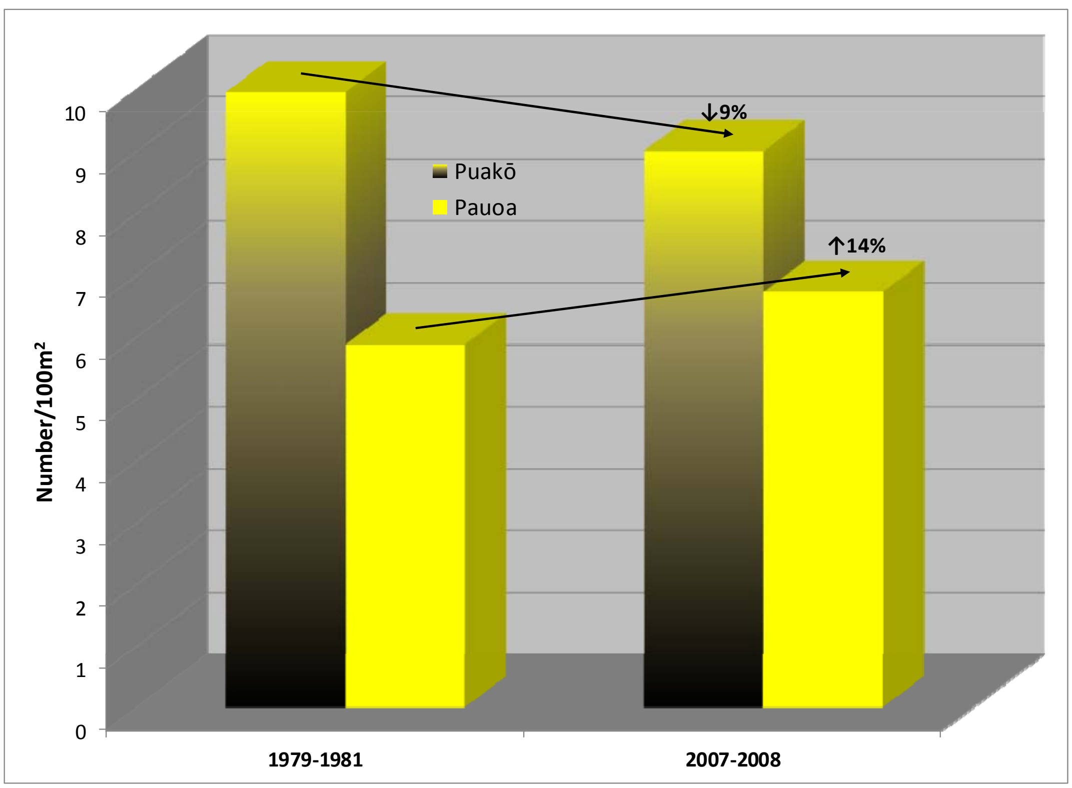


Figure 8. Long-term changes in Yellow Tang abundance at two South Kohala sites

Another long-term study underway at Ke′ei, on the south side of Kealakekua Bay, South Kona provides a more detailed view of decadal changes in fish populations. As with the South Kohala sites, the earliest surveys (i.e. 1970's) represent a largely unfished population. As aquarium collecting increased in West Hawai′i (Figure 9), Yellow Tang populations declined. Ke′ei became an FRA in 2000 and since that time populations have rebounded to where they are essentially the same nowadays as in the 1970's. Note the 4% difference between the 1970's and the 2010's is not statistically significant (t-test - ρ=0.2).

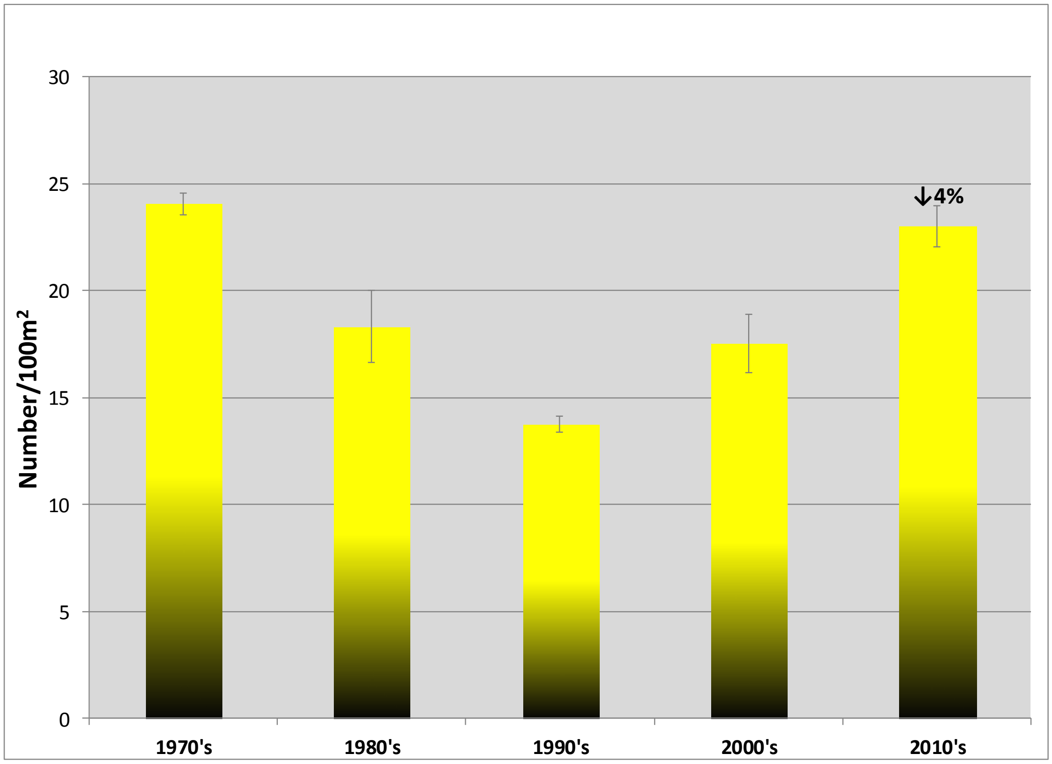


Figure 9. Long-term changes in Yellow Tang abundance at Ke′ei, South Kona

The reserve (i.e. FRA/MPA) effects described above in enhancing and sustaining targeted West Hawai'i fish populations are striking, but also of importance are the effects of the reserve network on the breeding populations of these species. While Yellow Tang can occur over a wide range of habitats (Ortiz and Tissot 2008) including the deeper (~ 70' -130') mesophotic reef (Bogeberg 2014), the bulk of the adult population occurs in relatively shallow reef areas. When Yellow Tang reach sexual maturity most leave the deeper coral rich reef areas where they settled (and where DAR transects are located) for shallower reef habitat (Claisse et al. 2009). For females this occurs at approximately 4-5 years of age and for males at age 5-7. To supplement long-term WHAP monitoring, DAR initiated a series of surveys in 2006 using Diver Propulsion Vehicles (DPV) of the shallow reef habitats (10'-20' depths) utilized by adult Yellow Tang.

Adult densities were highest within protected areas and in 'boundary' areas (open areas adjacent to protected areas) (Williams et al. 2009). Densities were lowest in open areas far from protected areas (Figure 10). The high densities in boundary areas are indicative of 'spillover' (outward movement from reserves into surrounding open areas) and indicate that protected areas supplement adult stocks not only within their own boundaries, but also in open areas up to a kilometer or more away. Thus, the 35% of the coastline in reserves sustains Yellow Tang (and other similar species) breeding stocks in about 50% of the coastline.

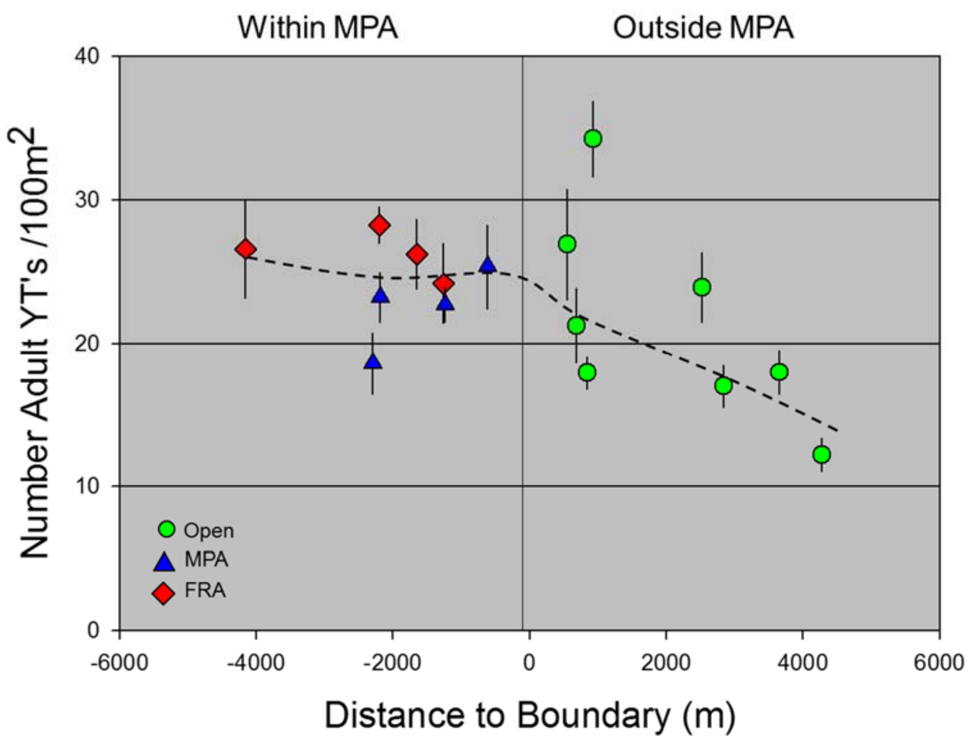


Figure 10. Yellow Tang abundance in adult habitats relative to distance of survey site from nearest protected area boundary. Data points represent mean ± 1 SE by site (n = 5 surveys per site). The trend line was generated using a LOESS smoothing function (after Williams et al. 2009)

If all Open and Protected Areas are considered together there are no significant overall differences (Figure 11 t-test ρ=0.71) in the abundance of adult Yellow Tang in open vs. closed areas based on shallow reef DPV surveys (2006-2010). Total estimated coastwise population of adult Yellow Tang in this depth range was estimated to be >2.5 million individuals. It should be noted that with the latest West Hawai'i Regional Fishery Management Area Administrative Rule there is now a bag limit of 5 Yellow Tang per person per day for fish > 4.5" Total Length (TL). This limit applies to all fishers and thus helps to ensure the productivity of the breeding population of Yellow Tang. There is also a similar bag limit for the smallest (<2") Yellow Tang which do not survive handling and transport very well.

For Yellow Tang it is clear that populations are robust and have been increasing in protected areas and in some cases have reached levels found decades ago before aquarium collecting expanded along the coast. In the shallower shoreline areas open to aquarium collecting, breeding populations of Yellow Tang are not significantly different than closed areas and in deeper WHAP survey site areas (30'-60') the population of smaller, aquarium-targeted, Yellow Tang has not significantly decreased over the last 15 years.

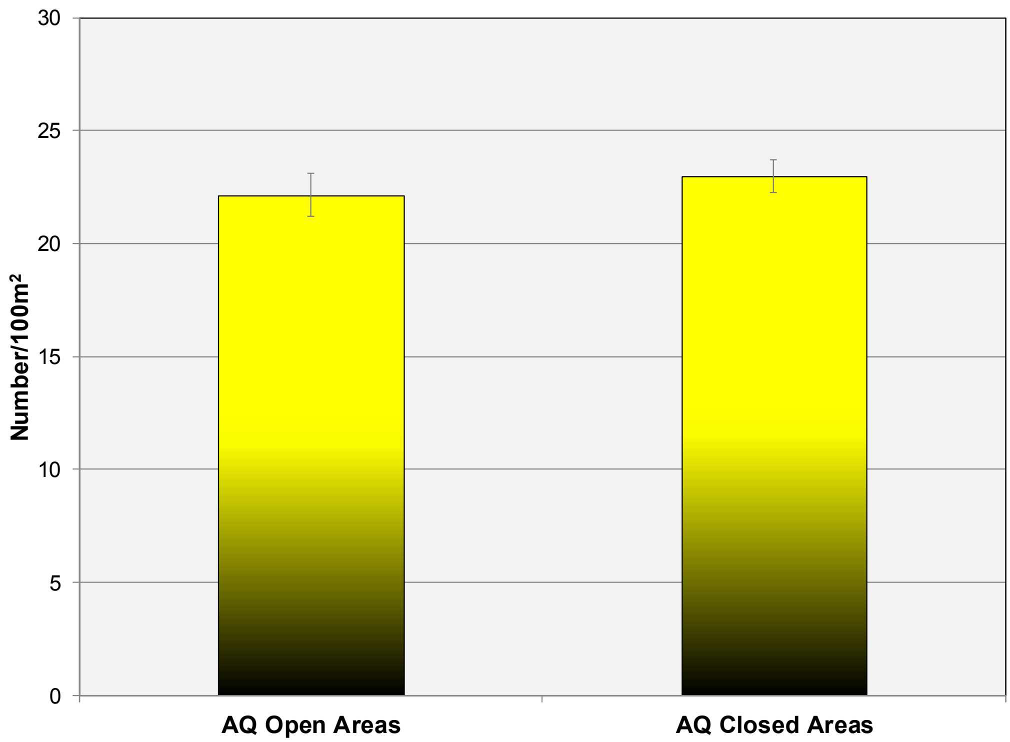


Figure 11. Adult Yellow Tang abundance (Mean ±SE) in West Hawai′i shallow water (10’-20’) habitats

The effectiveness of the West Hawai′i FRA network in increasing Yellow Tang populations within the protected areas is clear. The benefit of such increases extend beyond just the FRAs as larvae from a West Hawai′i FRA has been documented to seed unprotected areas (Christie et al. 2010). There is thus high connectivity among populations through larva dispersal and adult movement.

The importance of having multiple MPA sites (i.e. network) was also documented by a recent study by Grorud-Colvert et al. 2014 which compared Yellow Tang abundance in the West Hawai′i FRA network with that in non-networked Marine Protected Areas (MPAs) in Maui County. The researchers found that West Hawai′i had a significantly greater percent change in Yellow Tang density within the networked MPAs (and Open Areas) before vs. after network establishment as compared to the Maui non-networked sites during the same time period.

Another comparison with Maui using 2002-2010 WHAP and NOAA data (CRED -Coral Reef Ecosystem Division) found that for the 10 most collected aquarium fish in West Hawai′i, five were significantly more abundant in West Hawai′i’s *Open Areas* as compared to Maui MPA *closed areas* –Molokini MLD and Ahihi-Kina′u (Figure 12). This disparity is particularly noteworthy given that most of the current opposition to the West Hawai′i aquarium fishery is being prompted by a few activists from Maui.

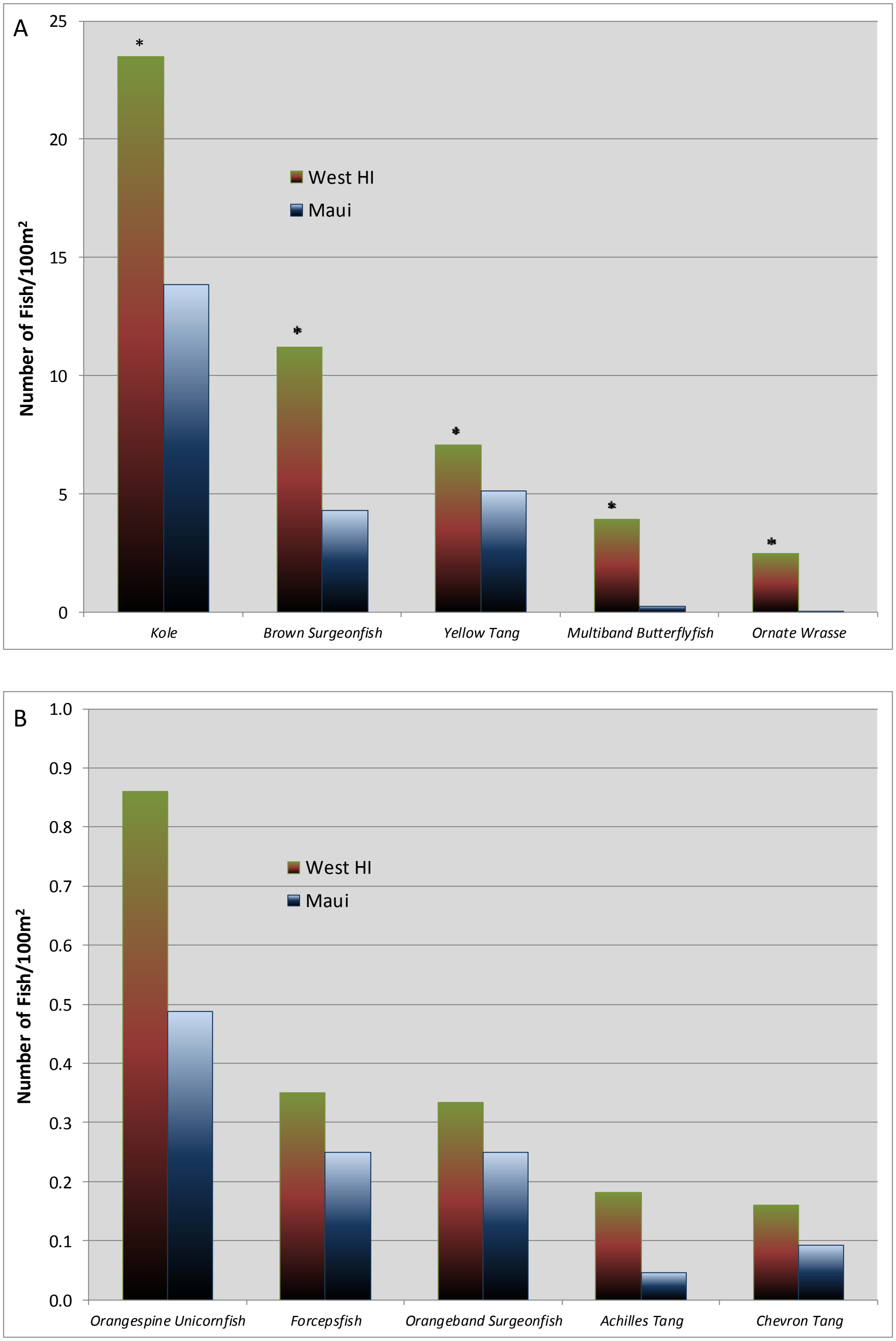


Figure 12. Comparison of aquarium fish abundances in West Hawai'i Open Areas with Maui MPAs 2002-2010. A - Asterisk indicates a statistically significant difference (t – test $\rho = 0.005$ or less)

Kole

The Goldring Surgeonfish (Kole - *Ctenochaetus strigosus*) is the second most collected species in the West Hawai'i aquarium fishery. Recruitment patterns are markedly similar between Kole and Yellow Tang likely due to similarities in spawning seasonality, location and daily timing (Walsh 1984, 1987). As with Yellow Tang, recruitment has been variable but generally reliable over the past 15 years. The number of Kole (excluding YOY) has increased significantly in all management areas, including Open Areas, (Figure 13) from 1999/2000 – 2012/2013.

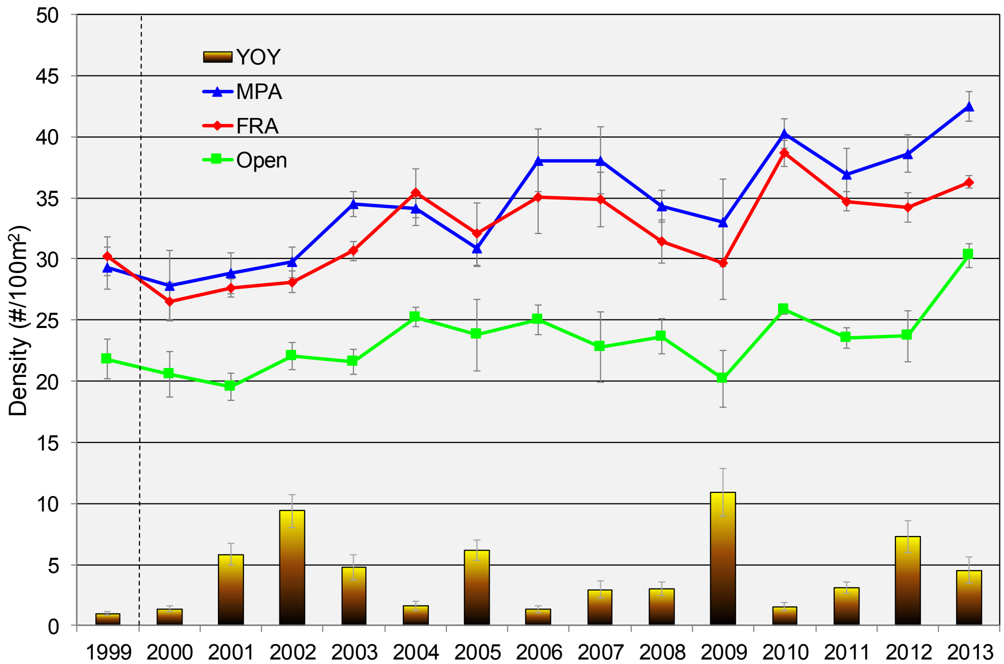


Figure 13. Overall changes in Goldring Surgeonfish (Kole) abundance (Mean ± SE) in FRAs, MPAs and Open areas, 1999-2013. Vertical bars indicate mean density (June-Nov) of Goldring Surgeonfish Young-of-Year (YOY). YOY are not included in trend line data

Kole abundance is lower (23.7% for 2012/2013) in the Open Areas relative to the FRAs but not as low as for Yellow Tang. This reflects the substantially lower take of this species in the aquarium fishery. The difference in Kole abundance between the Open Areas and FRAs has been largely stable over the years (Figure 14).

As with Yellow Tang, an effort was made by the WHFC to protect the breeding populations of Kole by establishing a bag limit of 5 Kole per person per day for fish > 4." TL. This limit, which applies only to aquarium collectors, was included in the latest West Hawai'i Regional Fishery Management Area Administrative Rule.

Overall Kole abundance in 30'-60' depth range over the entire West Hawai'i coast is estimated to have increased 49% (over 2.1 million fish) during this time period with a current estimated population of about 6.5 million fish. As with Yellow Tang, summer 2014 recruitment for Kole in many areas has been very strong. Recruitment at the Manuka survey site for example was 254% higher than on any other previous survey at the site over the last 15 years.

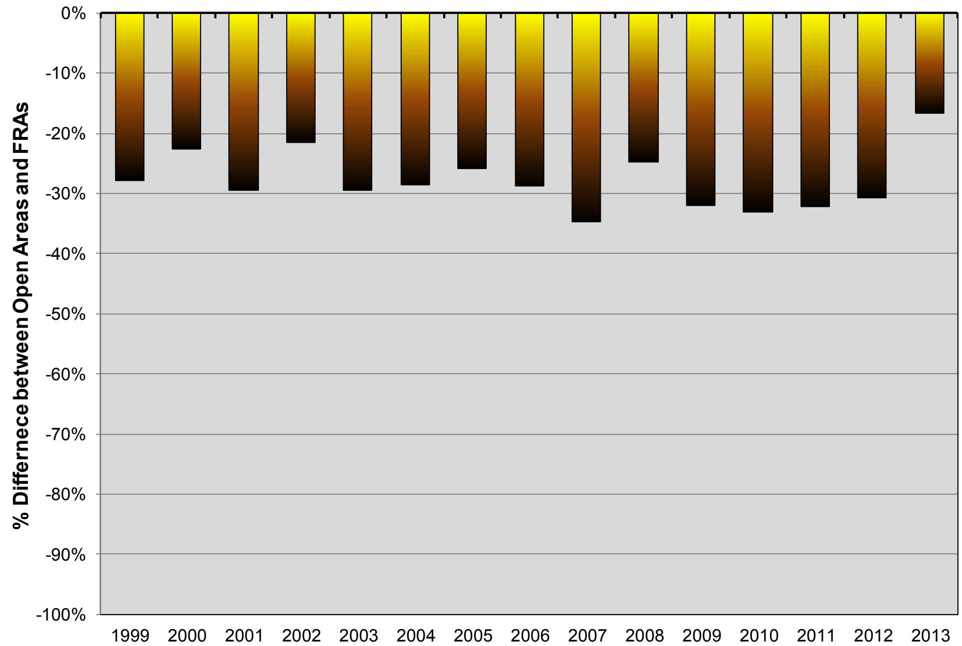


Figure 14. Difference in Kole abundance in West Hawai′i FRAs (n=9) relative to Open Areas (n=9). Bars represent the percent difference in abundance each year from 1999 to 2013. Bars *below* the x axis indicate greater abundance in the FRAs than the Open areas

Long-term West Hawai′i studies have found Kole to have decreased at both study sites. The most pronounced decreases occurred at the two South Kohala sites (Figure 15).

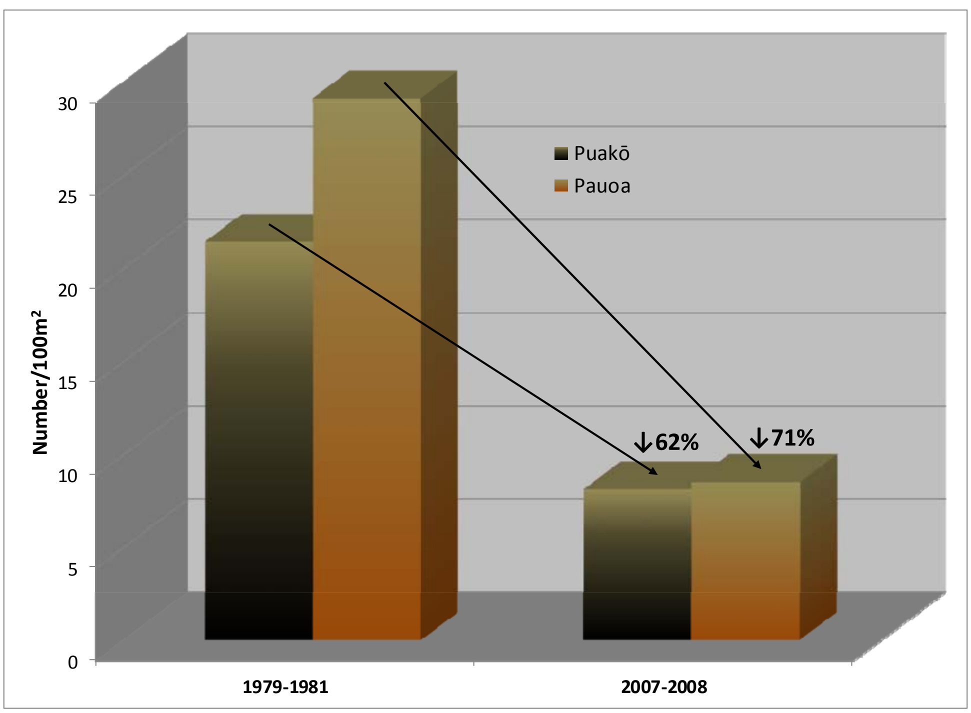


Figure 15. Long-term changes in Kole abundance at two South Kohala sites

The Pauoa FRA has been closed to aquarium collecting for 15 years and lay netting for 10 years. The Puakō FMA has been closed to aquarium collecting (i.e. no nets other than thrownets permitted) for 40 years. Given the length of protection at these two areas and the overall decline in habitat quality and fish populations at the South Kohala sites (Walsh 2013) it seems highly unlikely that the decline of the Kole population is due primarily to aquarium collecting.

At Ke′ei there has been an increasing trend in Kole abundance since 2000 when the area became part of an FRA (Figure 16) but current abundance is still significantly below what it was in the past (1970's – 2010's $\rho<0.001$).

Kole is regarded as a highly desired food fish by some fishers and targeted accordingly. Given the low aquarium catch of this species relative to its West Hawai′i population in Open Areas (0.79%), it seems inescapable that non-aquarium harvesting activities are an important contributor to observed population declines in West Hawai′i.

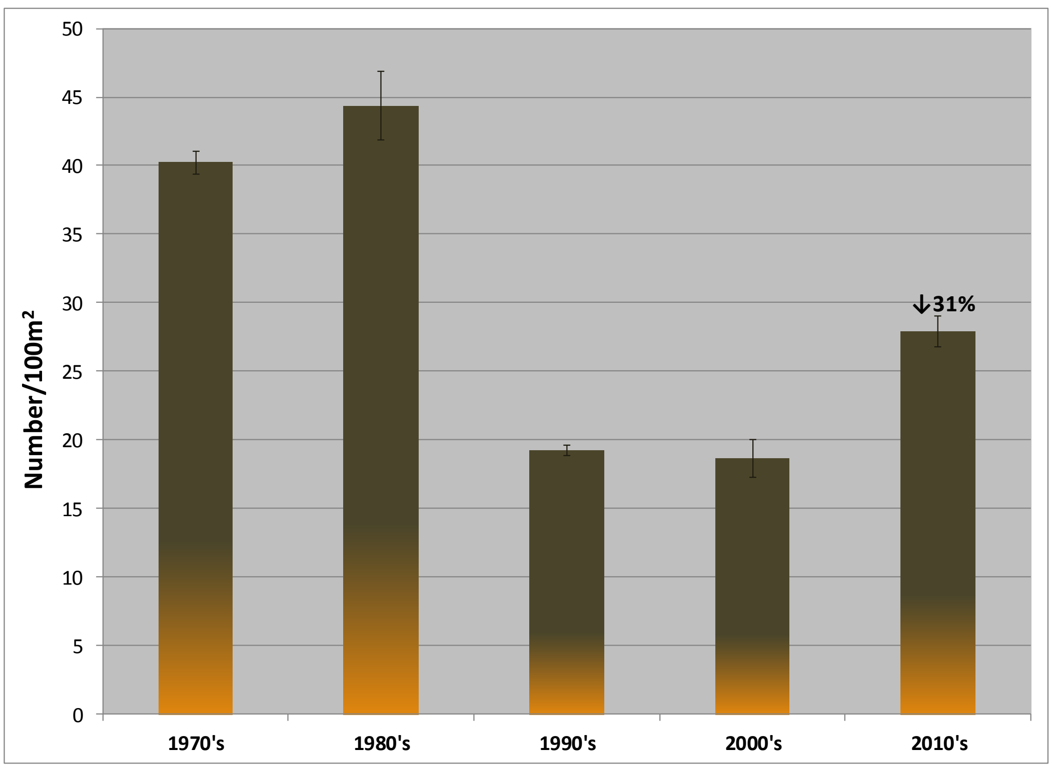


Figure 16. Long-term changes in Kole abundance at Ke′ei, South Kona

Even with the documented long-term declines in Kole populations in West Hawai′i, the species remains very abundant, at least in the smaller and mid-size ranges. Indeed, comparative surveys around the Main Hawaiian Island utilizing DAR and NOAA Coral reef Ecosystem Division (CRED) data (2006/2008) indicates Kole are substantially more abundant over most size ranges in West Hawai′i than any of the other Main Hawaiian Islands (Figure 17). Somewhat surprisingly, this is also true if West Hawai′i Kole populations are compared with Northwest Hawaiian Islands populations (Figure 18).

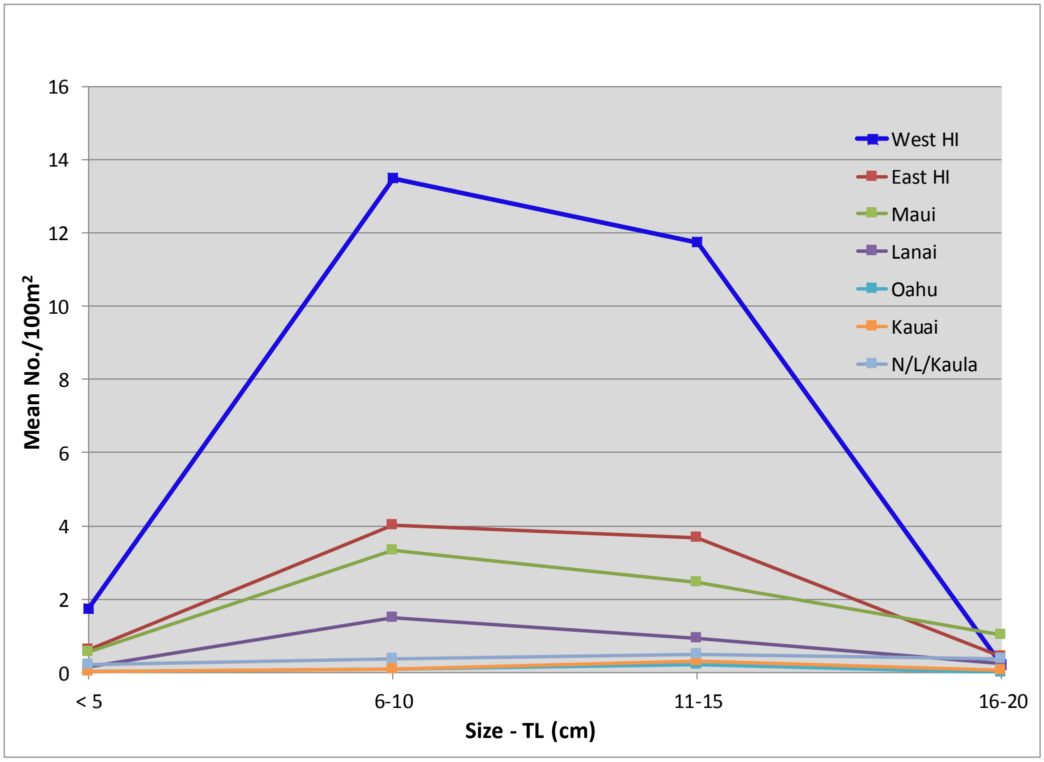


Figure 17. Comparison of size distributions of Kole at various Main Hawaiian Island (MHI) sites 2006/2008

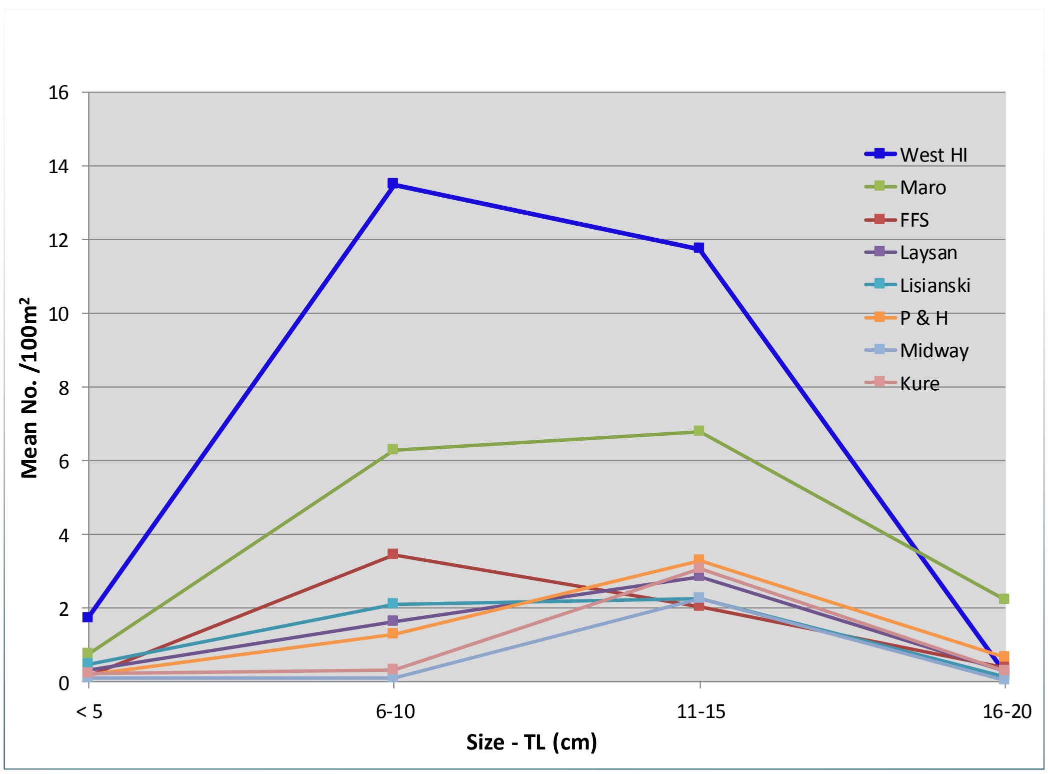


Figure 18. Comparison of size distributions of Kole at various Northwest Hawaiian Island (NWHI) sites 2006/2008

Achilles Tang

Achilles Tang is the third most collected species in the West Hawai′i aquarium fishery although relative to Yellow Tang and Kole the numbers taken are low, representing only 2.1% of the total catch.

Commercial aquarium landings of Achilles Tang have been declining in West Hawai′i over the past two decades. This has occurred in association with a recent dramatic increase in the ex-vessel value of the fish (Figure 19). Such opposing trends in catch and value are strongly suggestive of declining availability (i.e. abundance).

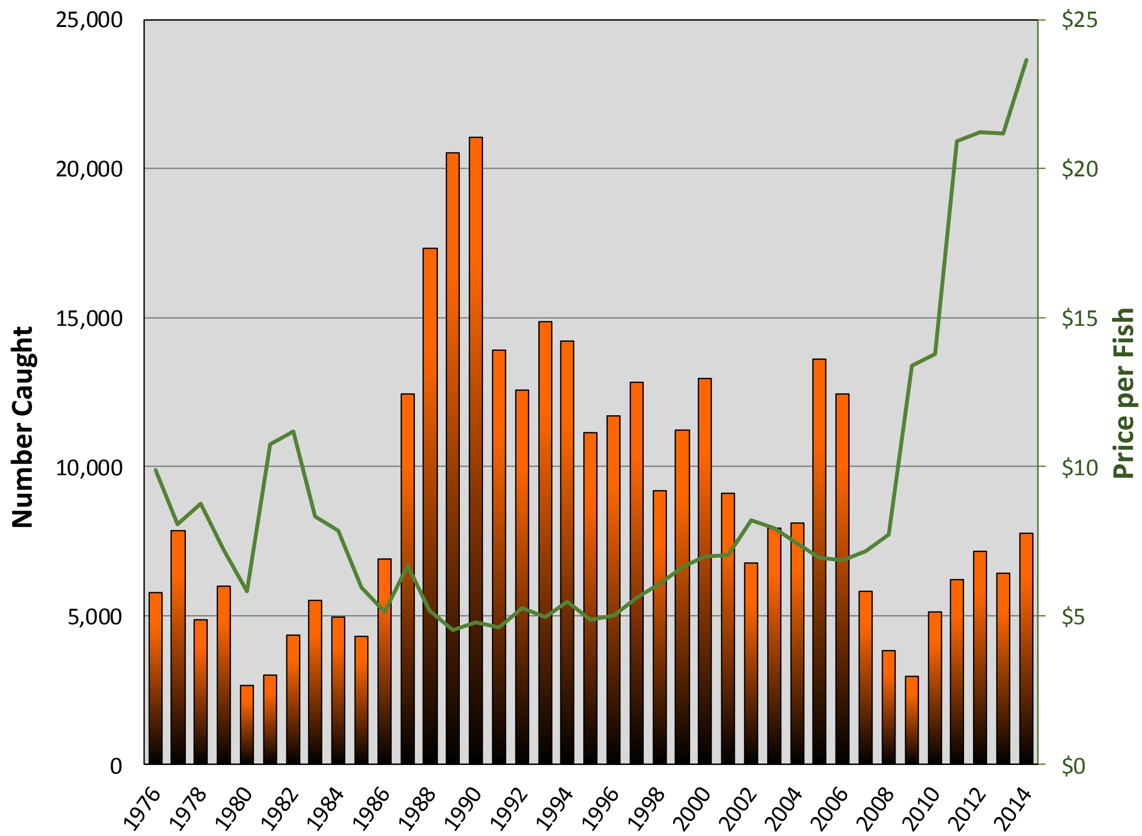


Figure 19. West Hawai′i commercial Achilles Tang aquarium landings and ex-vessel price per fish

Substantial decline of Achilles Tang populations in West Hawai'i is evident from several data sources. As can be seen in Figure 20, Achilles Tang have declined in FRAs and Open Areas over the last 15 years tempered somewhat by a slight increase in the last year or two. Only the FRA decline is statistically significant (Table 3). A similar declining trend is apparent within MPAs except for the last four years when Achilles Tang numbers have increased.

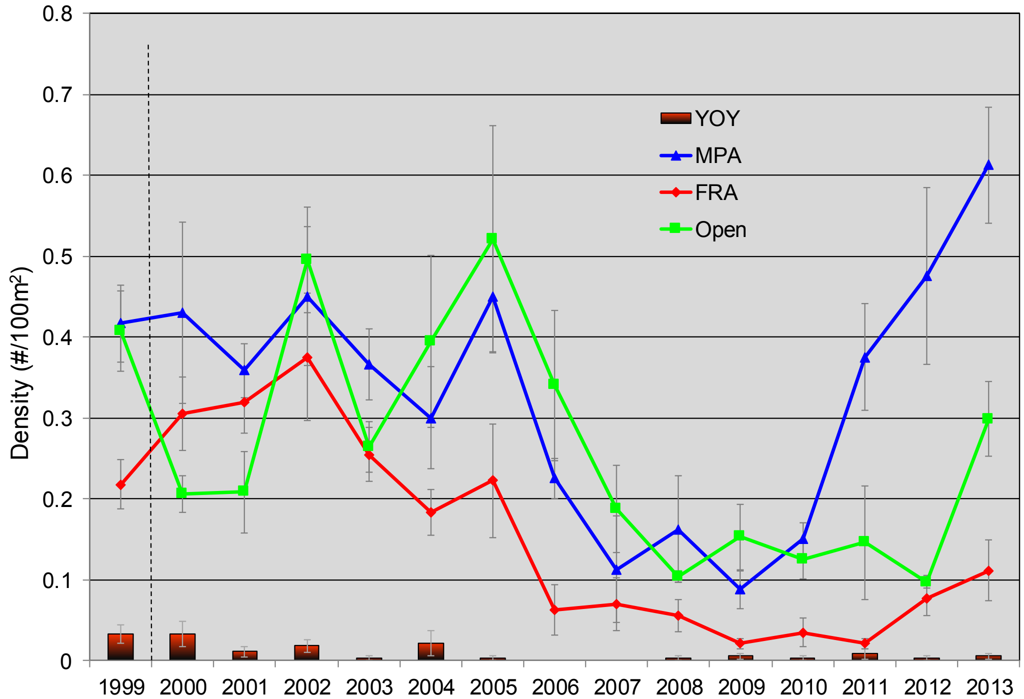


Figure 20. Overall changes in Achilles Tang abundance in FRAs, MPAs and Open areas, 1999-2013. Vertical bars indicate mean density (June-Nov) of Achilles Tang Young-of-Year (YOY). YOY are not included in trend line data

Average densities of this species are currently very low ($\bar{x} = 0.23/100m^2$) on all transects. An important caveat is that the reef areas where the WHAP transects are located are not the prime habitat for adults of this species. Rather, large adults prefer the high energy shallower surge zones more typical of the shoreline drop-offs areas in West Hawai'i. Presumably algal food resources are more abundant in these areas. As such the bulk of the population is not adequately surveyed by WHAP monitoring. These shallower reef areas are being surveyed by a different type of monitoring program (Shallow Water Resource Surveys) presently being conducted by DAR.

Unlike Yellow Tang and Kole, Achilles Tang have been more abundant over the past decade in Open Areas rather than the protected FRAs (Figure 21). The exact meaning of this is unclear at present but may reflect specific habitat differences in the management areas and/or habitat preferences of Achilles Tang.

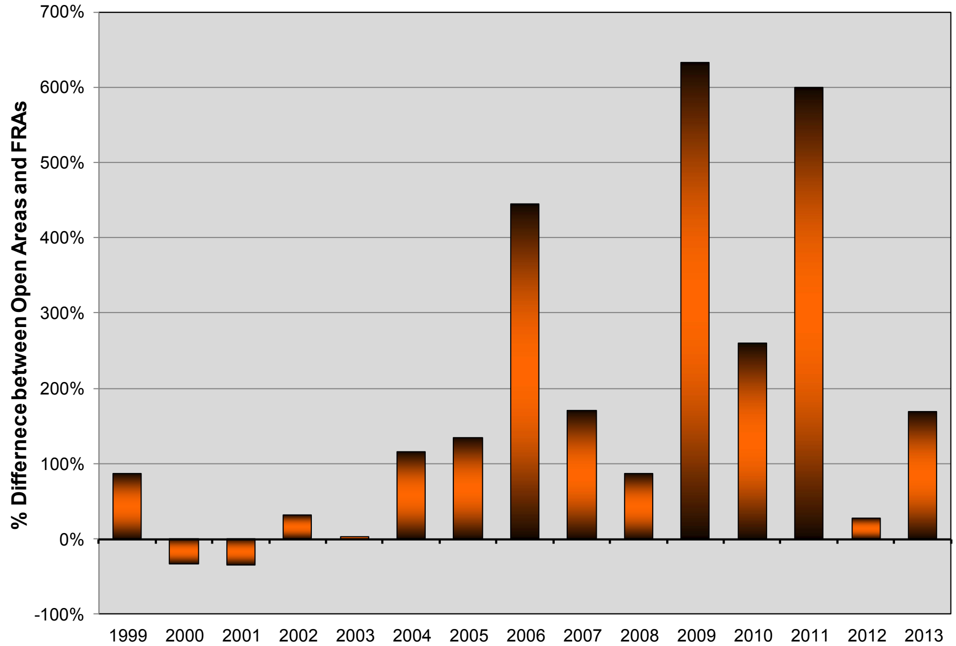


Figure 21. Difference in Achilles Tang abundance in West Hawai'i FRAs (n=9) relative to Open Areas (n=9). Bars represent the percent difference in abundance for each year from 1999 to 2013. Bars *above* the x axis indicate greater abundance in the Open Areas than the FRAs

Data from the long-term studies in South Kohala and South Kona also show a pattern of decline over the past decades (Figs. 22 & 23).

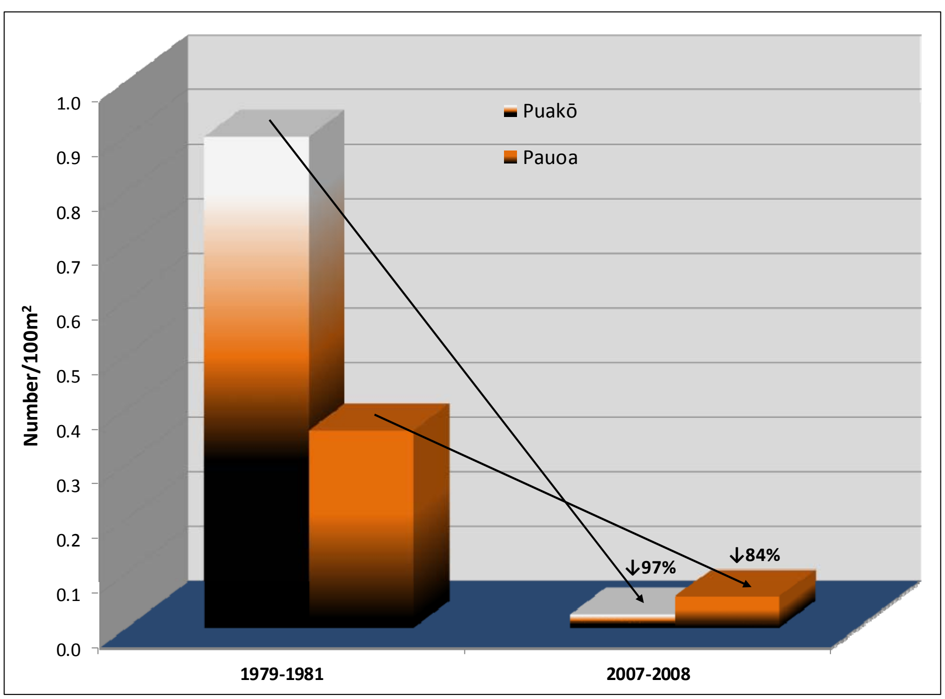


Figure 22. Long term changes in Achilles Tang populations at Puakō and Pauoa

At Ke′ei Kole have increased somewhat during the present decade. Achilles Tang abundance (small ones) in the present decade is not significantly different than in the in the 1980's (t-test $\rho=0.19$) or 1970's ($\rho=0.65$). Overall densities however are still very low.

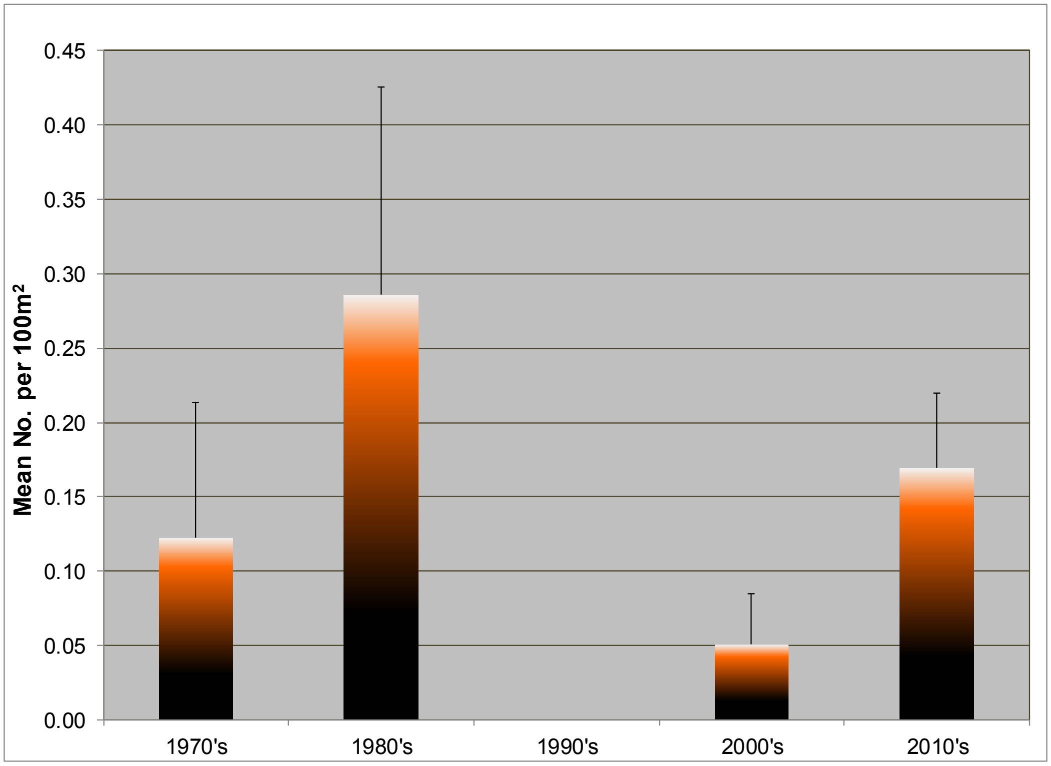


Figure 23. Long term changes in Achilles Tang populations at Ke′ei, South Kona

Results from the WHAP monitoring program and the long-term studies suggest there should be concern for the sustained abundance of this species. Achilles Tang are a very popular food fish as well as an aquarium fish and thus are being harvested both as juveniles and adults. Low levels of recruitment over the past 11 years ($\bar{x}$ (May-Nov) = 0.01/100m^2) appear insufficient to compensate for the existing levels of harvest. In order to address concerns regarding aquarium impacts on this species, the new West Hawai′i Regional Fishery Management Area Rule (HAR § 13-60.4) includes an Achilles Tang bag limit of 10 fish/person/day which applies only to aquarium collectors.

Commencing in January 2012, DAR's monthly aquarium catch report was converted to a *daily* aquarium fishing trip report. This daily trip report provided the opportunity to investigate the potential impact of the newly instituted Achilles Tang daily bag limit.

In West Hawai′i in 2012, 38 commercial aquarium collectors collectively caught (and reported) 8,111 Achilles Tang over a total of 515 days effort. Only 21% of the daily catches per fisher exceeded the proposed daily bag limit yet they represented 65.8% of the total catch. If the Achilles Tang bag limit had been in effect in 2012 the total catch would have been reduced by 3,227 fish – a 40.3% reduction in catch.

It is difficult to precisely project the overall impact of the West Hawai'i Achilles Tang bag limit. On the one hand, if there is good compliance with the limit and existing conditions regarding collecting, market forces and population abundances remain relatively stable, then a decrease in overall catch would be anticipated. If targeted effort towards this species increases, even while limited by the bag limit, total catch could actually increase. Achilles Tang catch subsequent to this analysis have not decreased but rather have increased slightly (Figure 21). Given the clear evidence for a marked decline in the population of Achilles Tang in West Hawai'i, the aquarium-only bag limit may prove insufficient to stem this decline.

It should be noted that Achilles Tang is the *only* species on the permitted aquarium "White List" which is listed as an "Ecologically Unsustainable Species" by the Sustainable Aquarium Industry Association (SAIA http://www.saia-online.eu/index.php/en/).

Adaptive Management of the Aquarium Fishery

When the White List of collectible aquarium species was being formulated by DAR and the WHFC, it was understood that the dynamics of marine ecosystems are complex and often poorly understood. Species populations can wax and wane over time and often this variability is unpredictable. It was thus considered essential to incorporate some management flexibility in the White List to respond to the changing situations of the various species. Such an approach can be termed "Adaptive Management" (McGraw-Hill 2005). Achilles Tang was a species which was in the forefront of the utilization of this approach.

To accomplish such adaptive management, the draft WHRFMA rule incorporated a provision allowing the Board of Land and Natural Resources (BLNR) to impose a moratorium on further collecting of a white list species. The moratorium would be triggered if DAR provided sufficient data to the BLNR indicating that the population of a particular species in West Hawai'i might be jeopardized (e.g. substantial decline in numbers) by overcollecting or other factors. A similar BLNR moratorium provision (regarding urchin harvesting) was incorporated in another West Hawai'i rule (HAR 13-37 Old Kona Airport MLCD) which was amended in 2005. Somewhat similar BLNR prerogatives also exist in other DLNR rules (e.g. HAR §13-94-11 – regarding bottomfish).

Although both the DAR legal fellow and DLNR's Deputy Director (a former Deputy AG himself) concurred with the board moratorium approach in the rule, the Deputy AG reviewing the rule would not approve such a moratorium and ultimately it was removed. The Deputy AG asserted that any such changes to the rule (i.e. a species-specific moratorium) could only be made by amending the rule via Hawaii Administrative Rule making (Chapter 91). Such a process can take many years to accomplish thereby obviating any real-time adaptive management.

Following this setback to effective management, an alternative strategy was attempted whereby WHFC/DAR would seek specific legislative authorization to institute a moratorium process in West Hawai'i (only). Such bills were introduced in 2012 (HB2129) and 2013 (HB 185) by Representative Cindy Evans (and others). These bills authorized the Board of Land and Natural Resources (BLNR) to impose temporary aquarium management measures (i.e., bag limits, closed seasons or moratoriums) within the WHRFMA without the need to go through the lengthy administrative rule-making process. It also required DLNR to establish a limited entry program for commercial aquarium fishers. Neither of these bills was approved by the Legislature and thus adaptive management of the West Hawai′i aquarium fishery is still not possible.

Other White List Species

Of the other top 10 collected aquarium species (Table 3) two species (Forcepsfish and Potter's Angelfish) had significant population increases in one or more of the management areas while two species (Ornate Wrasse and Fourspot Butterflyfish) declined significantly in one or more of the areas. While the latter two species declined in the Open Areas, they also declined in one or the other of the protected areas (FRA or MPA) suggesting that factors other than aquarium collecting were also affecting their populations.

Three of the top 10 species showed no significant change in any of the areas. It should be kept in mind that scientific studies on reef fishes are notoriously challenging to analyze due to the often high variability of fish abundance in both time and space. Even with a rigorous statistical design and 16 years of study, it is difficult to statistically detect changes in abundances except for the more common species that exhibit relatively large changes.

Table 4 shows Before and After changes for the other 24 species on the White List for which we have solid survey data. Of these, 5 species showed a significant population increase in one or more of the management areas while 11 decreased. Of the species which declined, only a single one (Bird Wrasse) declined exclusively in the Open Areas again indicating that factors other than aquarium collecting were also affecting the populations of these other species.

Table 4. Changes in abundance of the next 24 most collected aquarium fishes in West Hawai′i. 'Before' = Mean of 1999-2000; 'After' = Mean of 2012-2013. Shaded cells show statistically significant changes. Young of Year (YOY) not included

COMMON NAME	SCIENTIFIC NAME		MEAN DENSITY (NO./100M^2)		OVERALL CHANGE IN DENSITY	ρ
			Before	**After**		
Multiband Butterflyfish	*Chaetodon multicinctus*	**FRA**	**5.20**	**3.52**	**-1.68**	**<0.001**
		Open	4.00	3.73	-0.27	0.74
		MPA	4.94	4.64	-0.30	0.22
Goldrim Surgeonfish	*Acanthurus nigricans*	FRA	0.04	0.04	+0.01	1.00
		Open	0.01	0.07	+0.07	0.09
		MPA	0.11	0.14	+0.04	0.64
Saddle Wrasse	*Thalassoma duperrey*	**FRA**	**3.66**	**2.11**	**-1.55**	**<0.001**
		Open	**5.93**	**3.10**	**-2.84**	**<0.001**
		MPA	**4.39**	**3.04**	**-1.35**	**<0.001**

Yellowtail Coris	*Coris gaimard*	FRA	0.17	0.17	0.00	1.00
		Open	0.13	0.18	+0.06	0.33
		MPA	0.30	0.22	-0.08	0.40
Shortnose Wrasse	*Macropharyngodon geoffroy*	FRA	0.02	0.01	-0.02	0.57
		Open	0.02	0.03	+0.01	0.87
		MPA	0.01	0.03	+0.01	0.82
Bird Wrasse	*Gomphosus varius*	FRA	0.67	0.81	+0.13	0.12
		Open	**0.64**	**0.40**	**-0.23**	**0.01**
		MPA	1.04	1.16	-0.12	0.48
Brown Surgeonfish	*Acanthurus nigrofuscus*	**FRA**	**8.58**	**5.67**	**-2.91**	**<0.001**
		Open	**11.20**	**14.23**	**+3.03**	**<0.001**
		MPA	**7.68**	**10.16**	**+2.48**	**<0.001**
Spotted Boxfish	*Ostracion meleagris*	FRA	0.05	0.06	+0.01	0.88
		Open	0.10	0.09	-0.01	0.82
		MPA	0.10	0.13	+0.03	0.69
Thompson's Surgeonfish	*Acanthurus thompsoni*	**FRA**	**0.72**	**1.62**	**+0.90**	**<0.001**
		Open	0.69	0.85	+0.16	0.35
		MPA	0.66	0.88	+0.22	0.37
Lei Triggerfish	*Sufflamen bursa*	FRA	0.53	0.39	-0.14	0.09
		Open	0.75	0.71	-0.04	0.68
		MPA	0.57	0.50	-0.06	0.59
Pencil Wrasse	*Pseudojuloides cerasinus*	FRA	0.14	0.14	0.00	1.00
		Open	**0.05**	**0.18**	**+0.13**	**0.01**
		MPA	0.04	0.02	-0.02	0.73
Pyramid Butterflyfish	*Hemitaurichthys polylepis*	FRA	0.02	0.02	0.00	1.00
		Open	0.66	0.53	-0.13	0.30
		MPA	0.59	0.21	-0.38	0.51
Black Durgon	*Melichthys niger*	FRA	0.53	0.47	-0.06	0.62
		Open	0.43	0.35	-0.08	0.52
		MPA	**2.21**	**1.49**	**-0.72**	**0.02**
Milletseed Butterflyfish	*Chaetodon miliaris*	FRA	0.00	0.01	+0.01	0.61
		Open	0.04	0.07	+0.03	0.52
		MPA	**0.44**	**0.05**	**-0.39**	**<0.001**

Fourline Wrasse	*Pseudocheilinus tetrataenia*	**FRA**	**1.36**	**2.76**	**+1.40**	**<0.001**
		Open	**1.66**	**3.05**	**+1.39**	**<0.001**
		MPA	2.95	2.52	-0.43	0.09
Hawaiian Dascyllus	*Dascyllus albisella*	FRA	0.02	0.11	+0.09	0.08
		Open	0.51	0.54	+0.02	0.08
		MPA	0.12	0.14	+0.02	0.78
Eightline Wrasse	*Pseudocheilinus octotaenia*	**FRA**	**2.20**	**1.28**	**-0.92**	**<0.001**
		Open	**3.31**	**1.75**	**-1.57**	**<0.001**
		MPA	**3.17**	**1.88**	**-1.29**	**<0.001**
Blackside Hawkfish	*Paracirrhites forsteri*	**FRA**	**0.34**	**0.17**	**-0.18**	**0.004**
		Open	**0.41**	**0.19**	**-0.22**	**<0.001**
		MPA	0.26	0.34	+0.07	0.54
Blacklip Butterflyfish	*Chaetodon Kleinii*	FRA	0.00	0.00	0.00	0.77
		Open	0.00	0.05	+0.05	0.12
		MPA	0.02	0.02	0.00	0.98
HI Whitespotted Toby	*Canthigaster jactator*	**FRA**	**1.13**	**0.56**	**-0.57**	**<0.001**
		Open	**3.48**	**2.33**	**-1.14**	**<0.001**
		MPA	**2.87**	**1.21**	**-1.67**	**<0.001**
Gilded Triggerfish	*Xanthichthys auromarginatus*	FRA	0.14	0.04	-0.10	0.06
		Open	**0.31**	**0.10**	**-0.20**	**0.002**
		MPA	**1.26**	**0.84**	**-0.42**	**0.03**
Redbarred Hawkfish	*Cirrhitops fasciatus*	FRA	0.03	0.05	+0.02	0.76
		Open	0.15	0.09	-0.06	0.33
		MPA	0.06	0.03	-0.04	0.56
Bluestripe Snapper	*Lutjanus kasmira*	**FRA**	**0.07**	**0.23**	**+0.16**	**0.014**
		Open	0.12	0.07	-0.05	0.39
		MPA	0.19	0.01	-0.18	0.10
Peacock Grouper	*Cephalopholis argus*	FRA	0.57	0.46	-0.10	0.22
		Open	**0.57**	**0.23**	**-0.34**	**<0.001**
		MPA	**0.89**	**0.57**	**-0.32**	**0.03**

In the case of the Bird Wrasse, the only species to have declined only in Open Areas, it is also difficult to attribute the observed significant population decreases as being a result solely of aquarium collecting. Reported total annual aquarium take of Bird Wrasse is so low (Table 5) and constitutes such a minimal percentage of the total Open Area population (< 0.5%) it's unlikely that aquarium collecting alone could be the cause of this species' population decline in

For most of the species on the White List, collecting impact, in terms of the Open Areas. percentage of the population being removed annually, is relatively low with 8 species having single digit percentage catch and 23 species having catch values <1%.

Besides harvest impacts, species abundances can, and do, change over time due to other factors, both extrinsic (e.g. habitat degradation) and intrinsic (e.g. density dependence, reproductive success). A prime example of this is exemplified by the Saddle Wrasse (*Thalassoma duperrey*) which underwent significant declines in all management areas since 1999/2000 (Table 5, Figure 24). Note that it is consistently more abundant in the Open Areas than in the FRAs or MPAs (see Figure 24).

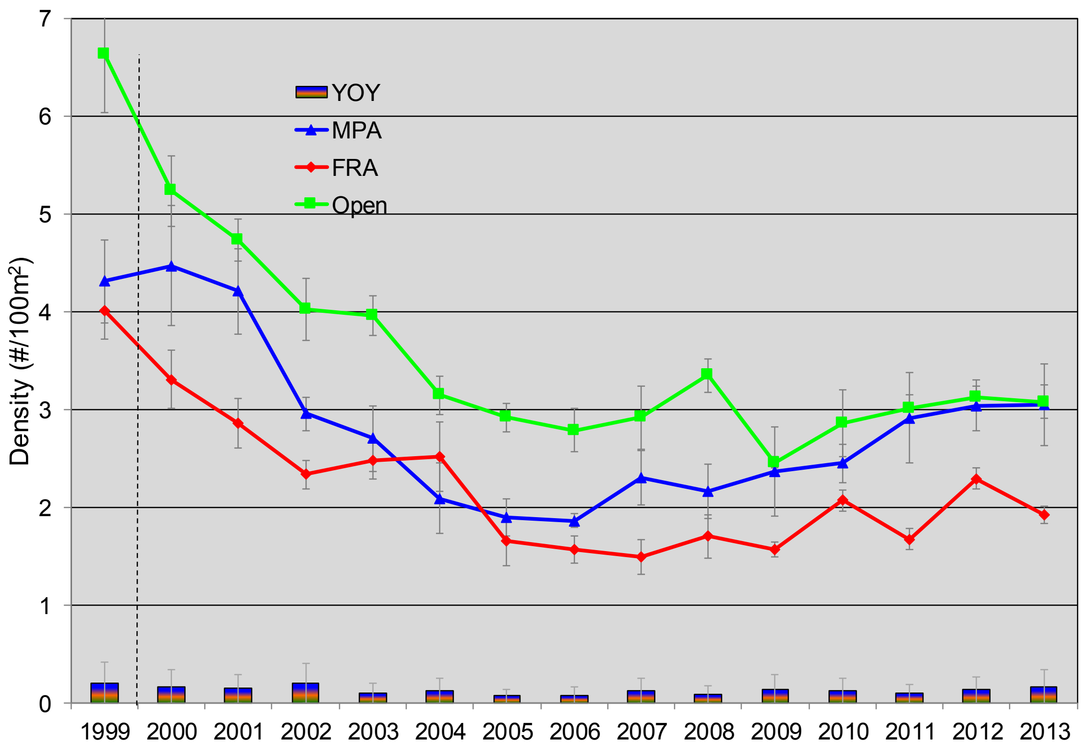


Figure 24. Overall changes in Saddle Wrasse abundance in FRAs, MPAs and Open areas, 1999-2013. Vertical bars indicate mean density (June-Nov) of Saddle Wrasse Young-of-Year (YOY). YOY are not included in trend line data

The Saddle Wrasse is very lightly collected (0.1% of total catch 2012/2013) and the catch represents a miniscule portion (0.06%) of the substantial population found in mid-depth (30'-60') Open Areas (Table 5). There is also no commercial food fishery for this species, at least in West Hawai'i and it doesn't appear to be highly targeted by non-commercial fishers. The cause of the overall declining abundance of Saddle Wrasse in protected and unprotected areas is unknown but clearly it is not due to aquarium collecting.

Table 5. Open Area population estimates of 'White List' species and % of that population taken annually by aquarium collectors. "Catch" is the average aquarium catch over FY 2013 - 2014 and 30'-60' Open Area Population" is an estimate of total numbers of fish in collected Open Areas of hard bottom habitat in 30'- 60' depths (CY 2012 – 2013). "Catch as % of Population" is the % of the species' population in collected Open Areas taken annually by aquarium collectors. "E" indicates an endemic species

Scientific Name	Common Name		Catch	30'- 60' Open Area Population	Catch as % of Open Area Population
Achilles Tang	*Acanthurus achilles*		7,073	21,627	32.70%
Yellow Tang	*Zebrasoma flavescens*		273,778	1,663,775	17.26%
Black Surgeonfish	*Ctenochaetus hawaiiensis*		4,045	34,678	11.66%
Shortnose Wrasse	*Macropharyngodon geoffroy*	E	258	3,222	8.01%
Goldrim Tang	*Acanthurus nigricans*		439	7,517	5.83%
Fourspot Butterflyfish	*Chaetodon quadrimaculatus*		699	22,000	3.18%
Orangeband Surgeonfish	*Acanthurus olivaceus*		698	26,101	2.67%
Orangespine Unicornfish	*Naso lituratus*		4,026	150,642	2.67%
Forcepsfish	*Forcipiger flavissimus*		1,045	43,999	2.38%
Spotted Boxfish	*Ostracion meleagris*		175	9,322	1.88%
Yellowtail Coris	*Coris gaimard*		288	19,762	1.45%
Milletseed Butterflyfish	*Chaetodon miliaris*	E	61	7,085	0.85%
Goldring Surgeonfish - Kole	*Ctenochaetus strigosus*	E	28,407	3,616,529	0.79%
Pencil Wrasse	*Pseudojuloides cerasinus*		108	19,390	0.56%
Bird Wrasse	*Gomphosus varius*		180	43,254	0.42%
Blacklip Butterflyfish	*Chaetodon kleinii*		23	5,593	0.40%
Potter's Angelfish	*Centropyge potteri*	E	945	237,149	0.40%
Ornate Wrasse	*Halichoeres ornatissimus*		724	192,404	0.38%
Black Durgon	*Melichthys niger*		71	38,033	0.19%
Gilded Triggerfish	*Xanthichthys auromarginatus*		19	11,186	0.17%
Lei Triggerfish	*Sufflamen bursa*		128	76,440	0.17%
Blackside Hawkfish	*Paracirrhites forsteri*		31	20,508	0.15%
Thompson's Surgeonfish	*Acanthurus thompsoni*		130	91,728	0.14%
Pyramid Butterflyfish	*Hemitaurichthys polylepis*		73	56,677	0.13%
Multiband Butterflyfish	*Chaetodon multicinctus*	E	670	580,196	0.12%
Hawaiian Dascyllus	*Dascyllus albisella*	E	43	57,796	0.07%
Saddle Wrasse	*Thalassoma duperrey*	E	327	537,688	0.06%
Redbarred Hawkfish	*Cirrhitops fasciatus*		6	9,665	0.06%
Eightline Wrasse	*Pseudocheilinus octotaenia*		35	187,557	0.02%
Fourline Wrasse	*Pseudocheilinus tetrataenia*		47	327,758	0.01%
Brown Surgeonfish	*Acanthurus nigrofuscus*		180	1,646,996	0.01%
HI Whitespotted Toby	*Canthigaster jactator*	E	20	250,573	0.01%
Bluestripe Snapper - Taape	*Lutjanus kasmira*		0	7,830	0.00%

Peacock Grouper - Roi	*Cephalopholis argus*		0	24,610	0.00%
Psychedelic Wrasse	*Anampses chrysocephalus*	E	236	N/A	N/A
Tinker's Butterflyfish	*Chaetodon tinkeri*		206	N/A	N/A
Longfin anthias	*Pseudanthias hawaiiensis*	E	130	N/A	N/A
Flame Wrasse	*Cirrhilabrus jordani*	E	67	N/A	N/A
Fisher's Angelfish	*Centropyge fisheri*		58	N/A	N/A
Eyestripe Surgeon	*Acanthurus dussumieri*		1	N/A	N/A
N/A – Species occurs in habitats not adequately surveyed by transects					

Examination of the yearly differences in a species' abundance between the Open Areas and the FRAs (e.g. Figures 6, 7 and 24) reveals that six species are consistently more abundant in the FRAs than in the Open Areas. These include the heavily harvested Yellow Tang and Kole. Eleven species showed no consistent pattern and 17 species were consistently more abundant in the Open Areas.

Endemic Species on the White List

An endemic species is a one whose presence is restricted to a specific geographic area. Of the 662 species of reef and shore fishes in the Hawaiian Islands, it is currently estimated that 25% of them are endemic (Randall 2007). Of the 40 species on the WHFC White List (Table 6), 11 (27.5%) are considered endemic to Hawaiʻi - only slightly above the average level of overall Hawaiʻi marine fish endemism. All but one of the endemic species (Psychedelic Wrasse - *Anampses chrysocephalus*) also occurs at Johnston Atoll.

A number of Hawaiian endemics are important food species and are harvested in substantial numbers both commercially and non-commercially. These include Āholehole, ʻAlaiʻihi ʻĀweoweo, Hāpuʻu, Kole, Kūmū, Mamo, Nabeta, Nohu, Uhu, Banded Spiny Lobster and three species of ʻOpihi.

Several researchers have commented on the relative abundance of endemic fishes. Gosline and Brock (1960) noted *"that many of the endemic fish of the Hawaiian Islands are the most abundant of their genera"* and similarly Hourigan & Reese (1987) state that *"many endemic species are the most abundant Hawaiian fishes in their families*." Randall (2007) commented that "*native species have evolved in isolated outposts such as Hawaii for long periods of time and therefore have had ample opportunity to become fully adapted to their environment*."

Table 6. Endemic species on the White List. References relative to abundance are listed below. Listed in the third column are population estimates on West Hawaiʻi reefs in hard bottom habitat in 30'-60' depths. These estimates are derived from WHAP survey densities (2013) and area estimates from NOAA habitat maps. The forth column lists the % of a species population in 30'-60' Open areas which is taken annually by aquarium collectors (based on FY 13-14 records)

Species	Abundance	30'-60' Open Area Pop	% AQ Catch 30'-60' Open Areas
Macropharyngodon geoffroy		3,222	8.01%
Chaetodon miliaris	Most common B-Fly[1,2]	7,085	0.85%

Ctenochaetus strigosus	Very common on HI reefs[1]	3,616,529	0.79%
Centropyge potteri	Most common angelfish[1]	237,149	0.40%
Chaetodon multicinctus		580,196	0.12%
Dascyllus albisella		57,796	0.07%
Thalassoma duperrey	Most common inshore wrasse[1]	537,688	0.06%
Canthigaster jactator	Most common Toby[1]	250,573	0.01%
Anampses chrysocephalus		NA*	NA
Cirrhilabrus jordani	Common in right habitat[3]	NA	NA
Pseudanthias hawaiiensis	Abundant at 40-199m[4]	NA	NA
NA* - Species occurs in habitats deeper than transects			

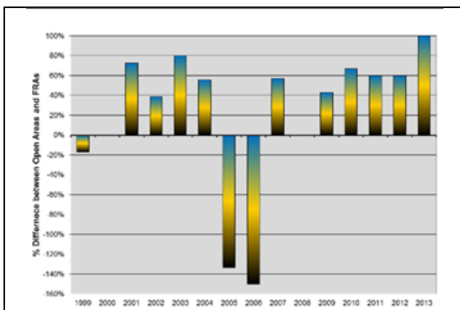
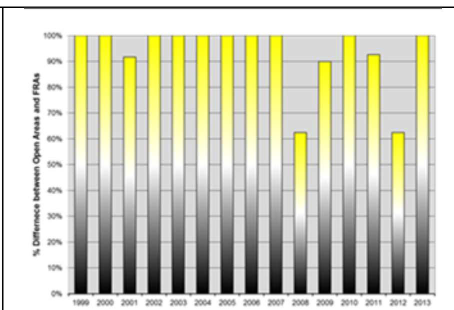
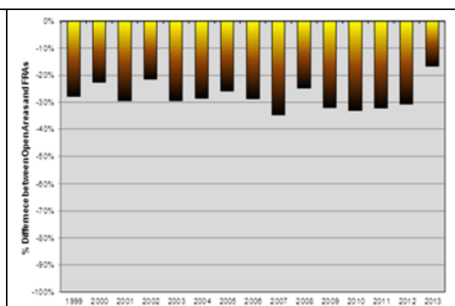
1. Randall J.E. 2007, 2. Brock V.E. and T.C. Chamberlain. 1968, 3. Hoover J.P. 2008,
4. Chave E.H. and B.C. Mundy. 1994.

Six of 11 endemic species on the White List are common in suitable habitat (Table 6). Collecting pressure on eight of these species, those for which we have adequate survey data, takes <9% of their Open Area population annually. Seven of the 8 species have <1% of their population collected annually.

Note that the population estimates presented in Table 6 represent only a portion of available habitat where these species occur and populations in MPAs and FRAs are essentially not collected. Thus total populations in all habitats are invariably higher than indicated for just the 30'-60' depth range indicated above.

Figure 25 shows the difference in an endemic species' abundance in West Hawai'i Fish Replenishment Areas (FRAs) relative to Open Areas. Of the eight endemic species for which we have good survey data, only Kole and the Multiband Butterflyfish (*Chaetodon multicinctus*) are consistently less abundant in the Open Areas relative to the FRAs.

Kole are currently (2012/2013) 23.7% less abundant in Open Areas than in FRAs (avg. 2012-2013). The Multiband Butterflyfish has also been consistently less abundant in the Open Areas but this difference has been decreasing in recent years and now the difference is only 5.9% (avg. 2012-2013). The % of the Open Area population of both these species taken by aquarium collectors in recent years is <1% (Table 5). Combined with the facts that the abundance of the other six endemic species are not consistently lower in the Open Areas and none of the 8 has significantly declined *only* in Open Areas, indications are that aquarium related impacts on these species are very low.

		
Macropharyngodon geoffroy	*Chaetodon miliaris*	*Ctenochaetus strigosus*

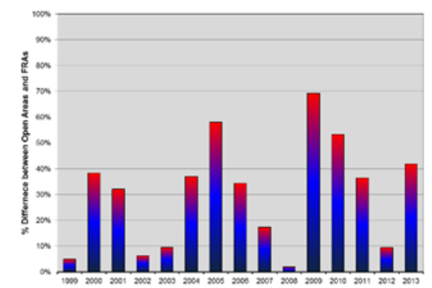
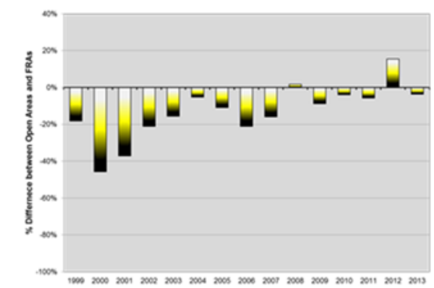
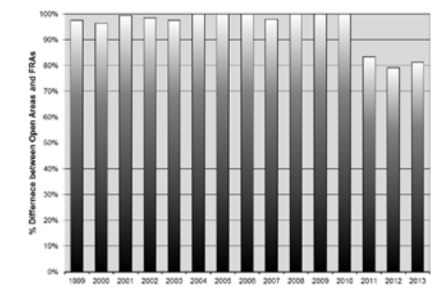
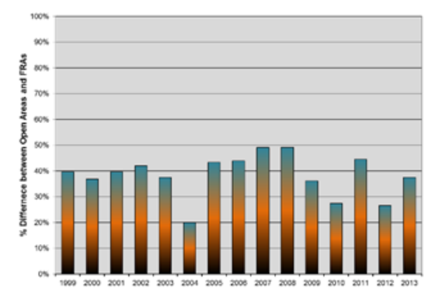
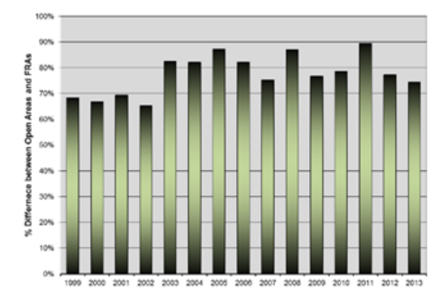
		
Centropyge potteri	*Chaetodon multicinctus*	*Dascyllus albisella*
		
Thalassoma duperrey	*Canthigaster jactator*	

Figure 25. Difference in the abundance of Endemic White List species in West Hawai'i Fish Replenishment Areas (FRAs, n=9) relative to Open Areas (n=9). Bars represent the % difference in abundance for each year from 1999 to 2013. Bars *above* the x axis indicate greater abundance in the Open Areas than the FRAs. Bars below the axis indicate greater abundance in the FRAs than the Open Areas

For three endemic species on the White List, Psychedelic Wrasse (*A. chrysocephalus*), Hawaiian Longfin Anthias (*Pseudanthias hawaiiensis*) and Flame Wrasse (*Cirrhilabrus jordani*), we do not have adequate population estimates to assess the impact of continued aquarium collection due to their deeper water habitats. There is also another non-endemic species, Tinker's Butterflyfish (*Chaetodon tinkeri*), for which data is similarly lacking.

Wherever possible other sources of data should be utilized to monitor the status of these species and their continued inclusion on the White List. Figure 26 shows the West Hawai'i aquarium catch and price paid per fish (adjusted for inflation) for the four species noted above. Meaningful trends in catch report data for these species aren't readily apparent although there is some indication of a downward trend in catch for Tinker's Butterfly. Value isn't increasing however as would be expected if scarcity was affecting prices. It is clear that collection of Hawaii Longfin Anthias is a relatively recent development. The value of individual fish received by collectors has been increasing for Flame Wrasse and Hawaiian Longfin Anthias and decreasing for Psychedelic Wrasse likely driven by market forces (i.e. aquarist preferences).

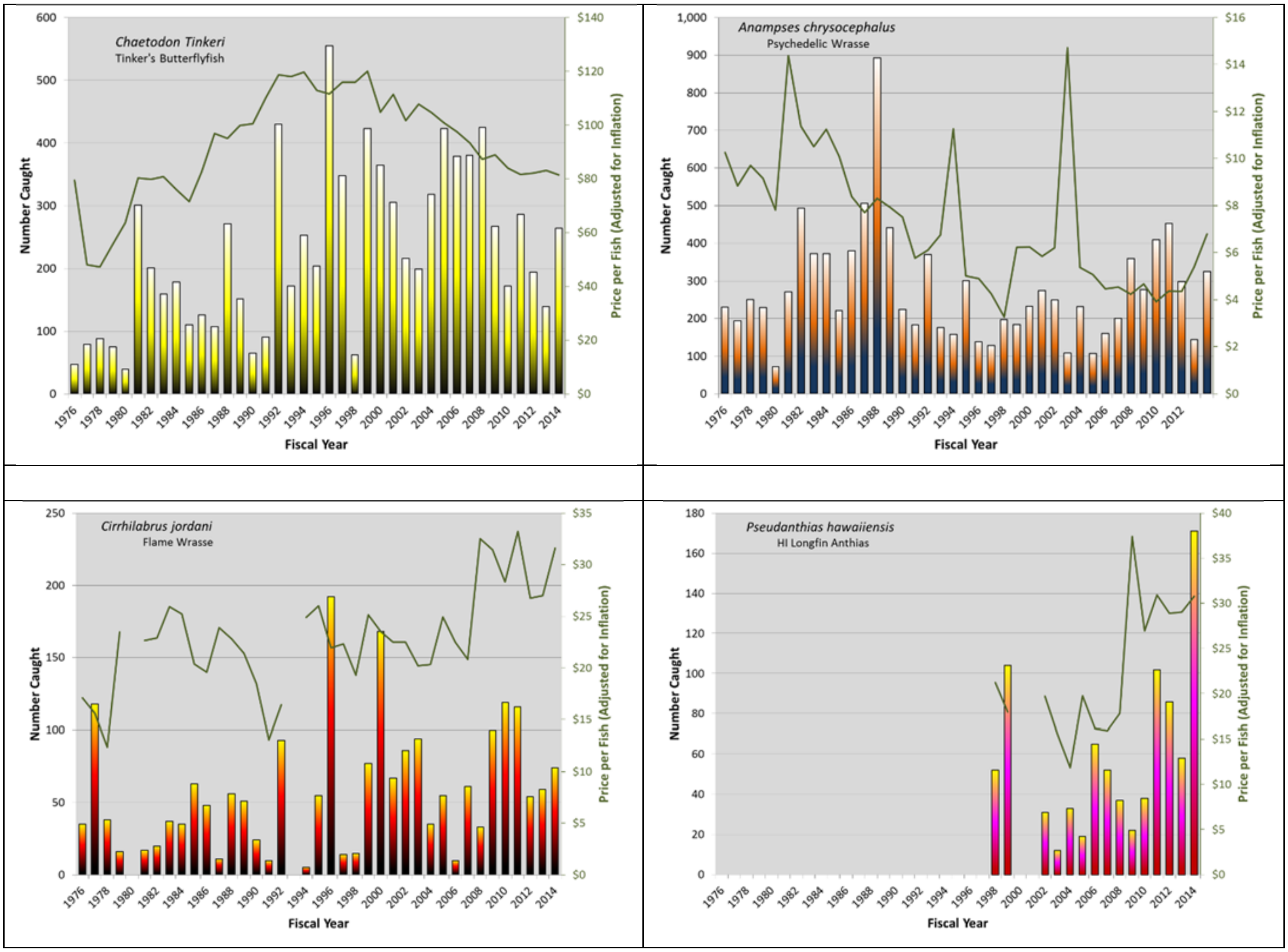


Figure 26. West Hawai′i aquarium catch (vertical bars) and ex-vessel price per fish of selected species

The only other relevant sources of information on these four species are observations at depth from the dive logs of local technical divers Gerard and Dr. Vicky Newman. Dives ranged from a minimum depth of 60 feet to a maximum depth of 331 feet. Figure 27 presents Gerard Newman's observations as percentage of dives on which a particular species was observed within a given type of management area over the period 2002-2011.

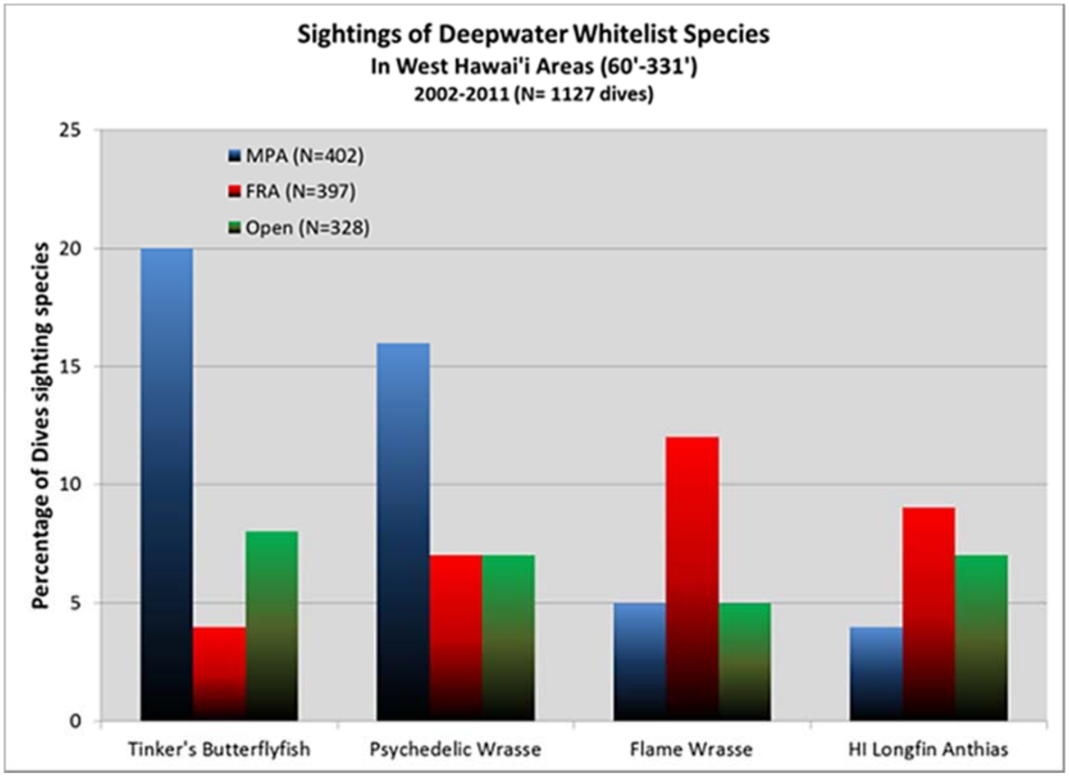


Figure 27. Deepwater sightings by West Hawai′i technical divers. N= 1,340 dives

Tinker’s Butterflyfish and Psychedelic Wrasse were substantially more common in the long term protected areas (MPAs) while Flame Wrasse and Hawaiian Longfin Anthias were more abundant in the FRAs. Sightings for all these species in all management areas did not exceed 25% of observational dives.

<u>Aquarium reef fish catch vs. non-aquarium catch</u>

The role of Herbivorous fishes in maintaining resiliency by exerting strong top-down pressure on macroalgae growth on coral reefs has been well documented (e.g. Bulleri et al. 2013). Of particular importance are the abundance of large herbivores such as parrotfishes (Ong and Holland 2010). Herbivore biomass in the West Hawai′i MPAs (Figure 28) is currently (2012/2013) significantly higher (1.8X) than in the FRAs or the Open areas (ANOVA $\rho<0.001$). Herbivore biomass is also a slightly but significantly greater in the FRAs than in the Open areas (ANOVA $\rho=0.001$). In contrast to the MPAs, there are significant declining long term trends of herbivore biomass in both the Open areas ($\rho=0.01$) and the FRAs ($\rho=0.02$).

Both the Open Areas and FRAs permit all fishers (excepting aquarium collectors) almost unrestricted take of herbivores such as surgeonfishes and parrotfishes with few size limits (all minimum sizes) and no bag limits. In contrast, the MPAs have additional restrictions affecting herbivore take including a few highly protected or no-take areas. Other types of fishing (i.e. food fishing) are likely responsible for observed differences between these areas and the more protected MPAs A newly instituted SCUBA spearfishing ban hopefully will provide additional coast-wide protection for important herbivores especially parrotfishes which are especially vulnerable at night.

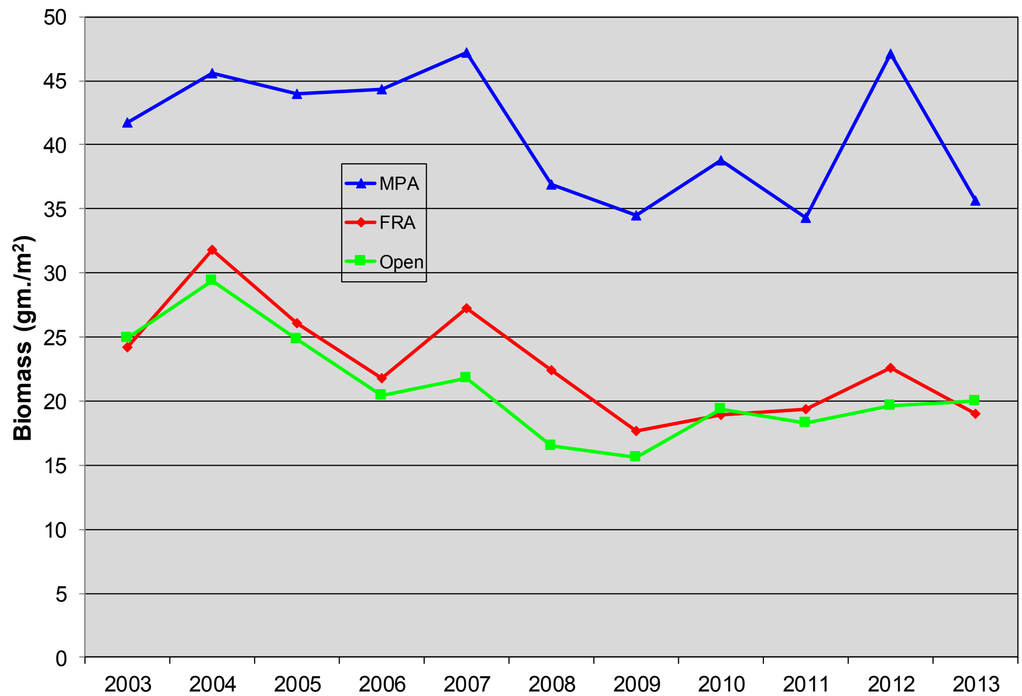


Figure 28. Overall change in herbivore biomass in FRA, MPA and open areas 2003-2013. Note WHAP fish sizing commenced in 2003

In order to gain a more balanced perspective on the generalized impact on reef fishes by aquarium collecting vis á vis other types of reef fishing activities, reef fish catch by aquarium collectors were compared with the catch of other commercial fishers and non-commercial 'recreational' fishers. Both aquarium collectors and other commercial fishers are required by law and Administrative Rule to submit catch reports and thus island specific reef fish catch data is available for each group. As noted previously (Figure 5), recent analysis suggests that aquarium catch reports appear to fairly accurately reflect actual catch. Unfortunately, similar assurance isn't available for other commercial catch reports and there is information suggesting that commercial catches are likely substantially underestimated (Milne 2012).

Recreational fishers in Hawai'i are not required to submit catch reports but such catch data has been collected since 2003 by the Hawaii Marine Recreational Marine Fishing Survey (HMRFS) and subsequently since 2007 by NOAA's Marine Recreational Information Program (MRIP). Species-specific recreational catch data on a statewide basis is available online: http://www.st.nmfs.noaa.gov/st1/recreational/queries/custom_time_series.html. All MRIP catch data from 2008 thru 2010 was decreased by a factor of 81.96% (i.e., 1/1.22) because of a count error made by NOAA in the population household numbers for Maui County (Hongguang 2012).

MRIP data is presented on a state-wide basis. Averaged over the period 2008-20011, the number of reef fishes caught statewide by the recreational and commercial sectors has been quite comparable averaging 1,511,025/yr. for recreational fishers and 1,554,010/yr. for commercial (i.e. non-aquarium) fishers.

The combined catch however is 1.7X the total statewide take (1,810,402/yr.) of aquarium fishes. The average yearly biomass (pounds) of reef fish caught by commercial fishers was similar for both commercial fishers (1,199,520 lbs.) and recreational fishers (1,160,337 lbs.). A biomass comparison was not made with the aquarium catch.

To compare total reef fish catches for the various fishing sectors on a more localized area basis, it was necessary to apportion the recreational catch among island areas. An adjustment factor was calculated based on the percentage of statewide commercial reef fish landings reported from each area (generally island or county as well as West Hawai'i). A separate adjustment factor was derived for both number of reef fishes caught and biomass. Biomass was estimated for aquarium fish catch by specifying a targeted size or typical maximum size of collected species based on information provided by active collectors (n= 7) and Stevenson et.al. (2011). Size data was then converted to weight utilizing length to weight conversion factors (DAR database).

In West Hawai'i, the aquarium fishery takes 1.8X the number of reef fishes taken by recreational and other commercial fishers combined. If Yellow Tang, which is primarily harvested at small sizes and not targeted by other fishers, is excluded, the recreational and commercial fisheries combine to take 3X the number of reef fishes caught by aquarium collectors (Figure 29).

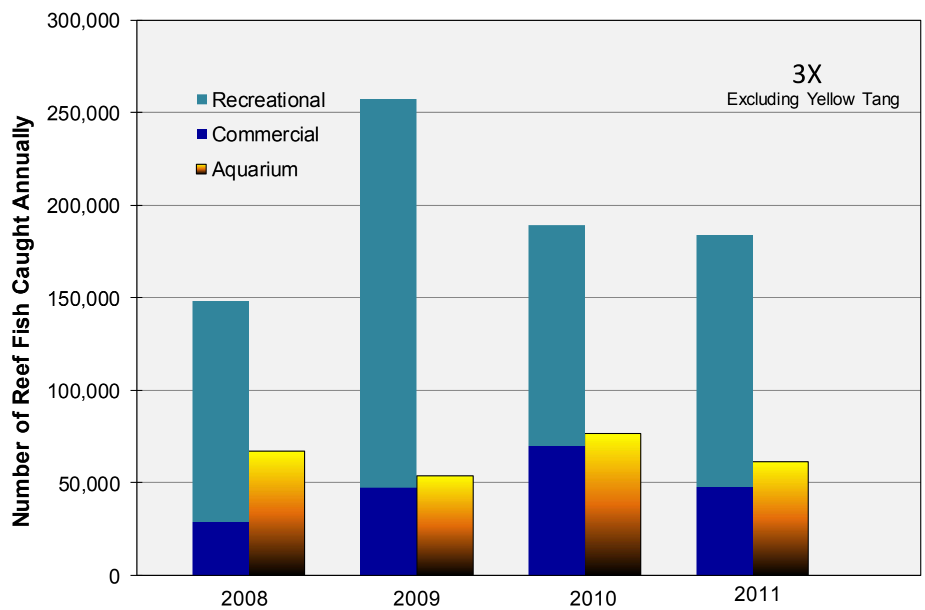


Figure 29. Comparison of the number of reef fishes, excluding Yellow Tang, caught by recreational, commercial and aquarium fishers in West Hawai'i

In terms of reef fish biomass caught by the different fisheries in West Hawai'i, considerably more biomass is taken by the combined recreational and commercial fisheries either including Yellow Tang (2.8X) or excluding it (8.6X) (Figure 30). Additionally, unlike the aquarium fishery which targets mostly immature fish, the other fisheries selectively target the larger breeding portion of the population which has profound implications for the sustainable usage of the resource. This is reflected in Figure 28.

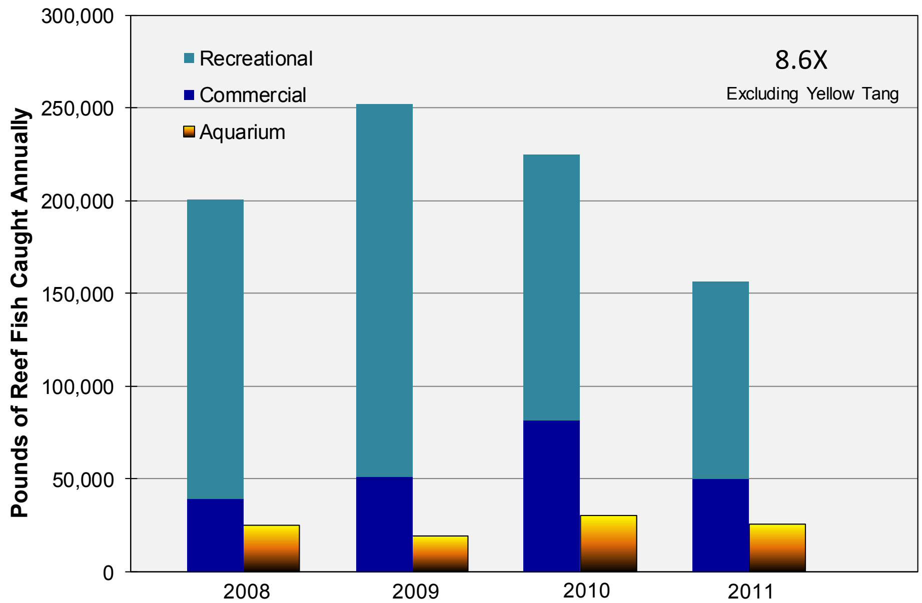


Figure 30. Comparison of the biomass of reef fishes caught by recreational, commercial and aquarium fishers in West Hawai′i

As in West Hawai′i (excluding Yellow Tang) the total take of reef fish by commercial and non-commercial ('recreational') fishers on other islands also greatly exceeds the numbers and biomass of the fish taken by aquarium collectors (Table 7). Note that in recent years the aquarium catch on Maui has declined markedly as several collectors moved off island. FY14 Maui aquarium catch (3 collectors) totaled 278 organisms.

Table 7. Island comparison of the number and pounds of reef fishes caught by recreational and commercial fishers relative to aquarium collectors 2008-2011. The far right column represents Total Non AQ catch of reef fish relative to the catch taken by aquarium collectors

Reef Fish Catch Numbers					
	Recreational	Commercial	Total Non AQ	Aquarium	Non AQ/AQ
West Hawai′i	146,176	48,498	**194,674**	**343,729**	**0.6X**
West Hawai′i w/o YT	146,176	48,498	**194,674**	**64,815**	**3X**
Maui	218,474	71,730	**290,204**	**13,316**	**22X**
′Oahu	675,520	196,417	**871,936**	**81,514**	**11X**
Kaua′i	218,423	93,223	**311,645**	**546**	**571X**
Reef Fish Catch Biomass (lbs.)					
West Hawai′i	153,193	55,468	**208,661**	**75,274**	**2.8X**
West Hawai′i w/o YT	153,193	55,468	**208,661**	**25,248**	**8.6X**
Maui	342,769	122,268	**465,037**	**3,217**	**145X**
′Oahu	496,132	242,812	**738,945**	**36,119**	**20X**
Kaua′i	215,685	63,794	**279,479**	**626**	**446X**

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Many people have played important roles in laying the groundwork for successful and adaptive marine resource co-management in West Hawaiʻi. David Tarnas is to be especially commended for his innovative and forward looking legislation. Sara Peck of UH Sea Grant College Program had been involved from the beginning and was instrumental in ensuring community participation and education. Many other people have played and continue to play important roles in West Hawaiʻi resource co-management. Some of them are listed below; Mahalo nui to those who are not listed:

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