Gearing towards the aquaculture of the Palette Surgeonfish

By the MASNA Board and Volunteers. Published January 27, 2016. Addendum Added August 24, 2016.

Introduction

The scene is set for the sequel to the incredibly successful Pixar/Disney movie Finding Nemo. Scheduled for release in June 2016, Finding Dory sets out to answer a question posed in the first movie: "where is Dory's family?" On the face of it, there is nothing concerning about this storyline. But two troubling flaws emerge from early information released about this movie and its predecessor: 1) the assertion that Dory is captive bred, and 2) that aquarium fish should be returned to the ocean. These messages indicate some troubling assumptions and assertions that may have dire implications for palette surgeonfish and its collection from the wild.

An adult palette surgeonfish (*Paracanthurus hepatus*). Public Domain, WikiMedia [https://goo.gl/7YI2dE]

Marine aquarists know that Dory is the cartoon depiction of a palette surgeonfish (*Paracanthurus hepatus*), also known as the Pacific blue tang, hippo tang, regal tang, and letter six fish. In Finding Dory, we learn that Dory was born and raised in captivity at an animal-friendly marine biology institute, and then released into the wild. Unfortunately, this concept is fiction; while captive breeding of *P. hepatus* is indeed being pursued, it has not yet been achieved, and 100% of *P. hepatus* specimens are collected from the wild.

Equally, if not more, problematic is the movie's underlying message that aquarium fish should be released back to the wild. On the back of the award-winning documentary Blackfish, the producers of Finding Dory and their celebrity spokesperson Ellen DeGeneres, are promoting the return of marine life to the ocean [http://tinyurl.com/qbq8jz5]. This message comes with tremendous ecological risk, as the release of aquarium fish back into the wild can lead to invasive species that will have dire consequences for the host ecosystem. For example, look no further than the *P. volitans* and *P. miles* lionfishes disaster across the Western Atlantic and Caribbean. No doubt Pixar and DeGeneres had a noble intent, or at least are trying to stave off critique like the one directed at SeaWorld, but in doing so, they promote a dangerous practice that does not serve anyone—aquarists, the public, and marine life alike—well. Returning injured marine mammals to their native habitats after rehabilitation at a public aquarium is a far cry from releasing *P. hepatus* into non-endemic Californian waters. Don't ever release your pet fish into the wild!

Thankfully our hobby and influential industry bodies are speaking out now about the movie's problematic messaging. The Sustainable Aquarium Industry Association (SAIA) has produced a YouTube video that steps through the reality of how "Dory" gets to our aquaria, and people like Michael Tlusty at the New England Aquarium have been in discussions with Pixar about fundamental flaws in the storyline that could have concerning implications. As hobbyists we can also be informed, help communicate the facts, and be responsible in our actions. To this end, this article summarizes some of the latest advances in captive breeding and culture of two signature species of tangs familiar to aquarists: the yellow tang (*Zebrasoma flavescens*) and, of course, the palette surgeonfish.

A shoal of adult "yellow belly" palette surgeonfish (*Paracanthurus hepatus*) in Pemba, Tanzinia. Creative Commons, Image © James Heilman, WikiMedia [https://goo.gl/R9Ybkr]

Lessons from Finding Nemo

Many aquarists remember the increased popularity of the anemonefishes that followed Finding Nemo. However there is concern about the fate of many of those pet fishes. There are many stories of indiscriminate purchases and poor treatment of anemonefishes by people who did not have the proper aquaria, information, or long-term interest to correctly maintain these animals. Today, captive bred anemonefishes are prolific in US pet stores. They are so ubiquitous, in fact, that the National Marine Fishery Service (NMFS) recently used the success of captive breeding as one of the reasons to reject the ESA petition of the orange anemonefish (*Amphiprion percula*) [http://tinyurl.com/h3wd3ym]. In itself, this is a tremendous success story for marine ornamental aquaculture. For anything other than professional breeders looking to diversify bloodlines, there is little reason to harvest anemonefishes from the wild. The palette surgeonfish, however, stands in stark contrast, though not for the lack of effort to aquaculture this and other species of surgeonfishes and tangs.

Tangs and surgeonfishes are all pelagic spawning fishes. Unlike demersal spawning fishes like gobies and anemonefishes that attach their eggs to the bottom or other types of substrates, pelagic spawning species release their eggs and sperm into the water column. The fertilized eggs are cast adrift and become part of the plankton 'soup', where they hatch and live until it is time to metamorphose into juveniles. At which point the post-larvae settle (drop from the water column into the reef) in a specific habitat, where they complete their metamorphosis. This broadcast mode of reproduction is common to many species of fishes and is evolutionarily very successful. The problem for captive breeding is that this pelagic spawning strategy does not make it easy for captive breeding. Broodstock systems often need to be very large to encourage sexually mature fish to spawn as groups or harems. An aquaculturist then needs to collect viable fertilized eggs from the water without damage. Eggs that do hatch produce very small, and poorly-developed larvae. It is with the small larvae that the real challenges sit and where current efforts to captively breed tangs is stalled. The problem is not getting these fish to spawn; it is in getting their larvae to develop and transition to juvenile fish.

Successful captive breeding of pelagic spawning species, like cobia or groupers, has been ongoing for decades. Martin Moe had early success with Caribbean angelfishes in the early 1970s. In the past decade we had Dr. Matthew Wittenrich build upon previous success of rearing dragonets, to develop commercial scale protocols for two species (*Synchiropus spp.*). We have also seen many of the pygmy angelfishes (*Centropyge*) being captively bred, mostly, in Hawaii by Frank Baensch's group. In 2014, Karen Brittain and Rufus Kimura reported notable success breeding and raising *Genicanthus personatus* (masked angelfish). And of course Wen-Ping Sui of Bali Aquarich is reporting success with new angelfish species seemingly every few months. Surgeonfishes and tangs, however, have so far eluded these and other capable aquaculturists, including research groups, professional aquaculture companies, and hobbyists. Several teams are trying to culture popular tangs with *Z. flavescens* and *P. hepatus* topping the list. There has been one successful group and many are very close.

Progress from the experts

Rising Tide Conservation

Rising Tide Conservation is an initiative of the SeaWorld and Busch Gardens Conservation Fund. Their mission is to protect reefs by developing techniques for rearing marine ornamental fishes, and promoting commercial production to provide alternatives to reef collection. This organization interacts and works with public aquaria with large systems where groups of fish are often spawning on a regular basis. Fertilized eggs or newly-hatched larvae are collected, and various larvaculture techniques are researched to develop optimized rearing protocols for commercial aquaculture. Integral to this group is the University of Florida's Tropical Aquaculture Laboratory (TAL), which has had *P. hepatus* broodstock fish spawning almost everyday for the last three years.

TAL Larval Rearing Room

Kevin Barden recently reported on the status of rearing the hatched eggs from these spawnings at the annual Marine Breeding Initiative Workshop. The Rising Tide team is now consistently getting post-hatch survival of *P. hepatus* larvae between 15 and 20 days. This in itself is significant. Two years ago, despite heavy feeding on copepods, larvae survived only 24-48 hours. This progress is attributed to refined protocols using *Parvocalanus copepods*, as well as improved broodstock conditioning. One important observation made by Kevin's team was that initial feeding of the larvae is relatively easy; getting the larvae to live and grow is the big challenge. He predicts that once they understand (and resolve) what is causing the mortalities at the 15-20 day post hatch period, then *P. hepatus* may be relatively easy to aquaculture.

TAL Marine Broodstock Greenhouse

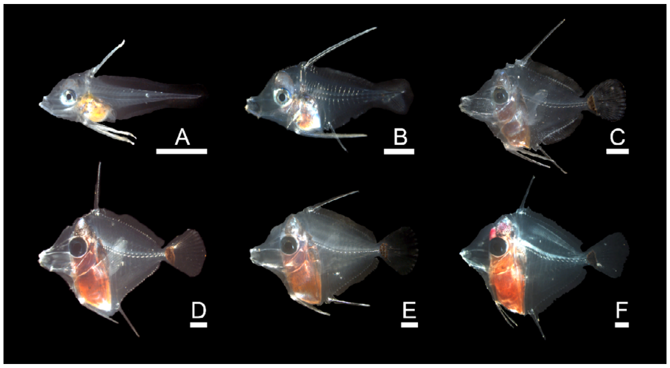
The Oceanic Institute in Hawaii

The Oceanic Institute (OI) at the Hawaii Pacific University started working on breeding yellow tangs, *Z. flavescens*, over a decade ago and were largely unsuccessful. That is until late October of 2015, when the ornamental aquaculture group at OI, lead by Dr. Chatham (Chad) Callan, announced that they were able to get *Z. flavescens* to the juvenile stage.

In the past, OI invested relatively little effort into the culture of ornamental species since their primary focus is on commercial culture of food fishes. The Oceanic Institute is now a collaborative partner with the Rising Tide Conservation group and has intensified its ornamental culture program. Their marine ornamental program at OI has been, and remains poorly funded. But the established food fish culture infrastructure provided a springboard for OI's renewed efforts to culture *Z. flavescens*. In their recent efforts, they were able to get yellow tang larvae to an age of 83 days-post hatch (DPH) in their first run, but could not achieve settlement.

A few of the 709 yellow tangs that OI has produced in their second successful rearing run. Note that different individuals are showing varying degrees of yellow coloration development. Image source Oceanic Institute.

Fine-tuning their methods for their second run and providing a plethora of foods over a much longer period of time, they were able to get their second batch of larvae to settle between 55 – 65 DPH of age (Video 1 http://tinyurl.com/ha6x3e9 & Video 2 http://tinyurl.com/znsdvdt). Reassuringly, the ages that the cultured fish were settling at were similar to wild settled yellow tang, suggesting that the methods currently employed by OI are allowing the larvae to achieve similar developmental milestones as their wild counterparts. OI plans on refining their methods, and ultimately establish an effective commercial protocol for yellow tangs.



Yellow tang larvae reared at OI. A) 14 DPH, B) 24 DPH, C) 36 DPH, D) 45 DPH, E) 50 DPH, F) 60 DPH. Scale bar = 1 mm. Image source Oceanic Institute/Rising Tide.

They hope to produce an initial scientific paper on the development of yellow tang in 2016, followed by more detailed methodologies later on. These protocols would be crucial for the establishment of not only yellow tang commercial scale aquaculture, but also culture of other tangs and surgeonfishes, like the palette surgeonfish. Following the success of OI with yellow tang, Kevin Barden of the Tropical Aquaculture Laboratory, has visited the OI facilities in hopes of replicating OI's success with the palette surgeonfish.

Updates from OI can be found on their Facebook page [http://tinyurl.com/z5qn577], and updates from the rest of the Rising Tide Conservation collaborators can be found on their blog [http://tinyurl.com/zvnneth] and Facebook page [http://tinyurl.com/juqvtpr]. These are great resource of the latest achievements in breeding marine ornamentals.

Sustainable Aquatics

For some time, Sustainable Aquatics (Tennessee) and others have imported wild-collected, small juvenile *P. hepatus* that have been grown out in pens/cages to a marketable and aquarium suitable size. Sustainable Aquatics has also been experimenting with captive breeding and culture of this species, as well as other tangs including the yellow tang and the purple tang (*Zebrasoma xanthurum*). Information available to date suggests that this team is also making viable progress with larvae but, like others, have not gotten through the critical settlement phase to juvenile fish.

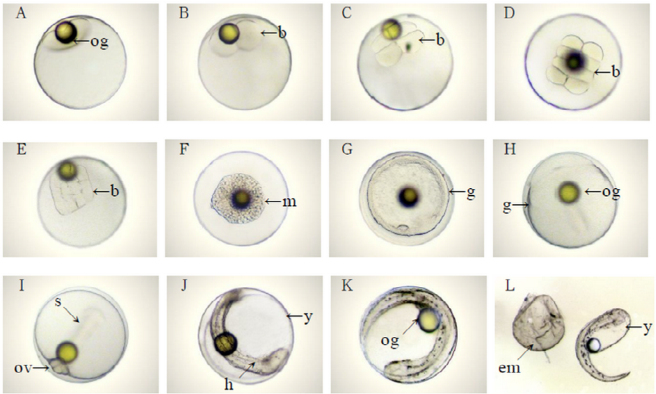
Fisheries Research Institute of Taiwan

The institutional record holder for post-hatch survival of *P. hepatus* comes from the Fisheries Research Institute of Taiwan. Yuan-Shing Ho and team have published larval development details through to 26 days post-hatch when transition to the juvenile stage began. Images of both embryonic development and morphological changes of the larvae support the publication. Ho's rearing protocol used a type of ciliate as the first feed, followed by rotifers, and then copepods.

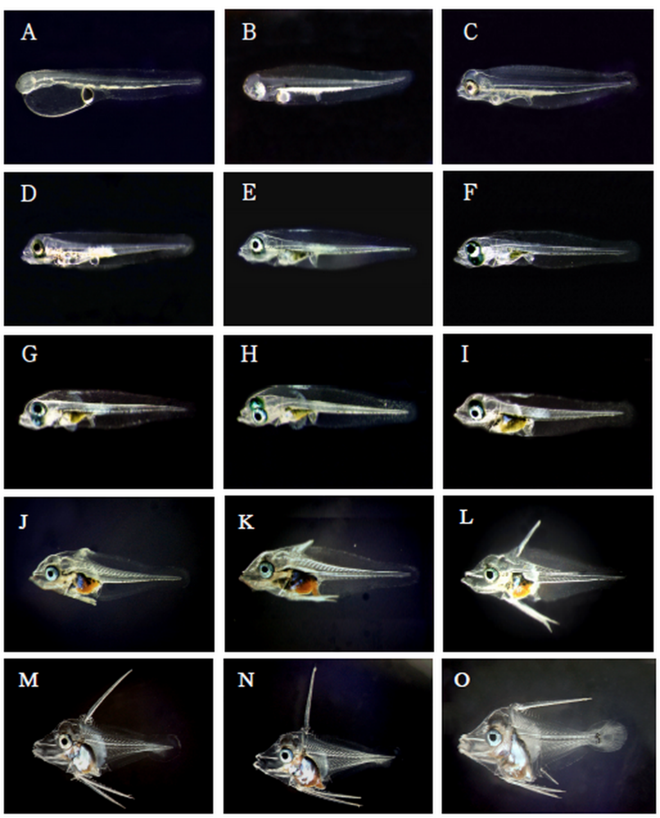
A wild juvenile palette surgeonfish (*Paracanthurus hepatus*). Notice the more oval shape compared to the elongated adult, and narrow black "figure 6". Public Domain, WikiMedia [https://goo.gl/H9eb8n]

Using ciliates as a first food for pelagic larvae is not new and has shown success with a number of species including the marine angelfish. Ciliates are recognized as an important microorganism in the natural food web, although it's still not completely clear what nutritional value they deliver [http://tinyurl.com/gm5xln4]. The team from Taiwan suggests the species of ciliate they used was key to a first feeding response of the *P. hepatus* larvae, whereas Kevin Barden's team achieved first feeding of larvae directly with a species of copepod. This empirical journey of trial and error, along with a realization of how many of nature's variables impact success or failure, is typical of the leading edge of marine ornamental aquaculture.

The Taiwan team reported start of transition to the juvenile stage at 26 days. This is encouraging for aquaculture potential, although it is unclear if any of the *P. hepatus* larvae studied survived through to juvenile fish. The mean pelagic larval duration (PLD) of this species in the wild is understood to be around 40 days followed by settlement onto the reef and a pre-metamorphosis period before full color transition into the juvenile fish. Indications of start of metamorphosis at 26 days suggest adequate nutrition and good development of the larvae.



Embryonic Development of *P. hepatus*, Yuan-Shing Ho et. al, Eastern Marine Biology Research Center, Fisheries Research Institute, Taiwan. A, Fertilized eggs ; B, 2-cell stage ; C, 4-cell stage ; D, 8-cell stage ; E, 16-cell stage ; F, Morula Stage (m) ; G, Blastula stage (g) ; H 2/3 of yolk was covered with blastodisc ; I, Optic vesicles appeared (ov) 7 somites (s) ; J, Optic lens (ol) and tail formed, tail freed from yolk sac ; K, 4/5 of yolk was surrounded with embryo ; L, Newly-hatched larvae ; b=blastomeres; bp= body pigment; em= egg membrane; h= heart; og= oil globule; tb= tail bud; y= yolk



Morphological changes of *P. hepatus* from larvae to fry stages, Yuan-Shing Ho et. al, Eastern Marine Biology Research Center, Fisheries Research Institute, Taiwan. A, Newly-hatched larva 1.52 ± 0.05 mm ; B, 2 DPH 2.16 ± 0.18 mm ; C, 3 DPH 2.29 ± 0.12 mm ; D, 4 DPH 2.41 ± 0.11 mm ; E, 5 DPH 2.42 ± 0.15 mm ; F, 6 DPH 2.47 ± 0.16 mm ; G 7 DPH 2.58 ± 0.21 mm ; H, 8 DPH 2.60 ± 0.19 mm ; I, 9 DPH 2.68 ± 0.19 mm, J, 12 DPH 2.96 ± 0.22 mm, K, 15 DPH 3.23 ± 0.31 mm, L, 17 DPH 3.50 ± 0.28 mm ; M 19 DPH 4.86 ± 0.39 mm ; N 20 DPH 5.18 ± 0.3 mm ; O, 26 DPH 6.20 ± 0.94 mm. DPH = days post hatch.

Larval settlement and full transition to juvenile fish seems to be a bottleneck common to *P. hepatus* and *Z. flavescens* with the latter species recorded as 54 days PLD on the reef. This is certainly an area of research and experimentation and once resolved may trigger success with aquaculture of other pelagic species. Factors affecting settlement likely include development/nutritional status of the larvae, lunar phases, and chemical triggers, but there is clearly much still to discover. Routine larvae runs that produce healthy, fully-developing larvae beyond 20 days with *P. hepatus* will greatly assist the necessary experimentation. Unfortunately the work of Yuan-sing Ho and team was suspended citing lack of commercial viability to aquaculture the palette surgeonfish using the techniques identified. This is not fully understood but may relate to cost of raising the appropriate species of ciliates believed by this team to be necessary for successful larval development.

Achievements from the hobbyist

The day 26 institutional record of larval development leads us to the individual record and the amazing success of an Australian hobbyist spawning *P. hepatus* in his home aquarium. Darren Nancarrow of Perth has shown that it is possible to have a pair of fish reach sexual maturity and start spawning when they were 6-7 inches after growing from 2 inch fish. Darren's MBI Breeding Journal Datasheet can be found here [http://tinyurl.com/hh8zn44]. The initial success was achieved in a FOWLR community aquarium of only 24 inches deep and approximately 180 gallon volume. He was able to reliably sex the pair based upon abdomen shape and so added a second ~5 inch female fish to encourage regular spawning. With high quality regular feeding and stable aquarium conditions, Darren was able to get this trio of fish to spawn several times per week.

Regarding diet for the broodstock, Darren found success using fresh pipi clams, cockles, and other shellfish to supplement typical aquarium food. Broodstock conditioning relied simply on sufficient high quality feeding. Other aquarists have since also reported *P. hepatus* spawning in home aquaria and such You Tube videos can be found online. Darren took things further and set up a convenient Facebook page titled "Regal Tang Breeding" [https://goo.gl/e3W6oT]. Here high quality still images and video of developing eggs and larvae are posted along with links to articles and information from others attempting the breeding of *P. hepatus*. Darren recorded some larvae survival past 60 days post-hatch, although he notes that development past two weeks was minimal with larvae being very fragile. It is likely that the larvae from these rearing efforts were not developing naturally due to a lack of ap-

P. hepatus in a marine aquarium. Photo credit to Stéphane Duquesne [https://goo.gl/zk1upq]

Darren's breeding of this species was interrupted when the broodstock fish died during a power outage while he was on vacation. He is currently growing out new broodstock in an attempt to repeat his success and further advance the raising of the larvae. Despite the recent set-back, his success remains an encouragement to other hobbyists that *P. hepatus* can breed in home aquariums and produce viable larvae for rearing attempts.

MASNA would like to encourage anyone with interest in helping complete the lifecycle of *P. hepatus* to join the MBI here [http://www.mbisite.org/] and start documenting your efforts in raising *P. hepatus* larvae.

Conclusions

It is nice to see that the home aquarist and educational institutions can contribute to the knowledge base that drives our hobby forward and helps further understand the natural environment that we want to protect. This is an important message for aquarists to keep communicating within and outside of aquarist circles. Finding Dory the movie will undoubtedly propel our hobby into the spotlight again in 2016. However, what we do not need is a huge increase in wild collected palette surgeonfish to supply an induced demand. Then, if we also see *P. hepatus* and other aquarium fish being released into the wild, as Pixar/Disney seems to be promoting, there are potentially further consequences for these beautiful fish and our reef environments.

The aquarium community and industry should support initiatives that have already started to inform the public with facts, and not the emotional conjecture of amazing animation and a good story. Many of us will be there at the cinema on opening day, but we should also be there informing people of the facts around *P. hepatus* and only encourage the responsible purchase of this species by those who have made the significant commitment to keep them in appropriate aquaria.

Acknowledgments

Sincere thanks to the following people who provided details and data for this article: Kevin Barden (Rising Tide Conservation), Chatham Callan (Oceanic Institutes), Yuan-Shing Ho (Fisheries Research Institute of Taiwan), and Darren Nancarrow (Perth, Australia).

Addendum: Captive Breeding Update (8/24/2016)

At the time this article was published, we reported that the University of Florida's Tropical Aquaculture Laboratory (TAL) had made good headway in the captive breeding of the palette surgeonfish. Following the success of Dr. Chad Callan and his team at the Oceanic Institute (OI) at Hawaii Pacific University with the yellow tangs (*Zebrasoma flavescens*) in October of 2015, TAL sent Kevin Barden to OI to learn the details of OI's success with *Z. flavescens*. Upon returning to TAL, Kevin Barden worked closely with his colleagues at the University of Florida to incorporate aspects of OI's methods into their own. The fruits of their collaborative effort was brought to bare earlier this year, when on the 20th of July 2016 Rising Tide Conservation Initiative announced the successful captive breeding of the palette surgeonfish (http://tinyurl.com/j22k8jl). The team at TAL were able to achieve settlement at 40 days-post hatch, and on day 51 of this first successful run, the first fish developed blue coloration.

Recently settled palette surgeonfish (*Paracanthurus hepatus*). The fishes in the back are still clear and have their larval coloration, while the three in the front have already begun to show patches of blue coloration and their characteristic black lines. Image credit: University of Florida IFAS File Photo – Photographer, Tyler Jones.

Both the OI and TAL teams have achieved great success thus far, but the work is not done. Both teams are working on reproducibility of their successes. In order for captive-bred tangs to become true success for the marine aquarium hobby, this initial success needs to be followed with scaling up to consistent commercial scale production. On the 24th of August of 2016, Dynasty Marine Associates, Inc. announced that they have exclusively secured the initial offerings of captive-bred *P. hepatus* from TAL (Dynasty Marine: http://tinyurl.com/jo9hf43, Reef to Rainforest: http://tinyurl.com/hmsu5ps).

They will auction two individuals to the highest bidder and remainder will be donated to Association of Zoos & Aquariums (AZA) accredited facilities for display and public education. Auction proceeds will be donated back to the UF Foundation to support continued research. These funds will surely help develop commercial scale production. Furthermore, as our aquaculture technology quickly advances, we are confident that commercial production is in the near future. However, by in large, the success of captive-bred tangs does not lie with researchers or commercial producers, it lies with us as the hobbyists. We must make the conscious and monetary effort to choose captive-bred fish when they are the more sustainable choice, even if they cost more. Unless this philosophy is not adopted industry wide, the efforts of many researchers and commercial producers would be for naught. Let us not let captive-bred tangs go the way of captive-bred dragonets. Let's support captive breeding for a sustainable hobby and industry through both our praise and wallets, and not just with "likes" on social media.

An older lot of captive bred palette surgeonfish (*Paracanthurus hepatus*). These individuals have fully developed their adult coloration. Image credit: University of Florida Tropical Aquaculture Laboratory – Photographer, Craig Watson. Images and permission granted by Craig Watson at TAL on 8/24/2016

Note on Captive Breeding

MASNA defines "Captive Bred" as: "Organisms that were spawned and raised in tanks / captivity in facilities on land." The adults may have been sourced from the wild, but they have since been conditioned to captivity, and spawned their eggs in captivity. Eggs collected in the wild and hatched in captivity do not constitute captive breeding.