Marine Biodiversity Hub

National Environmental Science Programme

# Monitoring of Spotted Handfish (*Brachionichthys hirsutus*) populations and on ground conservation actions

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*Project: A10 Monitoring and conservation of spotted handfish*

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## Important Disclaimer

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# EXECUTIVE SUMMARY

Spotted handfish are a critically endangered species with limited data available to track their conservation trajectory. In 2016 we completed a second meta-population scale survey of all known local populations of spotted handfish within the Derwent Estuary and conducted exploratory surveys in the D'Entrecasteaux Channel. We also consolidated all historic density estimates from these sites to provide trend data for this species. This has delivered a scientifically robust monitoring program to track conservation trajectories and performance of the recently signed recovery plan across all known local populations (Recovery plan actions 4a, 4b, 4d and 4e). Collecting this data is crucial for informed implementation of policy such as further targeted placement of artificial spawning habitat (ASH) (Actions 1c and 1d) and to determine minimum population size to inform sustainable capture of brood-stock for an 'ambassador fish' project to build capacity to undertake a captive breeding project with industry (Action 3b-c). Other on-ground conservation outcomes include purchasing eco-friendly moorings for placement into critical handfish habitat (Action 2c), and engagement with the broader community through talks, outreach and publications (Action 6a).

In 2014 we trailed a new method of variable length strip transects GPS parameterised underwater visual census (GUVC) that decreased logistical costs while maintaining statistical power to monitor handfish populations. When combined with our innovative georeferenced photographic method we can provide both individual level data and precise densities of fish within local populations as a proxy for abundance. This new method allowed expansion of the survey to include all 9 known extant sites for the species for the first time in the 2015 season, as a pilot program funded by the national Landcare program. This was repeated in 2016 as part of the NESP Marine Biodiversity Hub program and we also consolidated an 18 year time-series of previous data collected as part of earlier recovery plans.

This research has had a number of impacts, first our work has produced a reasonably robust, well replicated and established time-series which future actions can be assessed against. This impact is of importance to both State and Federal governments as it fulfils a component of the recovery plan and will provide a baseline against which other recovery actions, such as assessing the effectiveness of experimental planting of Artificial Spawning Habitat (ASH). Second, the discovery of the complex microhabitat requirements of spotted handfish has quantified how known threats to handfish, such as chain moorings, destroy habitat. This has allowed us, with our Derwent Estuary Program (DEP), Royal Hobart Yacht Club and Derwent Sailing Squadron partners to receive additional funding from NRM South for eco-moorings. Replacement of traditional swing moorings with 'eco-moorings' to minimise habitat damage is another recovery plan action. Third, as the spotted handfish is a local conservation icon we have been able to partner with community groups such as Rotary and institutions like the Tasmanian Museum and Art Gallery (TMAG) to conduct extensive outreach activities with the general public. This included talks and development of the 'Handfish memory card game'. Finally, as only one high density local population of spotted handfish is now known to exist, planning for the capture of brood stock and re-establishment of captive breeding for this

species and potentially other handfish species is prudent at this stage. Establishing captive bred populations is a priority for both State and Federal governments. Our surveys will provided critical stock assessment guidance for brood-stock capture based on our photographic capture-mark-recapture study. Through co-ordination with the recovery team and the drafting of a MoU we have received in-kind commitments to return spotted handfish into captivity at two aquariums during 2017. Our industry partners are CSIRO, Seahorse World at Beauty Point, Sea Life Aquarium in Melbourne and the Zoos and Aquariums Association (ZAA).

# 1. INTRODUCTION

## 1.1 General information

Once widespread across Southern and Eastern Tasmania, spotted handfish (*Brachionichthys hirsutus*, Lacepède,1804) were originally collected by western scientists in 1802 by François Péron, as part of Nicolas Baudin's French scientific expeditions to Van Diemen's land (Tasmania) (Last et al. 2007). While initially described as 'common', decline in the spotted handfish population was first noticed in the late 1980's. Spotted handfish was then listed as vulnerable and subsequently critically endangered under state, federal legislations as well as on the International Union for the Conservation of Nature (IUCN) Red List. Being the first marine species listed as critically endangered on the IUCN Red List, spotted handfish have become somewhat of a local and international conservation icon (Roberts & Hawkins 1999; Powles et al. 2000; Diamond 2005).

Unlike many other marine species, spotted handfish directly recruit onto the benthos at the point of spawning (Bruce et al. 1997). Following sexual maturity being reached after 2-3 years, females provide parental care of egg masses of between 60-100 eggs (Bruce et al. 1997). This may mean that spotted handfish post-hatch mortality can be low due to the relatively large egg size and parental care, however limited field data are available on hatchling mortality. Due to this strategy of direct recruitment it is likely that local benthic habitat modification can have a major impact on the population.

Since the listing of the species, three recovery plans had been developed, including 1999-2001 (Bruce & Green 1998), 2002-2006 (Green 2001) and most recently 2015-2020 (Commonwealth of Australia 2015). Extensive surveys across the historic distribution of spotted handfish have been undertaken (Barrett 1996, Green unpublished data; Green et al. 2012) but the population was believed to be restricted to 9 sites within the Derwent Estuary.

## 1.2 Surveys methods

To provide scientific support to conserve the spotted handfish population we have implemented a scientifically robust monitoring program to track conservation trajectories and performance of the recently signed recovery plan across all known local populations of the spotted handfish. We surveyed the population using a new GPS parameterised underwater visual census (GUVC) technique which reduced logistical limitations while still maintaining high statistical power (Lynch et al. 2015). In 2015, CSIRO and UTAS undertook a monitoring project (Wong 2015) across all known local population sites and successfully implemented the first meta-population scale survey. These surveys provided a pilot for establishing a baseline dataset for long-term monitoring. Continuing this survey will provide the opportunity to determine a population trend within these local populations. We also consolidated all previous density estimates for the species collected in the Derwent between 1998 and 2014.

With our 2016 work we now have established minimum replication (n<3) to establish recent trends for all 9 sites in the Derwent estuary.

# 2. 2016 SURVEY DATA

## 2.1 Population density

### 2.1.1 Derwent Estuary

We followed the same protocol as our 2015 survey (Lynch et al. 2015, Wong et al. in prep) but increased the survey size from 8 transects to 12 transects per site. Dive surveys within the Derwent Estuary were completed on 24/8/2016 (Figure 1).

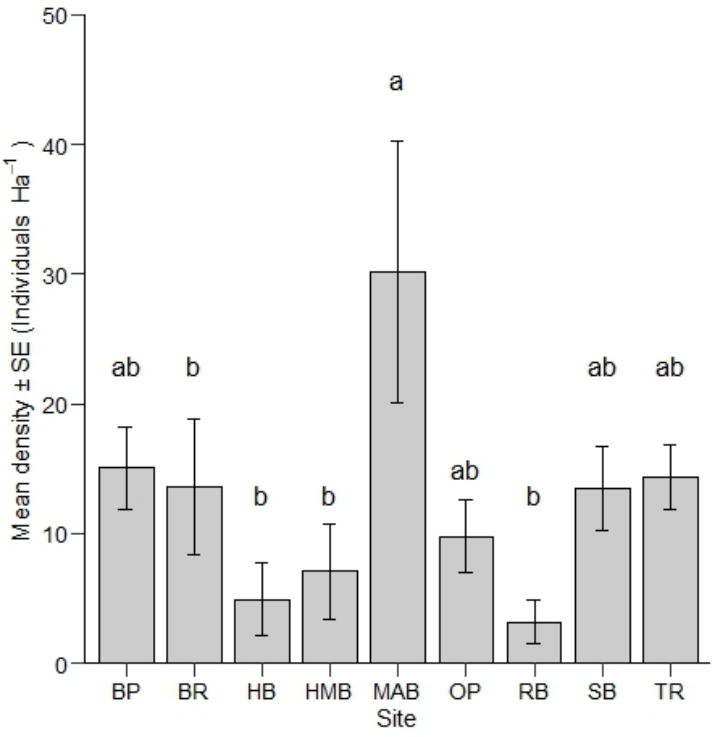


Figure 1 Average density (±SE) estimate from spotted handfish survey in 2016. Letter above bar indicated grouping of variables based on Tukey HSD post hoc testing on x+1 log transformed data.

The numbers of fish observed (n=90) was relatively similar to numbers observed in the 2015 survey. Total number of fish sighted at each site in 2016 ranged between 3 and 19 individuals. Similar to 2015, highest density was recorded at Mary-Ann Bay, with 30.2± 10.1 fishes $Ha^{-1}$. While the lowest density was recorded in Ralph Bay, with 3.19± 1.70 fishes $Ha^{-1}$

Comparing between the two consecutive surveys showed similar densities at most sites, with the exception to Bellerive, Howrah Beach and Tranmere. Both Bellerive and Tranmere demonstrated a small increase in spotted handfish sighting. On the other hand, less fish were sighted at Howrah Beach.

We consolidated 44 mean density estimates between 1998 and 2016 across all 9 sites in the Derwent Estuary and investigated inter-annual trends. A multi-factor ANOVA was conducted on the time-series data, comparing density estimates between sites over time. This analysis also compared data collected using standard belt transect (pre 2012) and the new GUVC method. We found differences between sites but no differences between methods or time. This provides us with some confidence that our change in methods has not impacted the results. While we are able to show persistence of the species overtime, there is no distinctive trend of density across site. Sites appear to be acting independently through time with sites demonstrating increasing, decreasing or stable trends.

While surveys were not completed over consecutive years excepting for 2015 and 2016, at Ralph Bay we were able to track a declining trend at multiple points through time. This local population displayed an exponential decline from 50 fishes $Ha^{-1}$ in 2005 to only 3.19 fishes $Ha^{-1}$ by 2016 (Green et al. 2012; Lynch et al. 2016).

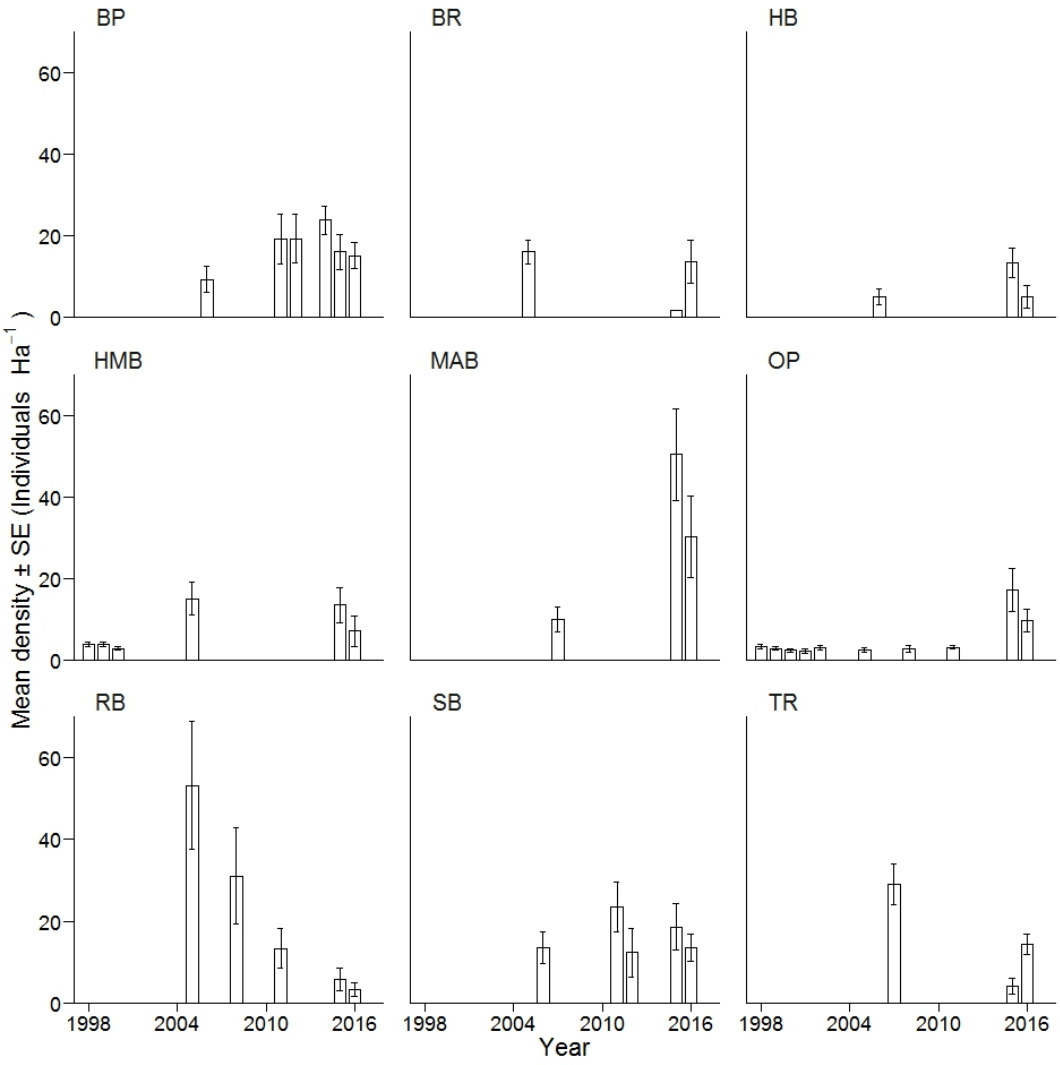


Figure 2: Density estimates of spotted handfish within all recognised sites (n=9) between 1998 and 2016 within the Derwent Estuary.

### 2.1.2 Exploratory surveys

Following anecdotal reports of spotted handfish at two locations in the D'Entrecasteaux Channel we conducted a series of dedicated surveys both in 2015 and 2016. Fish had been observed at Simpsons Point, located on the western shore of Bruny Island (-43.254583, 147.282183) in 1991 (Barrett pers. comm.) and at Flathead Bay, mouth of the Huon river (-43.286663, 147.099625) more recently in 2014 via Remote Operated Vehicle (ROV) (O'Brien pers. comm.). One fish was sighted within Flathead Bay in both 2015 and 2016 at the

southern end of the bay. Comparison between individual suggested the two sighting were different individuals (Table 1). The two fishes were approximately 70m apart, both were classified as adult. The fish sighted in 2016 was 100mm in size, suggesting the individual was at least 3 years old. We suggest that sighting of two separate individual within the same half of a bay demonstrated that a small population persists outside the Derwent Estuary.

In addition, during this season we also surveyed adjacent regions for spotted handfish (Figure 3). We surveyed a second bay (Surveyor Bay) north of Flathead Bay as well as further south, toward Roaring Bay. While benthic habitat was similar at Surveyor Bay with features such as filled depressions and low relief structure, benthic geophysical feature changes significantly further south, outside the mouth of Huon river. As the region become more exposed, the benthic habitat was dominated by empty sand ripples and limited benthic fauna, commonly associated with high wave energy. For the Simpsons Point site, we extended our search to the more sheltered water within Simpsons Bay, but again, similar to 2015, we did not encounter any fish during these surveys.

Table 1: Comparison of individual sighted in Flathead Bay between 2015 and 2016

| | *Year* | *Total Length (mm)* | *Depth (m)* | *Latitude* | *Longitude* |
|---|---|---|---|---|---|
| *Fish 1* | 2015 | 75 | 7.7 | -43.288074 | 147.100037 |
| *Fish 2* | 2016 | 100 | 10.8 | -43.287785 | 147.100754 |

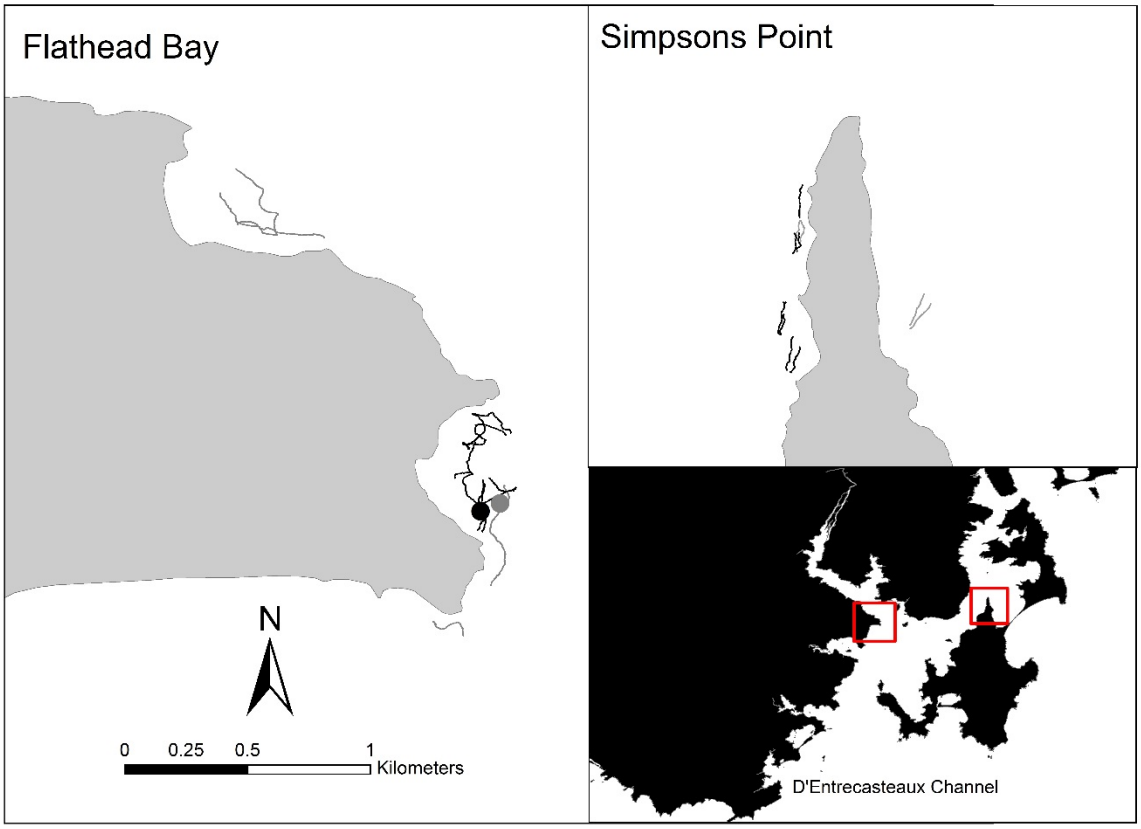


Figure 3 GPS tracks of search effort and location of observed spotted handfish (black is 2015, grey is 2016) at two sites inside the D'Entrecasteaux Channel which is the sheltered waterway immediately south of the Derwent

## 2.2 Photo identification

As the spot pattern of individual handfish is unique, the extensive collection of photographs of spotted handfish collected in 2015-16 were used for a non-invasive capture mark recapture (CMR) study. The spotted handfish photo database was constructed using the software *Interactive Individual Identification System* (I3S), which creates a pattern fingerprint for each photo to allow comparison of individual pattern. In particular, due to the complexity of individual spotted pattern, the most appropriate version of *I3S* appears to be *I3S Pattern*, which automatically identifies patterns based on predetermined thresholds.

We developed a protocol for processing all images based on preliminary testing and previous trials (Green per comm) using *I3S Pattern* for spotted handfish (Figure 4). Each photo of the lateral view of spotted handfish was first assigned an observation ID, a unique identifier based on the sequence of sighting. Photos were then input in to I3S to generate a fingerprint of the pattern. First, permanent features were selected as reference points to allow all photos to be aligned to the same 2 dimensional plane for comparison regardless of the scale and angle of the photo. We selected the front of the eye, rear base of first dorsal fin and operculum pore as the three reference points (Figure 5). A region of interest was then selected from the fish to automatically generate a unique fingerprint. We selected the area between the eye and the operculum pore as the area of interest, as this region is highly visible in all photos and are not affected if the fish was bended or partially hidden. After a fingerprint is identified for each fish, we compared the new observation to the existing database of known fish. Based on the difference between the fingerprints, a similarity index score was calculated where a lower score indicated a higher resemblance. Manual inspection is required for final decision on whether observations was of the same individual. The new entry was then archived into the database.

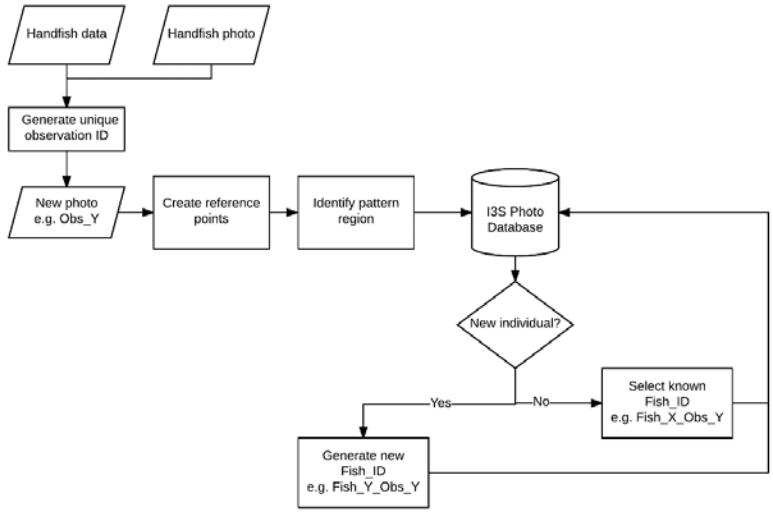


Figure 4 Work flow of identification process of individual spotted handfish using Interactive Individual Identification System (I3S) and storage of data in the photo database.

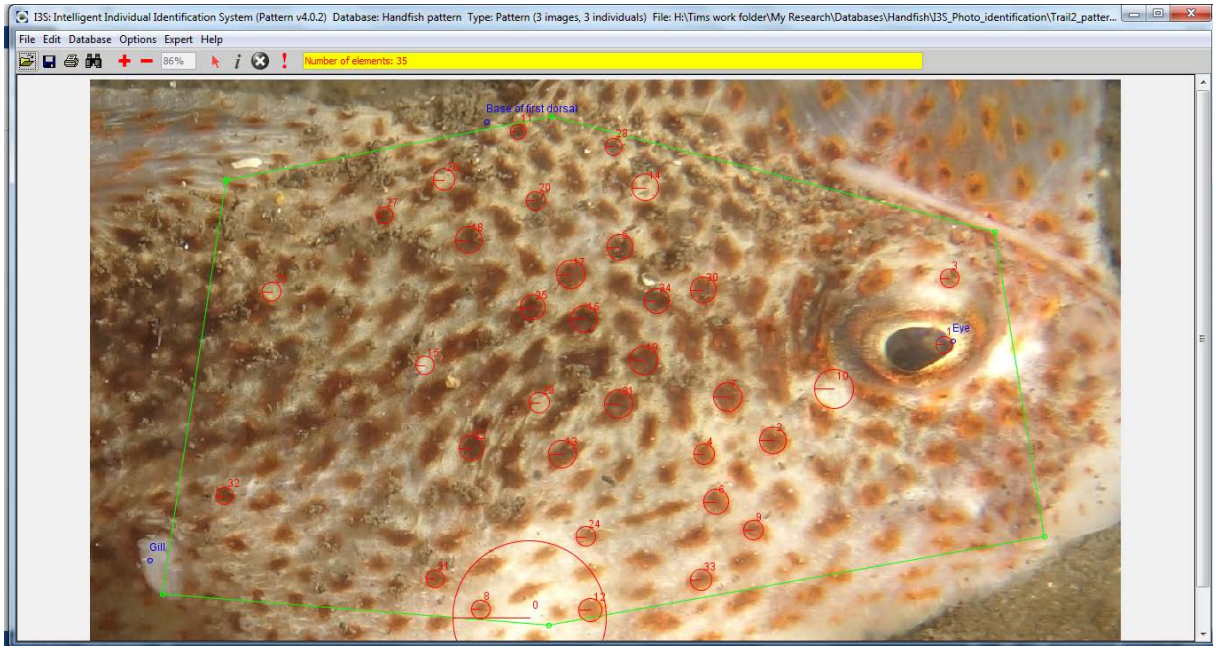


Figure 5 Screenshot of the Individual Identification System (I3S) Pattern software graphic user interface. This example illustrated the parameters: reference points (blue) and region of interest (green) required to generate an individual fingerprint (red) for each encounter.

All fish observations in 2015 and 2016 were input into the photo database. A total of 382 fingerprints from 170 individuals was generated and analysed. We identified one recapture. Both observations were made in 2016, 93 days apart (Figure 6). The individual was found within the same bay, Mary-Ann Bay and moved to shallower water, from 8.0m to 6.9m, approximately 60m due south. Length measurement of the fish indicate it grew from 83mm to 90mm.


Figure 6 Individual spotted handfish recaptured during the 2016 survey.

# 3. CONSERVATION STRATEGIES

## 3.1 Captive Breeding Program

### 3.1.1 Stakeholder engagement and liaison

Throughout 2016, we conducted extensive due diligence and liaison with both government and industry on establishing a longer term captive breeding and restoration program for the spotted handfish. Three workshops 26-27/10/ 2015, 2/2/2016 and 5/8/2016 have been held at the CSIRO in Hobart with the Zoo and Aquarium Association (ZAA), industry partners and both Federal and Tasmanian state governments representatives to develop plans to capture and breed fish in 2017. We have secured support and significant in-kind funding to commence a captive breeding program to host spotted handfish as 'ambassador fish' at two aquariums. A draft MoU between all parties (State and Federal governments, CSIRO, ZAA) has been developed and is awaiting signatures based on funding decisions.

The State Government, who are the owners of all spotted handfish, have outlined that sustainable take, hygiene and socio-economic considerations are key considerations for this stage of the project. This drafted program proposal will consider multiple stages. In the short

term, a small number of fish will be collected and transported to our two industry partners: Seahorse World, located at Beauty Point, in northern Tasmania and SEA LIFE Melbourne Aquarium, a subsidiary of the Merlin Entertainments Australia & New Zealand Pty Ltd located in Melbourne CBD. Spotted handfish will be displayed as 'ambassador fish' as part of both aquariums' exhibit. The benefit of this industry partnership may be two fold, first as tourist attraction, both aquariums are ideal locations for public engagement, outreach and education. Second, through conducting captivity trials with fish prior to the breeding program, this will provide opportunity for staff training and refinement of husbandry protocols (Bruce et al. 1997). The commercial setup of their business also provided infrastructures allowing for live food cultures, trained scientists on staff and sophisticated filtration for optimal water quality. In addition, in house veterinary will be available to monitor the welfare of captive fish. The initial phase will include collection and transport of 5 to10 spotted handfish to each aquarium. The State government has agreed to assist with the initial permitting. Selection of site for spotted handfish collection will be dependent on permitting based on the 2015 and 2016 surveys.

Further outreach occurred through talks and presentations. This included development of the handfish memory game with the Tasmanian Museum and Art Gallery (TMAG), which was presented to the public on a number of TMAG family events. We also gave talks to stakeholders at the Derwent Estuary Program, NRM South and to the Rotary club. In addition we presented at a professional conference, the NZMSS/AMSA 2016 conference in Wellington New Zealand.

### 3.1.2 Infrastructure construction

In early 2017, we have independently secured further funding from a CSIRO CAPEX grant to construct multiple holding tanks for small temperate marine fish at the CSIRO Battery Point site. These tanks will be used for temporary holding fish and act as a buffer between the wild and captive populations. Establishing protocols to receive, quarantine and release captive bred animals in the future is an important part of any future captive breeding program. This is because as a critically endangered species, surplus spotted handfish from any breeding program cannot be euthanised or sold to third parties, thus captive bred fish must either be held in additional tanks within the aquarium, which increases costs for the aquariums, or released back into the wild.

## 3.2 Ecomooring

Replacement of traditional swing moorings with ecomoorings to minimise habitat damage is a key recovery plan action for habitat conservation (Commonwealth of Australia 2015). With our partners the Derwent Estuary Program (DEP), Royal Hobart Yacht Club (RHYC) and Derwent Sailing Squadron (DSS), we have independently received an additional $10,000 from NRM South through their Waterways and Coasts Grant to replace traditional swing

moorings with ecomoorings. Five of the moorings owned by RHYC and DSS were selected for this initial trial. Three of the clubs' moorings were located within the Battery Point and Sandy Bay area (Table 2).

Table 2 Location of moorings within the Derwent Estuary selected for the ecomooring replacement trial

| *Mooring ID* | *Latitude* | *Longitude* | *Marking* |
|---|---|---|---|
| *5471* | -42.89562103 | 147.337573 | Rey buoy, RYCT marking |
| *D390* | -42.88933301 | 147.339503 | Yellow buoy |
| *E961* | -42.89993796 | 147.337206 | Small, white buoy |

# 4. DISCUSSION

With this year's monitoring of the spotted handfish population, we have successfully implemented a second wide-scale survey across all known sites. When combined with all historic data the density estimate demonstrated inter-site variability but no general temporal trends over the survey period. While care must be taken with interpreting the limited time-series data, their does not appear to be in consistent variability over time by the various local populations.

The spotted handfish population may now be a number of isolated local populations whose population dynamics are acting independently. If this has resulted from the fragmentation of connectivity, when combined with the species low dispersal natural history, individual site management becomes of prime importance for conserving the species. Fragmented local populations can be at an increased risk of local extinction. Possible examples of this are the documented collapse at Primrose Sands in between 1999 and 2005 (Green 2007) and the linear decline at Ralphs Bay.

An alternative hypothesis is that fish are well connected and are migrating between sites/local populations or to undiscovered sites; perhaps in response to changes in local environmental conditions such as food or microhabitat availability in their relatively dynamic shallow soft sediment habitat. An intermediate hypothesis could be that fish are connected between sites in close proximately within regions, such as between Battery Point (BP) and Sandy Bay (SB); Bellerive (BR) and Howrah Beach (HB); Tranmere (TR) and Ralphs Bay (RB) or around South Arm (MAB, OP, HMB) (Fig. 8).

The establishment of the new photo database will allow for analysis on an individual level and may provide a better understanding of fish movements within and between local populations. With surveys across a wide spatial range, this photo database may assist the estimation of local population size and determine with greater certainty the threat of fragmentation and/or local population isolation to meta-population connectivity. Some photos, particularly in 2015, were poor for the I3S systems requirements and further work is required on validation.

Handfish behaviour appears to be to exploit complex microhabitat features, with fish disproportionately found next to filled depression and filled ripples produced by both physical and biotic factors, such as bioturbation from other soft bottom dwelling taxa, such as scallops and rays. Spotted handfish may be using these features for camouflaging and cover, similar to other mid trophic level species (Auster et al. 1995; Stoner et al. 2007). Alternatively, complex habitat has been associated with increased invertebrate abundance and diversity (Taniguchi & Tokeshi 2004), thus it may provide increased food availability as well as natural spawning substrate for spotted handfish.

Previous recovery plans for spotted handfish have identified benthic habitat modification as one of the threatening process for spotted handfish (Bruce & Green 1998; Commonwealth of Australia 2015). The historic impact of scallop dredging on spotted handfish has been identified as a threating processes from direct mortality as a result of fishery bycatch (Bruce et al. 1997; Lynch et al. 2015). In addition, the reduction of bivalves may have an indirect effect on spotted handfish population through reducing number of burrows (depression) available for spotted

handfish to use. At the present time, traditional swing mooring chains, which are now at maximum density in the Derwent Estuary (MAST pers. Comm.), was suggested as one of the threats relevant to soft sediment benthic habitat alternation. Swing moorings rely on a chain anchored to the seafloor to provide shock absorption from snatch loads on the vessel generated by wind and waves, however these chains can cause mechanical/ physical disturbance to the benthic habitat. The movement of the mooring chain can scrape away the top layer of sediment, reducing microhabitat complexity and dislodging natural or artificial spawning substrates (Lynch et al. 2015).

Opportunistic swath mapping was undertaken at one site as part of a training exercise with CSIRO in 2016 and showed that in a dense mooring field a high percentage of habitat is scraped away, as the area of chain swings starts to interconnect. There also appears to be an interaction between chain moorings and the northern Pacific seastar, which may warrant further investigation.

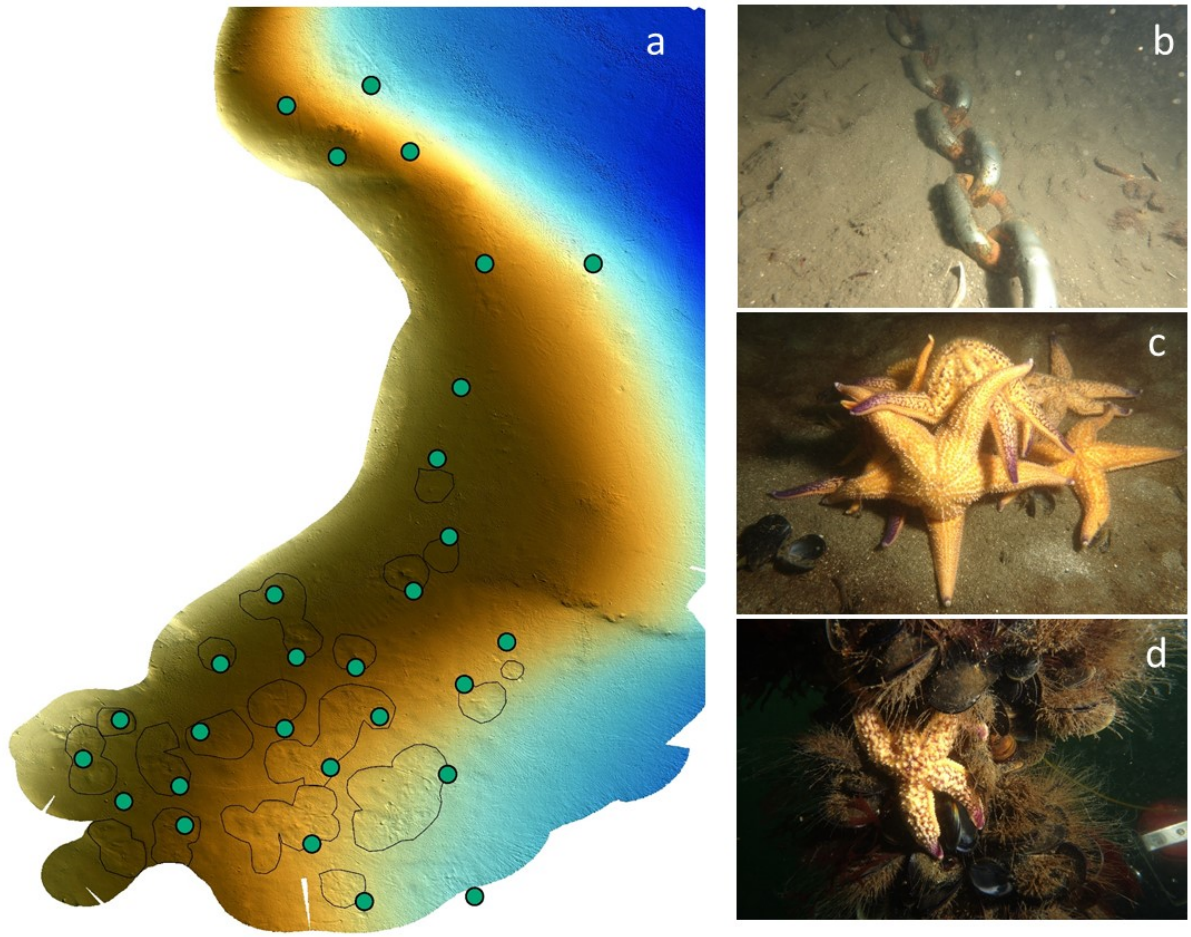


Figure 7. a) Swath mapping of Battery Point, blue dots are moorings and black outlines are scraped areas of sediment, b) mooring chain, c) northern Pacific seastars in the mooring field, d) seastars feeding on mooring tackle

Adjacent land use and coastal urban and infrastructure development may also impact on the species through changes to local geomorphology and benthic ecosystems as well as water

quality through increase nutrient and sediment loading. For instance, these processes can change algae cover and sediment grain size. This was observed at Ralph Bay in multiple years with the site dominated by 'ephemeral' algae (Green et al. 2012; Wong 2015). The ongoing bloom of ephemeral algae covered the soft sediment microhabitat and reduced the availability of shelter and spawning substrates for spotted handfish.

Historic heavy metal contamination within the estuary may also have indirect negative trophic effect on the handfish population through increased predator density in some locations. Higher trophic level piscivores, such as flathead, bio-accumulate heavy metals in the Derwent to such an extent that they are not fit for human consumption. This may have resulted in higher abundances and sizes of flathead within the fallout zone, which escalates top-down pressure on the handfish population. Conversely, outside of the fallout zone, flathead are heavily targeted by the recreational fishery, so handfish local populations such as those at Mary-Ann Bay, Opossum Bay, Half Moon Bay (lower Derwent Estuary) and D'Entrecasteaux Channel could be benefiting from high fishing pressure. Changes to fisheries regulations, for example increasing the allowable minimum size or introduction of a slot size for take by recreational anglers of flathead, could have a knock on effect on the spotted handfish population.

The introduction of northern Pacific seastars (*Asterias amurensis*) into the Derwent Estuary benthic system is also a long term concern for conservation of spotted handfish (Bruce & Green 1998) where northern Pacific sea stars consume natural spawning substrate such as stalked ascidian *Sycozoa* spp.) Individual seastars may also feed directly upon the eggmasses of spotted handfish but this has not been observed and parental care by adults may discourage egg predators. In addition to feeding on natural spawning substrate, northern Pacific sea stars are "notoriously efficient" predators of bivalves (Byrne et al. 1997) and particularly of larger bivalves (Ross et al. 2002). This and potentially other introduced species may have negative indirect impacts on the spotted handfish population through reduction of ecosystem engineers which maintain the habitat complexity of the system (Thrush et al. 2001).

Increased ecological understand of the spotted handfish population, in particular food web interaction can be vital for sustained conservation of the spotted handfish. Two PhD projects are in development but are not funded for the 2017 year. The first through UNSW in partnership with NSW OEH will focus on threats, such as moorings, while the second through UTAS will continue to develop conservation biology questions around the handfish and coastal species in general. Both projects will have wider application to both anthropogenic impacts in estuaries and conservation of coastal marine species. Honours projects, which would be a component of the PhDs, will be available in 2017 if students can be recruited.

In particular, the potential synergistic effect of moorings and invasive species such as northern Pacific sea stars and other introduced marine pests are an area of interest. Deployment of initial eco-moorings in 2017 allows for development of methods to gauge recovery of the benthos. This work looks to be scientifically novel – most previous work seems to be on fish farm impacts, which are biological (feed/waste fall) and involve rotation of cages or trawling which is intermittent. In contrast chain moorings have mechanical impacts and are ongoing and fixed into place. The limited research that has been done on the impacts of swing moorings has mostly focussed on seagrass, not soft sediment communities – though recently some fish assemblage work has being undertaken by UNSW. In the future these deployments will allow for an experimental approach for a potential PhD project between CSIRO, UNSW

and NSW OEH looking at macro-benthic community recovery following replacement of swing moorings with eco-moorings. The PhD has a wider focus across the impacts of swing moorings on bio-diversity and interactions with introduced pests and will have study sites in both the Derwent estuary and Sydney Harbour.

Investigations of once common and but now rare species must always be conducted with the caveat that what is being observed is a remnant. Individuals may not be in the densities, habitats or locations that were current for the historic stock but rather are now of a size and distributed in response to current threats and historic processes. Species can be persisting in the periphery of their historic geographic ranges (Channell & Lomolino 2000) or at lower extremes of abundance. Spotted handfish may be an example of such a remnant species. While recent trends do not substantiate overall rapid declines, anecdotal reports by expert fish biologists indicate a much lower abundances in the present then was the case more than 30 years ago and at least one site has declined in the past decade. As we learn more about this species it is becoming clear that individual sites need to be managed and protected so the species retains some viable habitat to avoid a slide into extinction – one local population at a time.

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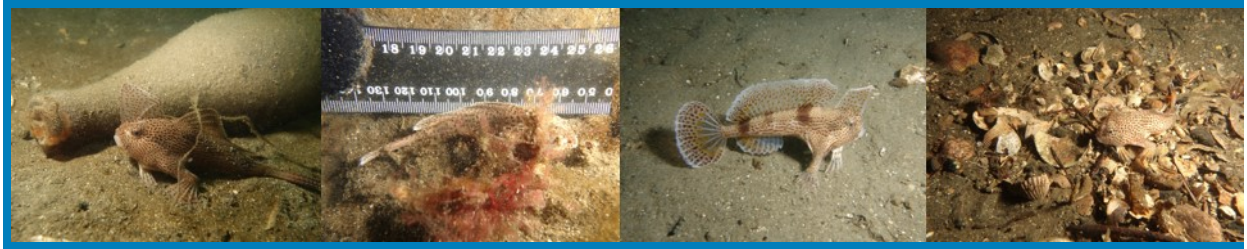

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