Division of Fish & Wildlife, CNMI

Freshwater Invasive Species Project

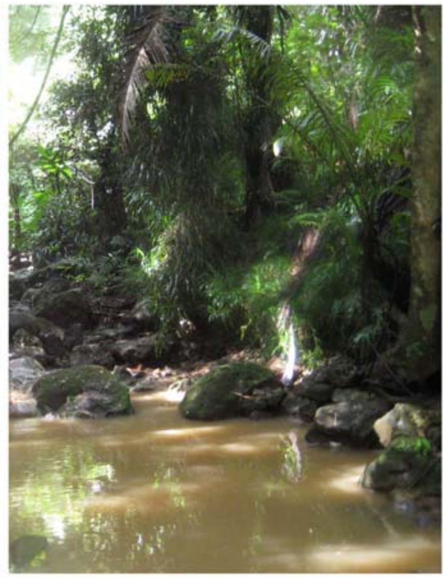

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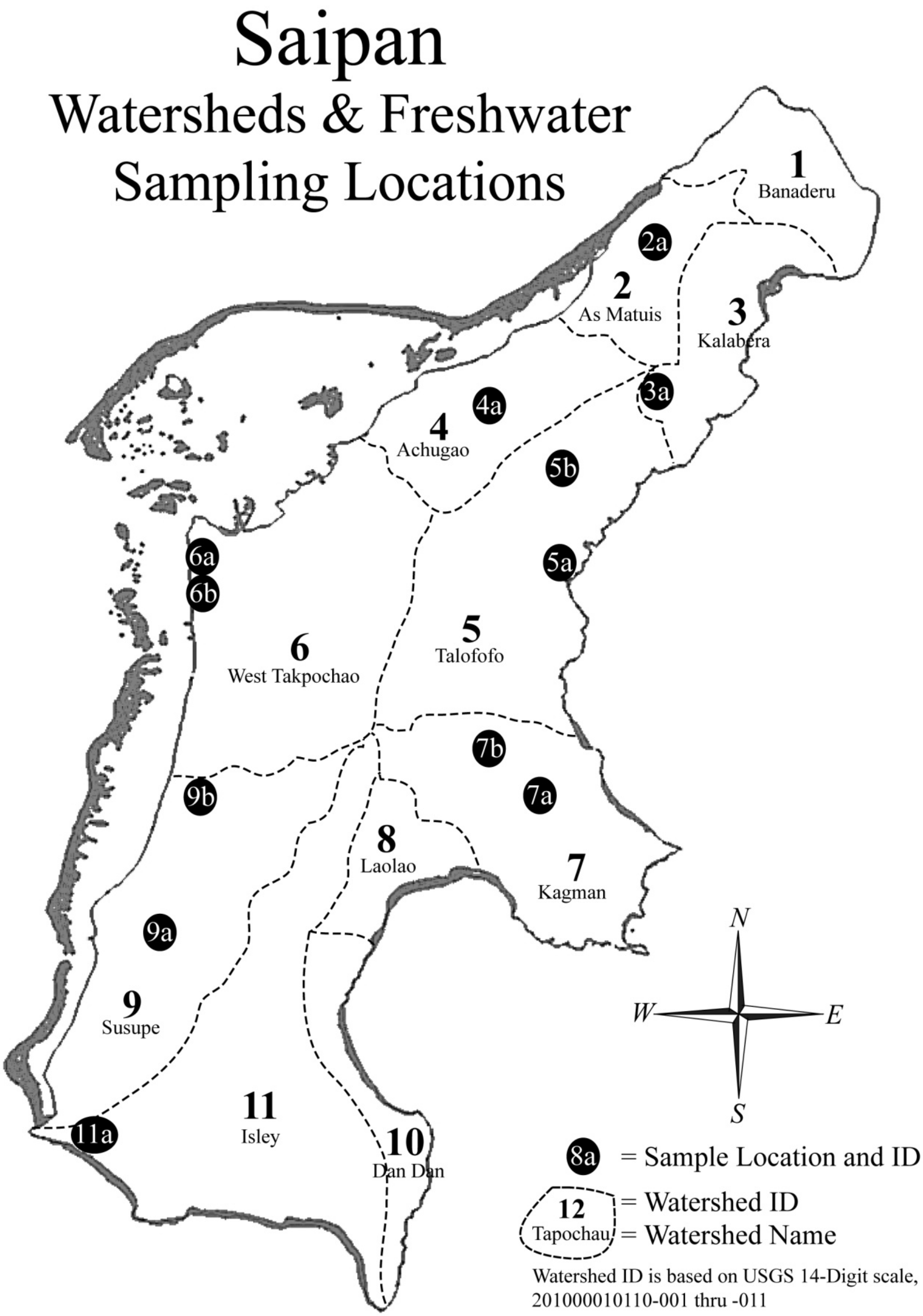
Figure-1 Saipan Map with Site Locations



I. Introduction

Very little was known about the freshwater ecosystems of the Commonwealth of the Northern Marianna Islands (CNMI) or the species that inhabit them prior to this study. Most information was both unpublished and anecdotal (Best 1981). Derek Stinson put a report together nearly twenty years ago, which defines most of the major wetland areas of the CNMI and provides some background information for larger lentic systems like Lake Susupe, but doesn't mention any of our interstitial stream systems (Stinson 1990).

An examination of freshwater fishes in the CNMI using Fishbase, a comprehensive fisheries web resource, lists 13 native and 2 introduced species (Froese 2008). Six of the native species listed, (4 mullets, 1 moony, 1 scorpion fish) are restricted by the small scale of our freshwater systems and are essentially limited to marine and brackish waters in the CNMI (Myers 1991). Two of the other native species listed for the CNMI in Fishbase are based on generalizations for all of Micronesia or extrapolations from findings in the India Ocean (Fricke 1999, Sukhavisidh 1974). This leaves us with five Fishbase species; two gobies (*Sicyopus leprurus* and *Awaaous guamensis*), the Indo-Pacific tarpon (*Megalops cyprinoides*), the Rock flagtail (*Kuhlia rupestris*) and Giant mottled eel (*Anguilla marmorata*) that actually have reasonable potential and/or a published presence in the CNMI (Ryan 1991, Myers 1991, Watson 1992, Parenti 1993, Best 1981, Elemanto 1975). We might be able to add an additional goby species (*Stiphodon elegans*) and the Japenese eel (*Anguilla japonica*) to this list as they have been found in streams on Guam and are known to breed within the region respectively (Concepcion 1999, Tsuchida 2003). Details and photographs of the species of primary concern for this project as well as those observed during these surveys can be found in Appendix A.

The two introduced species listed for the CNMI in Fishbase are the Mozambique tilapia (*Oreochromis mossambicus*) and the Mosquitofish (*Gambusia affinis*). We know that *O. mossambicus* were introduced into Lake Susupe from the Philippines in 1955 and that a US naval field trip released 200 more *O. mossambicus* fingerlings into the lakes on Pagan that same year, but no reference could be found to explain exactly when and where Mosquitofish were introduced (Nelson 1991. Sukhavisidh 1974).

In contrast, an examination of freshwater fishes on Guam using Fishbase lists only 4 native species and 15 introduced species (Froese 2008). Guam has a larger import/export industry, a greater population as well as larger streams and freshwater systems, which is why we might expect introduced species to appear there in advance of an arrival in the CNMI. The list includes; two cichlids (*Astronotus ocellatus* and *Cichla ocellaris*), two cat fish (*Clarias batrachus* and *Clarias macrocephalus*), the green swordtail (*Xiphophorus hellerii*), the Penang betta (*Betta pugnax*) and the common carp (*Cyprinus carpio carpio*).

Anecdotal information suggests that *Macrobrachium* shrimp have been a part of freshwater ecosystems in the CNMI for generations (Pacific Worlds 2003). There is also published information confirming seven native species of atyid shrimp on Guam including; *Atyoida pilipes, Atyopsis spinipes, Caridina longirostris, Caridina nilotica, Caridina serratirostris, Caridina typus, and Caridina weberi* (Leberer 2001, Leberer 2003), but little work has been done to examine these populations within the CNMI.

According to the Secretariat of the Pacific Community (SPC) the CNMI has historically only had aquaculture farms featuring Tilapia (*niloticus* and *mossambicus*) and Shrimp (*Panaied* and *Macrobrachium sp.*). In contrast, Guam has had a diverse history of aquaculture including; freshwater eels (*A. japonicas* and *A. rostrota*), milkfish (*Chanos chanos*), shrimp (*Macrobrachium rosenbergii*), tiger prawns (*Penaeus monodon*) and two species of Tilapia (*O. mossambicus* and the hybrid *O mossambicus x O. niloticus*) which peaked out at just under 150,000kg of production in 1993. At one point a private company even attempted to culture the soft-shelled turtle (*Trionyx sinensis*) from Taiwan (SPC 2009). Given the historically relaxed controls on aquaculture practices in the NMI and the ease at which people have been able to move between the islands we might expect to find some of these species in the freshwater systems of Saipan, Tinian and Rota.

In August of 2008 we performed dip net, trap and electrofishing surveys at twelve sites in eight different watersheds on Saipan in the first freshwater native and introduced species study of its kind. This report outlines the findings of that extensive two week sampling effort of Saipan's fresh waterways including full species lists, descriptions of each location, water chemistry information and findings from three different survey methods.

III. Materials & Methods

Field Methods

We generated a standardized field data sheet for use at all of our sampling locations to ensure consistency in data collection regarding site locality, site description, ambient conditions, water chemistry and biological survey specifics (Appendix B). Upon arrival to each location we began by designating a 50 meter long section of stream or bank to represent the sampling area. We then made our initial observations, GPS and water chemistry readings and deployed our survey traps. One surveyor then drew a map of the location and made additional observations about the site while the other two researchers performed the dip net survey. All three researchers then worked together to perform the electrofishing survey when possible and collected traps.

First, we collected information about site location, a description of the water body and the general health and stability of the system. Water turbidity and depth, stream width, canopy and aquatic plant cover were all considered key parameters. A blank version of our field sheet can be found in Appendix B. We also drew a map of each location illustrating major landmarks, the precise sampling and trap locations and any other relevant observations. These original drawing were done in pencil and can be found on the reverse side of each field form. The drawings were later redone using Adobe Illustrator and placed in Appendix D.

Water temperature, pH, dissolved Oxygen, salinity and conductivity readings were all collected using a YSI 556 meter. The meter was recalibrated each day, in accordance with CNMI-DEQ SOP #409, for fresh water prior to field sampling and when appropriate recalibrations were performed in the field to account for sites with high conductivity or salinity (Bearden 2007).

At the beginning of each survey two un-baited 2 foot conical mesh net fish traps were deployed at each sampling site. One was placed directly into the same 50 meter sampling area in which dip netting and electrofishing later occurred, the other was placed approximately 50 meters beyond the sampling area for comparative purposes.

Two different researchers worked independently for 30 minutes using long dip nets at each sampling location. For consistency, we had our most experienced researcher using one of the dip nets at every sampling location. The priority was to sample all fish and shrimp species within each system, but gastropod and insect samples were also collected when caught.

We used the Smith-Root LR-20 Backpack Electrofisher to sample each of our sampling locations where conductivity and salinity levels would allow. Each member of the team had previously passed the FWS-FIS2C01 course, Principles & Techniques of Electrofishing, to increase safety and efficiency and to standardize the overall effort. Details of the course can be found in Appendix G. An attempt was made to cover the entire 50 meter sampling region using the backpack in the upstream direction, with two surveyors using dip nets to collect the stunned specimens. The voltage, frequency, duty cycle and total shock time were noted for each sampling location, as well as a general observation of efficiency. A typical setup had a voltage of 200, frequency of 30, duty cycle of 30 and 150 seconds of shock time.

Specimens for each survey method and surveyor were stored and labeled separately, for a comparison of method efficiency. Photographs were taken of some specimens in the field, but most samples were frozen for later analysis in the lab. Toads and other large, non-target specimens were only photographed and released.

Laboratory Methods

Each sample location was treated independently, with the entire continents from that survey thawed, photographed, processed and refrozen or fixed in 10% formalin before starting work on the next set of samples. The information for each site was logged onto our standardized lab form as shown in Appendix B. Lab sheets were later entered into an Excel™ workbook for further analysis (Appendix F).

Once thawed and sorted samples were photographed so that both sexes and the entire range of ages in the specimens were represented. Where possible the fork length for each specimen was measured to the nearest millimeter and weighed to the nearest tenth of a gram or, when size or quantity were limiting, lengths were estimated and weights were batched.

Fish species were identified on site, keyed out in the lab or sent to Shelley James and Holly Bolick at the Bishop Museum in Hawaii for genetic testing. Fish samples were eventually flown to Hawaii as checked baggage on a separate trip and delivered to the Bishop Museum to minimize thawing and denaturation. Ten different fish samples were tested at the Bishop museum for cyt*b* and COI sequences matches within GenBank. The report generated by the Bishop Museum can be found in Appendix H.

Shrimp specimens from each sampling location were shipped to an expert, Yixiong Cia, in Singapore for morphological identification. These samples had to be shipped on blue ice due to hazardous material shipping restrictions and were held an extra day in Singapore customs but still arrived in acceptable condition for anatomic identification.

A few samples from each species were fixed in formalin and then stored in 10% ethyl alcohol, but most were refrozen.

IV. Site Descriptions

The USGS 14-digit scale divides Saipan into eleven different watersheds, 201000010110-001 thru -011, from north to south (Unified 1998). Sample locations were prioritized within each watershed and twelve locations were selected based on preliminary sampling, anecdotal information and input from natural resource professionals (Figure-1). Care was taken to include a combination of lentic and lotic as well as upland and coastal systems into this survey. We also applied local knowledge and professional judgment to strike a balance between surveying both pristine and disturbed systems.

Three of the eleven different watersheds (Banaderu-001, Laolao-008, Dan Dan-010) either did not contain any wetland or stream systems, were seasonally dry during sampling, or were minor enough that they fell below priority status. The other eight watersheds all contained at least one sampling location, labeled in accordance with its USGS code and a letter indicating sampling order. A photograph, brief written description and illustration of each site can also be found in Appendix C, for further clarification of location, sampling area and trap deployment details.

Below you will find a description of the physical condition of each site, the base water chemistry measures and an examination of trap, dip net and electrofishing findings. Photos and sketches for each of the twelve site location can be found in Appendix C.

002a. MCC Golf Course, Pond at Hole #6

Label – 2a-81808
Watershed – As Matuis
Latitude – 15°15.750
Longitude – 145°47.690
Date Sampled – 8/18/08

Physical Description – This man made pond is approximately 300 m^2 and is approximately 1ft deep at the banks and 3ft deep in the middle. The sampling area, just adjacent to the tee, is full of bull rush which is slowly taking over the whole pond and is scheduled for removal via pond draining in the near future. The pond is surrounded by cut grass with virtually no canopy cover and is probably exposed to a considerable amount of fertilizer and possibly pesticides.

Water Chemistry – The water temperature was quite warm at 32.28°C. The pH was fairly neutral at 7.32. DO was surprisingly high at 129.3%, one of three sampling locations we found to be supersaturated. The pond also had a surprisingly high salinity of 7.32 and the greatest conductivity of any site at 12.87 μS/cm, which is somewhat surprising given that the altitude and distance from the ocean precludes this pond from saltwater intrusion.

Biological Findings – Tilapia, *Oreochromis sp*. according to genetic analysis, was captured in this pond using both dip net and trap survey methods. The conductivity was too high for effective electrofishing. No other species of interest were observed within the pond, though golf course attendants said they were having a problem with feral cats disturbing the local bird population.

003a. DPS Gun Range, Marsh

Label – 3a-81808
Watershed – Kalabera
Latitude – 15°14.270
Longitude – 145°47.373
Date Sampled – 8/18/08

Physical Description – This marsh, which appears to be at least partly created from local road grading, is approximately 250 m2 and tapers off to approximately 3ft deep in the middle. Sampling was performed along the south edge of the marsh, where there was marginal canopy coverage; otherwise the pond was almost completely covered with aquatic plants. Outside of the road and potential influence from scattered livestock the riparian buffer around the marsh appears to be good.

Water Chemistry – The water temperature was relatively warm at 29.2°C. The pH was acidic at 5.9. DO was relatively low at 49.1%. The pond also had a very low salinity of 0.05 and conductivity of 0.117 μS/cm.

Biological Findings – Dip net surveys found a couple of aquatic insects and Ramshorn snails were found to almost completely line the bed of the marsh but the real story here was the number of cane toads (*Chaunus Bufo marinus*). A great number of carcasses lined the coral road passing the marsh and a great number of mating groups could be found along the shore and in the marsh shallows. Netting efforts also found substantial egg sack clusters nested among the aquatic plants.

004a. Tanapeg, Bobo Achugao Stream

Label – 4a-81308
Watershed – Achugao
Latitude – 15°14.183
Longitude – 145°45.798
Date Sampled – 8/13/08

Physical Description – This stream location appears to be relatively pristine, though just downstream a considerable amount of old industrial equipment is leaching and collapsing into the stream itself. The banks of the stream range from 9 to 15ft across with depths ranging from just a few inches to nearly 2ft. These measures were taken after recent moderate rains and would be expected to increase dramatically during heavy rain events. There is approximately 75% canopy cover in this location and the riparian buffer, at least above the industrial mess, should be considered excellent.

Water Chemistry – The water temperature was relatively cool at 25.84°C. The pH was slightly basic at 8.02. DO was average at 79.4%. The stream, as expected, had a low salinity of 0.21 and conductivity of 0.437 μS/cm.

Biological Findings – Electrofishing was very effective in this location. Dip nets and traps also did a fair job of collecting the common *Macrobrachium lar* shrimp species. Trail users also informed us that eels have been observed in this stream in some stretches slightly higher up, making this one of three sampling locations where eels have been present anecdotally but were not observed in our surveys.

<u>005a. Jeffry's Beach Stream</u>

Label – 5a-81408-0
Watershed – Talofofo, Lower
Latitude – 15°12.970
Longitude – 145°46.772
Date Sampled – 8/16/08

Physical Description – This sampling location is just a couple hundred yards above the mouth of the stream at Jeffry's beach, just below the cement bridge. The banks of the stream range from 13 to 20ft across with depths ranging from just over an inch to nearly a foot deep. The bridge, just above the sampling site, forces the stream to pass over an extensive cement slab where the water was running less than an inch deep during the sampling period. Farther upstream the stream appeared to have recently rerouted depositing a considerable amount of fresh brown mud into the system. There is approximately 50% canopy cover in this location and despite the presence of the bridge and recent sediment input, the local riparian buffer is good.

Water Chemistry – The water temperature was relatively cool at 26.72°C. The pH was neutral at 7.21. DO was average at 73%. The stream, as expected, had a low salinity of 0.13 and conductivity of 0.272 μS/cm.

Biological Findings – Electrofishing was very effective in this location, as were dip nets, while the traps failed to collect any specimens. Three different types of shrimp were observed at this location including *Macrobrachium lar* and *Caridina typus* species. This was also the only stream where rock flagtails (*Kuhlia rupestris*) and gobies (*Stiphodon elegans*) were observed. Both are considered to be native and neither have been previously identified in the CNMI.

Secondary Sampling – An additional sampling was performed with the dip nets just up from the cement bridge to help discern if it was a major barrier to species migration. In this secondary sampling only the largest of the observed *Macrobrachium lar* shrimp species were observed, suggesting that the bridge is indeed a barrier.

<u>005b. Tegata's Upper Stream</u>

Label – 5b-81908
Watershed – Talofofo, Upper
Latitude – 15°13.811
Longitude – 145°46.350
Date Sampled – 8/19/08

Physical Description – This sampling location is believed to represent the upper reaches of the stream that eventually runs down into Hidden Beach, just North of the Kingfisher Golf Course. Based on location, accessibility and local land use this would appear to be the most pristine of all our sampling locations. The stream ranged from 6 to 12 feet across during our sampling period and from 3 inches to nearly 3 feet in depth. There is nearly 100% canopy cover at this site and the riparian buffer is excellent.

Water Chemistry – The water temperature was relatively cool at 25.32°C. The pH was neutral at 7.04. DO was relatively low at 38.8%. The stream, as expected, had a low salinity of 0.24 and conductivity of 0.507 μS/cm.

Biological Findings – Electrofishing was the most effective sampling method in this location, followed by dip netting and then trapping. *Macrobrachium lar* and *Caridina typus* shrimp were collected in this area, and in a far greater abundance than in any other area. A fish, believed to be a goby, was also observed by DFW staff biologist Michael Tenorio during dip net sampling, but it could not be captured.

Additional Sampling Location – The health of this upland stream and the lower reach of the neighboring stream at Jeffry's beach make hidden beach, the terminus of Tegata's stream, a prime site for additional sampling.

006a. Garapan Slough at Fiesta Hotel

Label – 6a-81108
Watershed – West Takpochao
Latitude – 15°12.785
Longitude – 145°42.992
Date Sampled – 8/11/08

Physical Description – The Garapan slough at Fiesta Hotel is tidally influenced and receives a considerable influx of salt water daily during high tide. The entire system is constructed of channelized cement with a soft mud bed. Storm water drainage pipes feed into the slough from several locations running underneath the streets of Garapan. The riparian zone surrounding the site is dominated either by cement sidewalks and roads or cultivated yards. The channel is approximately 4 feet across above the small foot bridge with depths ranging from 5 to 9 inches, and is much wider and shallower just west of the foot bridge before reaching the beach.

Water Chemistry – The water temperature was relatively hot at 32.62°C. The pH was neutral at 7.41. DO was relatively low at 33.3%. The slough, as expected during high tide, had a high salinity of 15.5 and conductivity of 25.78 μS/cm. It is noteworthy that prior readings, during low tide, found salinity measures below 1.0 and conductivity levels below 2.0 μS/cm, indicating a huge daily fluctuation.

Biological Findings – Electrofishing was not effective at this site due to conductivity, but both dip netting and trapping proved effective. The slough bed was thick with tiny Thiarid snails. Only one Tilapia specimen was captured in the survey though many were seen. The Bishop museum is currently in possession of the Tilapia sample and could perform a genetic analysis at a future time. Sailfin Molleys (*Poecilia latipinna*) were the primary species in the system, and a far greater number of females were collected than males. Juvenile milkfish (*Chanos chanos*) were also collected at this site and were misidentified prior to genetic testing as possibly being juvenile mullets.

006b. Garapan Slough at Hafa Adai Hotel

Label – 6b-81208
Watershed – West Takpochao
Latitude – 15°12.493
Longitude – 145°42.983
Date Sampled – 8/12/08

Physical Description – The Garapan slough at Hafa Adai Hotel has a considerable sand burm at its base, restricting direct ocean interaction outside of storm events or very high tides. Most of the water running down the hills east of Garapan, including the Hospital area, eventually feed into this slough. The sampling area was predominantly sand and mud ranging from 9 to 11ft across and maxing out at about 6 inches deep, with a 25% canopy cover. Just up from the sample location was a large cement slap with a very thin layer of water and culvert which routs the water into the slough from drainages ditches across the street. This provides a barrier which is only passable during there is active runoff. The riparian zone surrounding the site is dominated either by beach, parking areas or thin foliage.

Water Chemistry – The water temperature was relatively normal at 29.45°C. The pH was neutral at 7.72. DO was relatively normal at 66.8%. The slough, as expected due to its proximity to the ocean, had a high salinity of 5.71 and conductivity of 10.17 μS/cm, which indicate that the sand burm is not a complete barrier.

Biological Findings – Electrofishing was not effective at this site due to conductivity, but both dip netting and trapping proved effective. This is the only site where milkfish (*Chanos chanos*) were captured both in the nets and in the traps as were Indo Pacific Tarpon (*Megalops cyprinoides*). This location also included the same species observed at our other Garapan site, including: Thiarid snails, Sailfin Molleys (*Poecilia latipinna*), juvenile milkfish were also sampled here and originally misidentified as happened at sight 6a. Spinecheek gudgeon (*Eliotris acanthopoma*) were also captured at this site in an education and outreach return visit in the summer of 2009. Tilapia were seen in drainages that feed into the slough, and some form of eel was reportedly present in the same location recently but none were seen by surveyors.

Additional Research – The slough at Hafa Adai beach represents the terminus of all runoff coming from the Hospital, a region Gary Denton of WERI found to be high in mercury contamination. Denton believes that runoff through this slough may be eventually feeding into the near coastal waters and causing a spike in mercury contents for local marine fish. If this is the case, we would expect the fish living in these inner pools to also show elevated levels of mercury. Remaining samples from this survey effort will be sent to WERI for analysis.

007a. Kagman Mitigation Ditch

Label –	7a-81508
Watershed –	Kagman
Latitude –	15°10.426
Longitude –	145°46.059
Date Sampled –	8/15/08

Physical Description – The Kagman mitigation ditch is one in a series of new water management structures designed to facilitate runoff within the relatively recently developed Kagman watershed. These ditches are a man made featured designed to connect large cement storm-water holding structures with local wetland areas. Due to recent rains the pools collected within the ditches were more than 3 feet deep in their center at the time of this survey and approximately 24 feet across by 85 feet long. The ditches are surrounded by thick grass, roads and homes, which provide almost no canopy cover or riparian buffer.

Water Chemistry – The water temperature was relatively high at 32.04°C. Surprisingly, the pH was very basic at 8.93. DO was super saturated at 154%. The ditch had a low salinity of 0.19 and conductivity of 0.413 μS/cm.

Biological Findings – Surveying in this location was not very fruitful. One cane toad was captured and photographed on site along with a large cluster of tadpoles and a couple different aquatic insects. Anecdotal evidence suggests that Red-eared Slider turtles (*Trachemys scripta elegans*) have also been found in abundance in seasonal ponds near this location.

Additional Sampling Location – A better sampling location might be the man made pond located just further up the road on the left hand side at 15°10.35 N longitude and 145°46.05 W latitude (Stinson 1990).

007b. Kagman Shrine, Upper Stream

Label –	7b-81408
Watershed –	Kagman
Latitude –	15°10.915
Longitude –	145°45.828
Date Sampled –	8/15/08

Physical Description – This sampling site is located just below a homestead containing an old Japanese shrine, just below the Mobile station in Kagman. Though the stream and riparian buffer are fairly pristine, including 100% canopy cover, we expected survey results to be a bit stunted here due to the likelihood of fishing pressure from local homes. The stream itself ranged from 2 to 9 feet across and was more than 2 feet deep in certain holes. Some wartime debris could still be found in and around portions of the stream as well.

Water Chemistry – The water temperature was relatively cold at 26.67°C. The pH was neutral at 7.88. DO was the highest of all our stream locations at 98.2%. This stream also had a low salinity of 0.49 and conductivity of 1.006 μS/cm.

Biological Findings – Electrofishing was considerably more effective than dip netting for this location and trapping was completely ineffective. *Macrobrachium lar* and *Caridina typus* shrimp were observed during surveys as were Thiarid snails. Anecdotal evidence also suggests that eels have been found in deeper pools within this stream system, but none were observed during our surveys.

009a. Lake Susupe

Label –	9a-81308
Watershed –	Susupe
Latitude –	15°09.171
Longitude –	145°42.609
Date Sampled –	8/13/08

Physical Description – Lakes Susupe is part of a wetland area containing 17 potholes as well as the 17 ha lake (Stinson 1990, Reichel 1994). The potholes can dry up during extremely dry years, but the lake is perennial, with no outlet to the sea (Stinson, 1990). Lake Susupe sampling took place from the front yard of the only home situated on the western shore of the lake in an area with 50% canopy cover along the bank created by ironwood trees which surround the entire lake. The banks drop off steeply and the water is a fairly turbid brown due to suspended particulates.

Water Chemistry – The water temperature was very warm at 33.03°C. The pH was slightly basic at 7.93. DO was average at 74.9%. The lake had a fairly high salinity of 03.25 and conductivity of 6.06 μS/cm.

Biological Findings – Electrofishing was not effective at this site due to the high conductivity, but both dip nets and trapping were fairly successful. Lake Susupe is the only location where 3 different types of snail were observed, including the common Thiarid, Ramshorn and rarer invasive Apple snail. Mangrove prawns (*Palaemon concinnus)* were captured in dip nets at this location and were not captured anywhere else on the island. Three different fish species were also found including: Tilapia (*Sarotherodon galilaeus multifasciatus*), Sailfin Molleys (*Poecilia latipinna*) and mosquitofish (*Gambusia affinis*). Cane toads were also seen at this site and there is anecdotal evidence that Red-eared Slider turtles and possibly large Tarpons or even eels have been collected here in the past. Interestingly, the Tilapia caught at this site no longer appear to be the *Oreochromis mossambicus* species that was introduced by the military over 50 years ago. Somewhere along the line Tilapia of the species *Sarotherodon galilaeus multifasciatus* were introduced and took over.

Additional Research – DFW staff attempted to fish Lake Susupe with baited hooks from a canoe in the Fall of 2007 in an attempt to capture additional species. Unfortunately, these additional efforts were only successful in landing more Tilapia specimens. Application of a surround net or use of rotenone may be a viable option for future research here if traditional methods continue to fail.

<u>009b. Costco Marsh</u>

Label –	9b-81508
Watershed –	Susupe
Latitude –	15°10.227
Longitude –	145°42.833
Date Sampled –	8/15/08

Physical Description – Costco Marsh is a protected wetland area just east of the Price/Costco shopping center in Chalan Laolao. The whole area is fenced off and the marsh within has nearly 100% aquatic plant cover due mostly to aquatic grasses and reeds, but virtually no canopy cover. The site is surrounded by roads, parking lots, homes and light industry, lending the marsh a poor riparian buffer. Sampling was performed starting at the DFW bird observation tower and heading north along the fence line.

Water Chemistry – The water temperature was a little warm at 29.95°C. The pH was neutral at 7.39. DO was low at 22.4%. As expected the marsh also had a low salinity of 0.24 and conductivity of 0.499 μS/cm.

Biological Findings – Dip netting came up with Thiarid and Ramshorn snails, as well as a couple of different aquatic insects. Electrofishing and trapping both came up empty. Tilapia were observed by surveyors and were captured previously at this location by DFW staff in the fall of 2007, but none were successfully captured during the 2008 survey effort.

011a. COP Golf Course, Pond at Hole #5

Label –	11a-81708
Watershed –	Isley
Latitude –	15°07.181
Longitude –	145°41.785
Date Sampled –	8/17/08

Physical Description – This man made pond is approximately 10,000 m2 and 2.5ft deep in the middle. The sampling area, down from the tee at hole #6, is surrounded by manicured grass with virtually no canopy cover and could be exposed to a considerable amount of fertilizer and pesticides.

Water Chemistry – The water temperature was hot at 34.19°C. The pH was very basic at 8.97. DO was surprisingly high at 141.2%. The pond also had a surprisingly high salinity of 3.43 and conductivity of 6.388 μs/cm.

Biological Findings – Tilapia was captured in this pond using both dip net and trap survey methods and samples are in storage at the Bishop museum should for future genetic testing if necessary. The conductivity was too high for effective electrofishing. No other species of interest were observed within the pond and the Tilapia that were collected did not seem to be healthy, with many samples suffering ruptured stomach cavities before they could be frozen.

V. Results

Each sampling site provided a unique combination of physical characteristics (Table 1). The only three locations we classified as undisturbed were lotic stream systems that had a very high level of canopy cover. We lumped site 0005a into the pristine group because the level of disturbance there was minimal compared to other locations. All of the disturbed or modified sites had a canopy cover of 50% or less. Aquatic plant cover was only observed at lentic sites, with the highest levels found in areas classified as disturbed. The difference in average canopy cover and aquatic plant cover between the disturbed and pristine locations is quite telling.

Field #	002a	003a	006a	006b	007a	009a	009b	011a	Avg.	004a	005a	005b	007b	Avg.
Water Body	Pond	Marsh	Channel	Channel	Ditch	Lake	Marsh	Pond	Disturbed	Stream	Stream	Stream	Stream	Pristine
Canopy Cover (%)	0	0	0	25	0	50	0	0	9.4	75	50	100	100	81.3
Aquatic Plant Cover (%)	75	100	0	0	0	75	100	0	43.8	0	0	0	0	0.0
Undisturbed										x		x	x	
disturbed		x					x				x			
Modified	x		x	x	x	x		x						
Lotic	x	x			x	x	x	x	75.0					0.0
Lentic			x	x					25.0	x	x	x	x	100.0

Table 1 – Physical Characteristics of Sampling Sites

There was a considerable range for all of the chemical variables measured between sites (Table 2). The water temperature varied more than 8°C between the warmest pond and coolest stream system. Pristine locations were consistently 5°C cooler than their disturbed counterparts. The warmest pond, located at the COP golf course, also had the highest pH and DO levels. The lowest pH was observed at the Costco marsh site and the lowest DO was measured at the marsh across from the DPS gun range.

There is a strong correlation between conductivity and salinity at all sites, but only two of the five brackish systems are known to receive an influx of ocean water. The other three locations, two ponds and one lake, have elevated levels that are either the result of runoff from fertilizers, previous marine water intrusion, or inputs from underlying and locally mined limestone.

Field #	002a	003a	006a	006b	007a	009a	009b	011a	Avg.	004a	005a	005b	007b	Avg.
Water Body	Pond	Marsh	Channel	Channel	Ditch	Lake	Marsh	Pond	Disturbed	Stream	Stream	Stream	Stream	Pristine
Temp. (C)	32.28	29.20	32.62	29.45	32.04	33.03	29.95	34.19	31.6	25.84	26.72	25.32	26.67	26.1
pH	7.35	5.90	7.41	7.72	8.93	7.93	7.39	8.97	7.7	8.02	7.21	7.04	7.88	7.5
DO (%)	129	49	33	67	154	75	22	141	83.9	79	73	39	98	72.4
Salinity (ppt)	7.32	0.05	15.50	5.71	0.19	3.25	0.24	3.43	4.5	0.21	0.13	0.24	0.49	0.3
Cond. (μS/cm)	12.87	0.12	25.78	10.17	0.41	6.06	0.50	6.39	7.8	0.44	0.27	0.51	1.01	0.6

Table 2 – Chemical Characteristics of Sampling Sites

As a result of these surveys we found species in locations they were not previously known to inhabit and species that had not previously been identified in the CNMI (Table 3). Fresh water eels and red slider turtles both have a strong anecdotal presence in the streams and ponds of the CNMI respectively, but neither were sited or surveyed during our sampling period. The Bishop Museum performed genetic testing on ten of our samples and was able to identify all of our specimens to the genus level and most to the species level (Appendix H). We could not confirm the presence of Tilapia species Oreochromis *niloticus* or *mossambicus* at any of our sights, though genetic testing confirmed that the genus Oreochromis was sampled at site 2a. The Tilapia species *Sarotherodon galilaeus multifasciatus* was a 99% genetic match for the specimens taken out of lake Susupe, though it had never been identified in the CNMI by the Secretariat of the Pacific, and despite the fact that the original Tilapia seeded into lake Susupe 50 years ago were *O. mossambicus* (SPC 2009). Sailfin mollies (*Poecilia latipinna*) were caught in abundance at three locations despite having no local documentation in the literature or Fishbase.

Field #	002a	003a	006a	006b	007a	009a	009b	011a	% Present	004a	005a	005b	007b	% Present
Water Body	Pond	Marsh	Channel	Channel	Ditch	Lake	Marsh	Pond	Disturbed	Stream	Stream	Stream	Stream	Pristine
Eel sp.				A					12.5	A			A	50.0
Misc. Tilapia sp.			S	O			O*	S	50.0					0.0
Oreochromis sp.	S								12.5					0.0
S. g. multifasciatus						S			12.5					0.0
Poecilia latipinna			S	S		S			37.5					0.0
Chanos chanos			S	S					12.5					0.0
Megalops cyprinoides				S					12.5					0.0
Stiphodon elegans									0.0		S	O		50.0
Eliotris acanthopoma				S					12.5					
Kuhlia rupestris									0.0		S			25.0
Gambusia affinis						S			12.5					0.0
Macrobrachium lar									0.0	S	S	S	S	100.0
Caridina typus									0.0	S	S	S	S	100.0
Palaemon concinnus						S			12.5					25.0
Thiarid Snails			S	S		S	S		50.0				S	25.0
Ramshorn Snails		S				S	S		37.5					0.0
Apple Snails						S	S		25.0					0.0
Cane toad		S							12.5					0.0
Tad poles					S		S		25.0					0.0
Red slider turtles					A**	A			25.0					0.0
Overal Diversity	**1**	**2**	**4**	**6**	**2**	**8**	**5**	**1**	**3.6**	**3**	**4**	**3**	**4**	**3.5**

S = Surveyed, O = Observed, A = Anecdotal

* Samples were collected in Fall 07, ** DFW Staff observed turtles in drainage ponds near sample site

Table 3 – Species findings at sampling sites

The gobiidae species observed at Jeffry's beach was genetic match for *Stiphodon elegans* which had been observed in Guam but never in the CNMI. Prior to genetic testing the specimen was believe to be *Sicyopus leprurus*, a fish identified on Rota in 1992 (Parenti 1993). The native Rock flagtail (*Kuhlia repestris*) and Indo-pacific Tarpon (*Megalops cyprinoides*) also already have a documented presence according to Fishbase (Froese 2008)

Three shrimp species were identified either from collection in interstitial streams, *Macrobrachium lar, Caridina typus*, or from Lake Susupe, *Palaemon concinnus.* Both our analysis expert, Dr. Cai Yixiong University of Singapore, and anecdotal evidence suggests that these shrimp have probably been found in CNMI freshwater streams for generations (Pacific Worlds 2003). Shrimp presence was limited to Lake Susupe and our more pristine stream sampling locations, they were not found in any of the more disturbed locations.

The trap, dip net and electrofishing methods all showed some success, especially in lotic systems (Figure 2). There are several things to note when we compare the success of each method in the lentic and lotic systems of Saipan. First, we must make it clear that both the dip net and electrofishing surveys were done with an emphasis on collecting as many different species as possible within the system and not with the intent of maximizing biomass. So, in many cases the surveyors skipped areas where easily collectable but redundant specimens could have been sampled in favor of locations that may have contained hitherto unknown specimens. This means we can consider both the dip net and electrofishing values to be the lower end of the potential biomass catch.

Second, it is important to note that only the dip net method was suited for the collection of snails and other benthic organisms which, in some cases, were the dominant biomass at a given site.

Third, though trapping was the only method to collect Sailfin Mollies at Lake Susupe, byinlarge it caught less fish and a lower diversity than dip nets or electrofishing at each site and was even less efficient in shrimp dominated locations.

Fourth, the electrofishing backpack was either unusable or yielded no results in every lentic system. In contrast, electrofishing was the most efficient method within the lotic systems. Without the electrofishing method we would have not captured any of the Rock flagtails and may have missed the gobie species found at Jeffry's beach, as only a single specimen was captured via other methods. Dip net and electrofishing had identical species composition collection for the other five lotic sites where both methods were employed. Electrofishing also dramatically increased our success at collecting shrimp biomass.

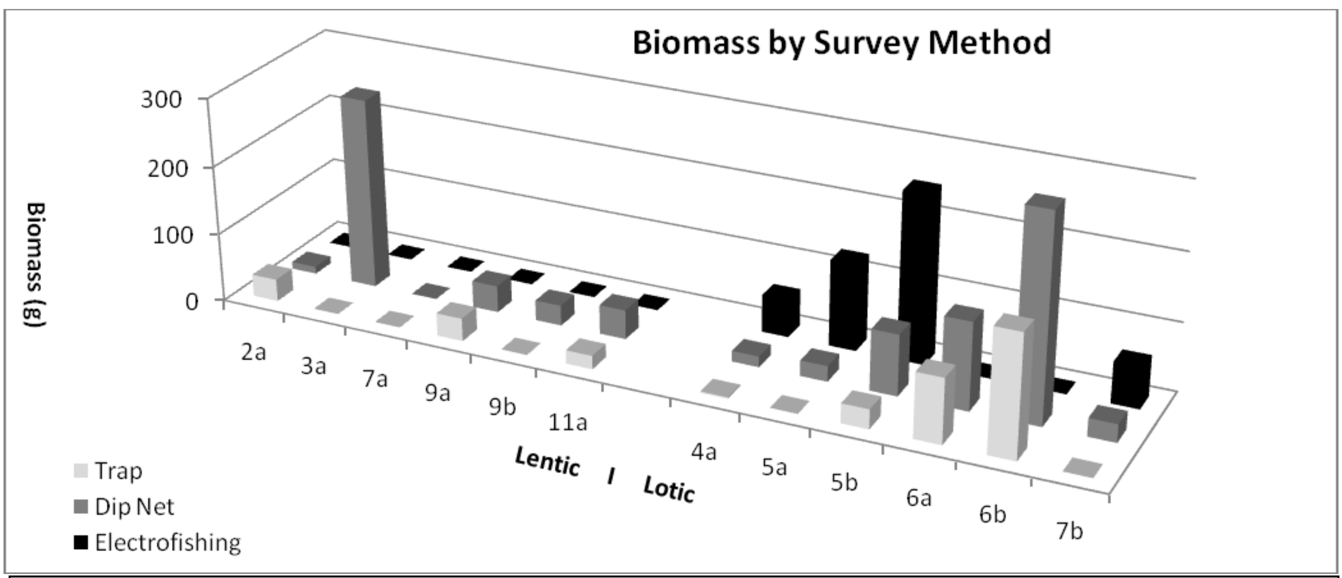


Figure 2 – Method Efficiency Comparison

Method	Locations	Effort (hrs)	Total Species	Biomass (g)
Dip Net	14	14	11	1019.1
Electrofishing	4	11.25	4	485.7
Trap	14	11.25	5	393.9

* Species count and biomass only includes fish and shrimp species

** Electrofishing effort based on estimated 45minutes each site x 3 surveyors

*** Trap effort based on trap time in water not deployment time

**** Tilapia, Macrobrachium and Atyid Shrimp species are lumped together at this time

Table 4 – Method Effort Comparison

A regression analysis shows that electrofishing was the most effective in lotic systems, while dip nets were the most effective in lentic systems (Figure 3). The method comparison is a bit nebulous for lentic systems, especially since the biomass in the one location where dip nets really dominated was almost completely driven by Ramshorn snails. In lotic systems dip nets were nearly three times more effective than traps and electrofishing was nearly three times more effective than the dip nets, though both methods were very consistent with respect to composition of species captured. We will add a Shannon-Weaver test once all of our species identifications have been confirmed.

As of June 16th 2009 we still need to get species confirmation for the goby species found in the stream at Jeffry's beach as well as the mosquitofish, tilapia and guppy species found at several sites. Table 3 doesn't currently have guppy species listed as they have been lumped in with the Sailfin molly's due to the similarities between juvenile and female specimens across those species. We need to get species confirmation and then recount specimens from those locations to distinguish the population/biomass numbers if we want to perform any higher level analysis.

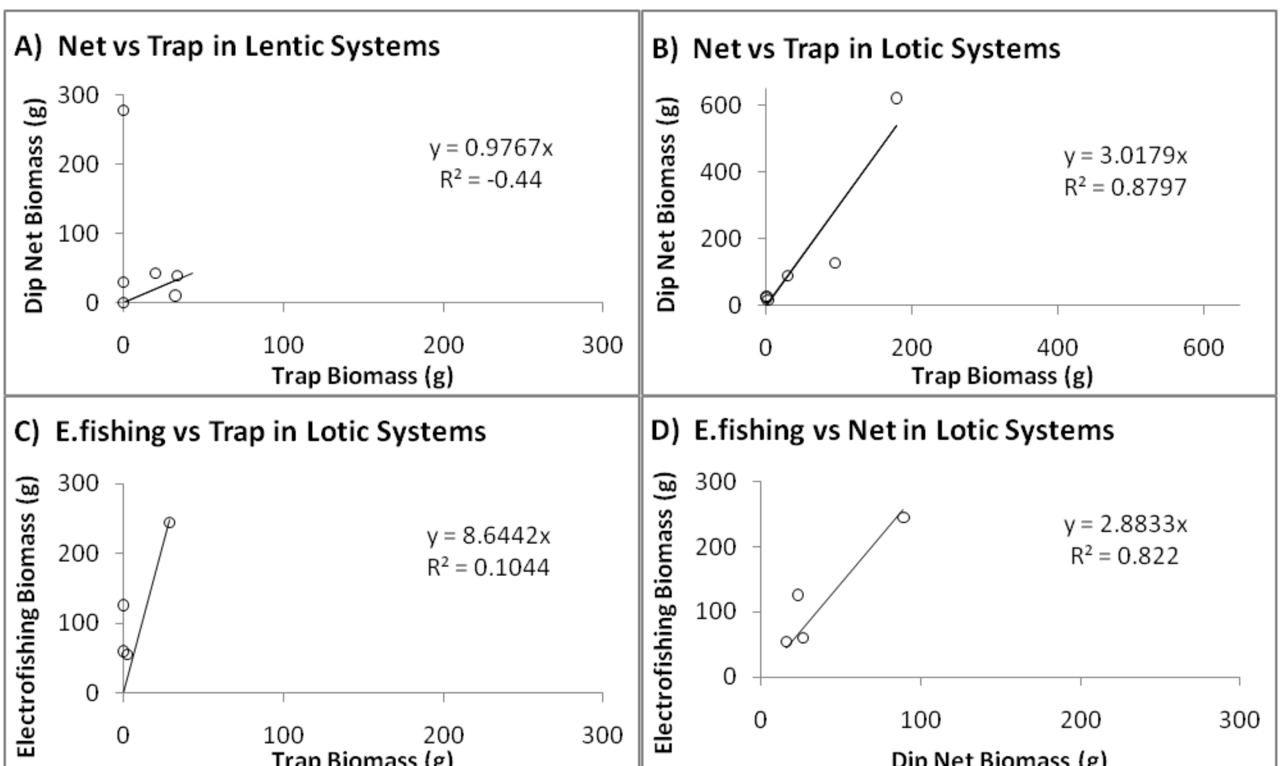


Figure 6 – Method Efficiency Regression Analysis

VI. Discussion & Recommendation

Upon detailed review of the literature, analysis of our findings and discussions with other agencies we would recommend surveying a few additional sites. Our attempts to find the permanent man made pond in Kagman were unsuccessful in August of 2008, but we now have a more detailed location (15°10'35"N, 145°46'05"E) and description of the site (Stinson 1990). The pothole ponds east and south of Lake Susupe may also provide a unique habitat for certain species. There are also more stream and pool systems in the Upper Telefofo region, just below wireless ridge, that have the potential to house hitherto un-surveyed species, including the elusive eel. It would be interesting to see if the lower reaches of Hidden Beach contain the same native fish species we observed at Jeffry's beach. There are three more golf courses to survey, including Kingfisher where both Tilapia and mosquito fish were observed by fisheries staff in spring of 2007. We should also look to add a GIS component to the site description section to improve our ability to duplicate surveys with a better rendering of space and scale.

Most of the sampling locations contained two species of fish or less. Jeffry's beach was the only site where two native species were observed in the same system including the Rock flagtail and a species of Gobie. The highest fish species diversity and most of the introduced fish species were found in the highly disturbed and modified channel systems in Garapan and at Lake Susupe. The channels are also the only sites where the native Indo-Pacific Tarpon was observed.

Fish were not collected in any of the undisturbed upper stream locations, but those locations were fairly thick with *Macrobrachium* and *Caridina* shrimp and biologists saw what appeared to be a gobie at Tegeta's stream, but they failed to capture it.

There was a considerable amount of effort and time put into preparing for and using the electrofishing equipment. Upon review, this may not have been necessary given the small and confined nature of our interstitial streams. Without the electrofishing equipment we would not have captured the Rock flagtail in our survey at Jeffry's beach and we would not have realized the extent of shrimp biomass in our streams, otherwise everything was duplicated in our much simpler dip net surveys.

Survey results suggest that native species have been almost completely chased out of the modified and disturbed systems. Juvenile tarpons and milkfish appear to be holding on within these systems, but it is limited to the cement drainages running through Saipan's most urban areas. Tilapia, Sailfin molleys and/or Mosquito fish dominate all the disturbed systems we sampled on the west side of the island and propose a risk to the undisturbed stream systems on the east side of the island, though the intermittent nature of those systems seems to only be truly favorable to shrimp. As such, we would recommend an annual dip net survey of key undisturbed locations like Jeffry's beach, in an attempt to control the further spread of introduced species. Additionally, we would recommend performing full stream surveys for the few remaining pristine habitats so that we can get a more complete view of what species are found through the systems and what roads, developments or other impediments may be threatening the streams.

The Fisheries Section also needs to be more involved in fish farming ventures in the CNMI as these enterprises have definitely played a role in the spread of Tilapia and possibly shrimp within the freshwater systems of Saipan. This is also an issue for saltwater species due mostly to the fish farming taking place within the NMC CREES program. Hazard Analysis and Critical Control Point (HACCP) review would be a good start in monitoring these threats. NMC CREES recently started exploratory fish farming with the marine grouper species *Ephinephelus coiodes*, has been involved in developing an abalone farm in Tinian harbor, and is also considering trapping local fry in an effort to farm native species.

Ramshorn and Thiarid snails appear to completely dominate certain systems with a presence in at least half of our sampling sites. Though outside the scope of this project, we would recommend a gastropod population dynamics and risk analysis study for the wetlands of Saipan and the whole CNMI. State Wildlife Grant (SWG) funds are currently funding a land snail survey for the southern islands of the CNMI by Barry Smith of the University of Guam (UOG) marine lab. He has already completed his first paper which details findings on Aguiguan (Smith 2008).

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Appendix A – Freshwater Species Sheets

Most of the photos and technical information for each species were taken from Fishbase and Wikipedia. Additional citations are listed within the text where applicable. Additional photos were taken from Google Images when necessary and should not be reproduced for use outside of this report without specific permission.

Species Name:	***Stiphodon elegans***
Family Name:	Gobiidae (Gobies)
Common Name:	*Stiphodon elegans*
Photo:	
Features:	This goby has a maximum size of 5.2cm and is more colorful than the other potential species of the CNMI.
Where Found:	Found in Guam, and may be present on Rota in the CNMI (Concepcion 1999).
How Introduced:	Native if present
Ecology:	These gobies can survive in a pH range of 6.0 to 8.0, and usually inhabit clear and relatively swift rainforest streams near the coast. They feed on algae and have a high minimum population doubling time (less than 15 months). The gobies have modified pectoral fins that allow them to climb waterfalls.
Special Notes:	*Stiphodon elegans* may require larger or more perennial streams than are found on Saipan.

Species Name:	***Awaous guamensis***
Family Name:	Gobiidae (Gobies)
Common Name:	*Awaous guamensis*

Photo:

Features: They often burrow into the substrate with only the eyes showing.

Where Found: Collected in Rota by Watson in 1981, but does not resemble the Goby species caught at Jeffry's beach (Watson 1992).

How Introduced: Native

Ecology: Adults occur from lowland streams and rivers to relatively swift streams at elevations of 1000 m. They often burrow into the substrate with only the eyes showing; feed on filamentous algae, worms, crustaceans, various insects and insects larvae, and suspended food particles. Larvae develop and metamorphose in the marine zooplankton and as juveniles, about 161 days old, recruit to freshwater streams, where they undergo rapid growth and morphological changes necessary for upstream migration to the adult habitat (Radtke 1988). The gobies have modified pectoral fins that allow them to climb waterfalls.

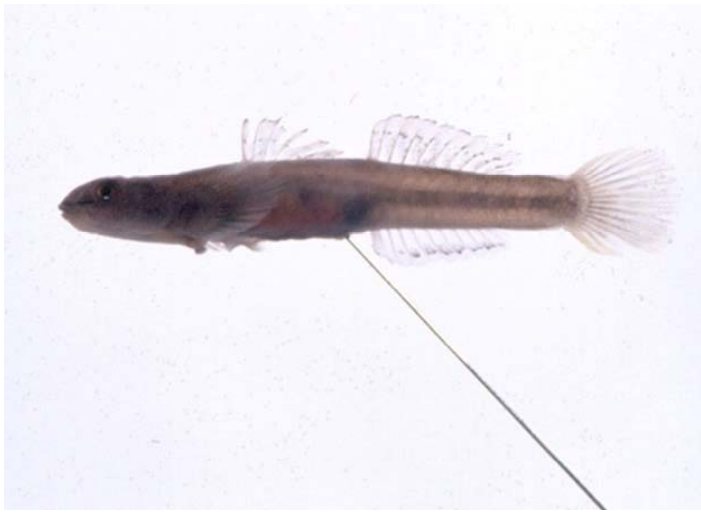
Special Notes: *Awaous guamensis* may require larger or more perennial streams than are found on Saipan.

Species Name: ***Sicyopus leprurus***

Family Name: Gobiidae (Gobies)

Common Name: *Sicyopus leprurus*

Photo:



Features: *Sicyopus leprurus* is dark and thin with clear fins and is only a couple inches in length, making it difficult to capture and identify.

Where Found: This fish was first identified in Rota by L.R. Parenti in 1989. We believe this fish was also captured by our electrofishing survey at Jeffry's beach in Saipan, August 2008 (Watson 1995)

How Introduced: Native

Ecology: These gobies prefer fast flowing streams and are believed to have a relatively high minimum population doubling time (15 months) which could explain their continued success in the CNMI. The gobies may have modified pectoral fins that allow them to climb waterfalls and to traverse the spillway and enter the reservoir from downstream.

Special Notes: *Sicyopus leprurus* may also be found in the stream at Hidden Beach, just north of Jeffry' beach in Saipan.

Species Name: ***Kuhlia rupestris***

Family Name: Kuhliidae (Aholeholes)

Common Name: Rock flagtail

Photo:

Features: The Rock flagtail is most readily identified by the black edged with white in the soft portion of the dorsal fin. These fins are mostly black in adults.

Where Found: Collected by B.J. Maciolek in Rota in 1981 and identified by L. R. Parenti in 1989 and believed to be captured at Jeffry's beach stream in Saipan in August 2008 (Randall 2001).

How Introduced: Native

Ecology: Primarily a freshwater inhabitant but may penetrate adjacent marine habitats. Adults occur in estuaries and the middle reaches of rivers; usually in relatively fast-flowing, clear streams. Often found in the rocky pools below waterfalls. Adults are omnivorous, feeding on small fishes, insects, crustaceans and fruits that drop into the water. Specific breeding habits are unknown, but adults move downstream into estuaries or to the sea to spawn

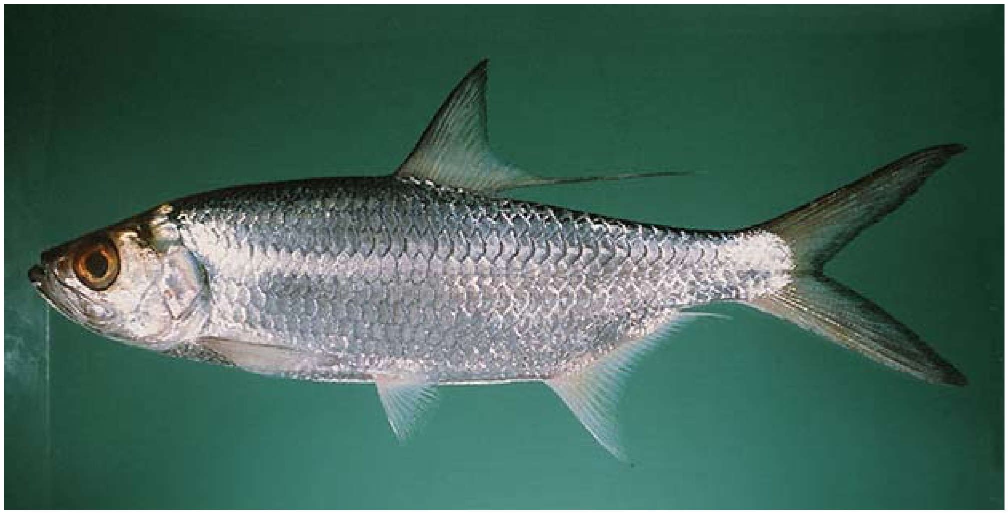
Special Notes: *Kuhlia rupestris* may also be found in the stream at Hidden Beach, just north of Jeffry's beach in Saipan.

Species Name: ***Megalops cyprinoides***

Family Name: Megalopidae (Tarpons)

Common Name: Indo-Pacific tarpon

Photo:



Features: The lower jaw of *cyprinoides* projects beyond the snout, the last ray on dorsal fin is long and filamentous and is silver in color with large scales.

Where Found: Garapan drainage at Hafa Adai hotel.

How Introduced: Native

Ecology: The Indo-Pacific tarpon is capable of living in oxygen poor water by 'breathing' air into lung-like air bladder. Young typically inhabit river mouths, inner bays and mangrove areas while adults are generally found at sea. They can also be found in freshwater lakes and rivers and can tolerate a wide range of pH (5.2-9.1) and salinities from 0 to 100.

Special Notes: None

Species Name: ***Liza vaigiensis (fry)***

Family Name: **Mugilidae**

Common Name: *Squaretail mullet*

Photo:

Features: Adults have distinctive square shaped yellow tail. Juveniles, as seen above, appear in groups and are bright silver in color with fairly rounded heads and broad under jaws than *Neomyxus leuciscus*, the other mullet species which is often seen on Guam.

Where Found: Mullet fry were found in both of the channel areas leading out of Garapan.

How Introduced: Native.

Ecology: *(From Fishbase)* Inhabit lagoons, reef flats, estuaries, and coastal creeks, in shallow coastal areas and protected sandy shores (Ref. 40488). Usually within tidal influence, but may enter fresh water, ascending 10 km into rivers (Ref. 40488). Form large schools, frequently in mangrove areas (Ref. 2334). Juveniles may be found in rice fields and mangroves and may be used as bait fish (Ref. 9812). Oviparous, eggs are pelagic and non-adhesive (Ref. 205).

Species Name: ***Anguilla marmorata***

Family Name: Anguillidae (Freshwater eels)

Common Name: Giant mottled eel

Photo:

Features: The Giant mottled eel can reach lengths up to 200cm. Adults have brownish to black marbling on a yellowish background. Younger eels are grayish to orange with less obvious marbling and all have whitish bellies.

Where Found: Anecdotally found in the pools of upper stream systems and possibly in Lake Susupe (Elemato 1975)

How Introduced: Giant mottled eels are believed to be native if they are still present and have not been mistaken for *Anguilla japonica*.

Ecology: Young *Anguilla marmorata* live in estuaries and seas and migrate to freshwater areas as adults. Adults later return to deep sea gullies to breed. They are predominantly nocturnal.

Special Notes: It is still unclear which species of eel was once common in the CNMI, but none were seen during our 2008 survey efforts.

Species Name: ***Anguilla japonica***

Family Name: Anguillidae (Freshwater eels)

Common Name: Japanese eel

Photo:

Features: The Japanese eel can reach lengths up to 150cm and are plain in color, usually green.

Where Found: Anecdotally found in the pools of upper stream systems and possibly in Lake Susupe, bu may be mistaken for *Anguilla marmorata* (Tsukamoto 1992).

How Introduced: *Anguilla japonica* was possibly introduced during Japanese occupation of the Mariana Islands.

Ecology: Spawning occurs in the sea; small eels ascend the rivers in schools; develop and grow in freshwater. The species may crawl over land at night from one place to another. Spawning has been observed by deep ocean surveys on several sea mounts in the Mariana's (Tsuchida 2003).

Special Notes: It is still unclear which species of eel was once common in the CNMI, but none were seen during our 2008 survey efforts.

Species Name: ***Poecilia latipinna***

Family Name: Poeciliidae (Poeciliids)

Common Name: Sailfin molly

Photo:

Features: *Males have large sail-like dorsal fin.* Speckled black and silver and orange (above) specimens were observed during surveys in Saipan.

Where Found: Lake Susupe, and Garapan drainages

How Introduced: *Latipinna* were most likely introduced as a result of released fish from the aquarium trad

Ecology: Sailfin molly's can be found in freshwater and brackish environments (they have even been found in waters with a salinity of 87ppt) and have a temperature tolerance of 20-28°C. They can also survive in environments with low dissolved oxygen by exploiting the thin film of oxygen rich surface water wit their upturned mouths.

Special Notes: Potential pest, according to Fishbase

Species Name: ***Poecilia reticulata***

Family Name: Poeciliidae (Poeciliids)

Common Name: Guppy

Photo:

Features: *Reticulata* has a very similar appearance to female Sailfin molly's and mosquitofish.

Where Found: Unsure, may have been mistaken for female *latipinna* or *Gambusia*.

How Introduced: Guppy's were most likely introduced as a result of released fish from the aquarium trade

Ecology: Guppy's have a limited pH range of 7.0-8.0 but a broad salinity range and requires warm temperatures 23-24°C and quiet vegetated water for survival. Widely introduced and established elsewhere, mainly for mosquito control, but had rare to non-existing effects on mosquitoes, and negative to perhaps neutral effects on native fishes (Kottelat 1996).

Special Notes: Potential pest, according to Fishbase

Species Name: ***Gambusia affinis***

Family Name: Poeciliidae (Poeciliids)

Common Name: Mosquitofish

Photo:

Features: *Gambusia affinis* seems to differ from *Gambusia holbrooki* based on its lack of an abdominal spot.

Where Found: One species of *Gambusia* is present in Lake Susupe and in Garapan drainages, but it seems more likely that it is the Eastern Mosquitofish due to its higher tolerances.

How Introduced: It is unclear if it is present, but if so it was likely introduced in order to reduce mosquito populations.

Ecology: The Mosquitofish has a less robust constitution than the Eastern mosquitofish, and can survive in a pH range of 6.0 to 8.0 and a temperature range of 12-29°C. Effective in mosquito control and widely introduced, but found to compete with indigenous fish and to upset the ecological balance.

Special Notes: Potential pest, according to Fishbase

Species Name: ***Gambusia holbrooki***

Family Name: Poeciliidae (Poeciliids)

Common Name: Eastern mosquitofish

Photo:

Features: *Gambusia holbrooki* seems to differ from *Gambusia affinis* based on its abdominal spot.

Where Found: One species of *Gambusia* is present in Lake Susupe and in Garapan drainages, but it seems more likely that it is the Eastern Mosquitofish due to its higher tolerances.

How Introduced: It is unclear if it is present, but if so it was likely introduced in order to reduce mosquito populations.

Ecology: The Eastern Mosquitofish can survive in a pH range of 6.0 to 8.8 and a temperature rang of 12-35°C. Probably introduced to Australia during the 1920s, firstly as aquarium pets, but were soon released widely into native waters to control mosquito populations. It is now widely accepted that their effect has been minimal and even may have exacerbated the problem due to their voracious appetite for natural invertebrate predators of mosquit larvae (Allen 2002).

Special Notes: Potential pest, according to Fishbase

Species Name: ***Oreochromis mossambicus***

Family Name: Cichlidae (Cichlids)

Common Name: Mozambique Tilapia

Photo:

Features: Weak banding compared to other Tilapia. Also has a strongly protruding snout in adults Mozambique also tends to be yellowish in color.

Where Found: Lake Susupe and possibly in the Garapan Channels and at the golf courses

How Introduced: Introduced into Lake Susupe and the Pagan ponds by the Navy in 1955 (Nelson 1991).

Ecology: *Mossambicus*, like all Tilapia are nest builders (8in diameter x 2in deep) and vigorously defend their territories. Females keep the eggs in their mouths until fry hatch. This species is listed as one of the 100 worst invasive species by the ISSG due largely to its spread across the US.

Special Notes: Potential Pest, according to Fishbase

Species Name: ***Oreochromis niloticus***

Family Name: Cichlidae (Cichlids)

Common Name: Nile Tilapia

Photo:

Features: The Nile tilapia has regular vertical stripes throughout the depth of the caudal fin and does not have the enlarged jaw of *mossambicus*.

Where Found: Unsure. We are waiting on genetic tests from the Bishop Museum.

How Introduced: *Niloticus* is a major fixture of CNMI aquaculture according to the Secretariat of the Pacific Community (SPC 2009).

Ecology: *Niloticus*, like all Tilapia, are nest builders (8in diameter x 2in deep) and vigorously defend their territories. Female's mouthbrood until fry hatch. This species has a natural temperature range of 12.5-33°C.

Special Notes: Potential Pest, according to Fishbase

Species Name: ***Tilapia zilli***

Family Name: Cichlidae (Cichlids)

Common Name: Red Belly Tilapia

Photo:

Features: Resembles spotted tilapia (*Tilapia mariae*) but has 8 or 9 thin cross bars along its flanks. *zilli* also has stout firmly anchored teeth unlike *mariae*.

Where Found: Unknown. Our Guam contact, Brent Tibbatts, believes this may be one of the new specie of Tilapia found during our surveys.

How Introduced: Unknown

Biology: Red Belly Tilapia have a very high salinity tolerance (up to 45ppt), and a low tolerance fo cold temperatures with successful spawning taking place between 22.5 and 31.4°C. *Zilli* are nest builders (8in diameter x 2in deep) and vigorously defend their territories. Males typically are larger and more colorful.

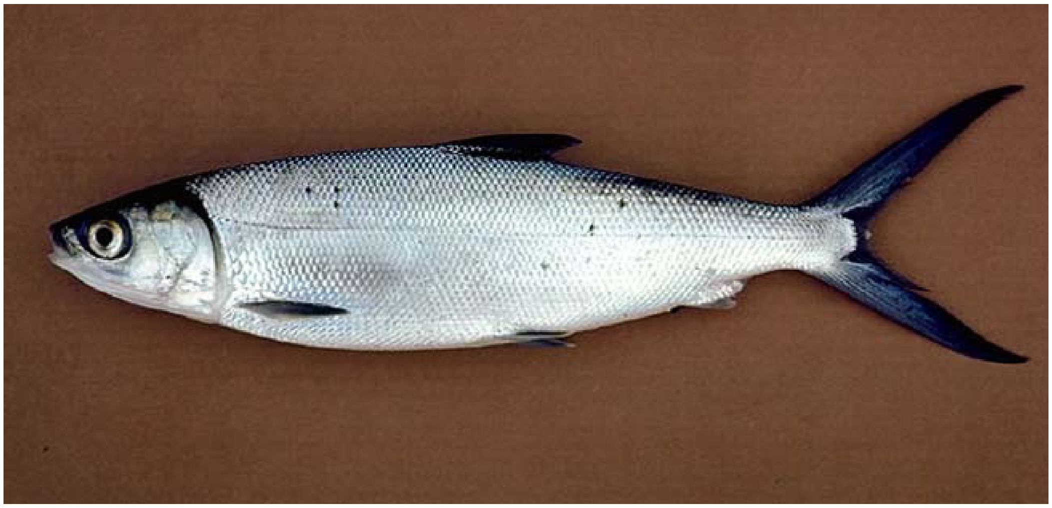
Special Notes: None

Species Name: ***Chanos chanos***

Family Name: Chanidae (Milkfish)

Common Name: Milkfish

Photo:



Features: *Chanos chanos* is elongate with a toothless mouth, silvery flanks and dark bordered fins. The 4 branchiostegal rays differentiate this as a more advanced species than the bonefish.

Where Found: Garapan channel just south of the Hafa Adai hotel, Site 006b.

How Introduced: The Government of Guam introduced milkfish from the Philippines for a small-scale culture operation in the 1980s. Problems with supply of fry were encountered when the Philippines enforced a moratorium on export of milkfish fry (SPC 2002). These early aquaculture efforts could be the source of the fish we see here.

Ecology: Milkfish are herbivorous, unlike most large saltwater fish, which makes it viable fish for aquaculture. · In nature, the larvae seek out clear coastal and estuarine waters warmer than 23°C with 10-32 ppt salinity and abundant phytoplankton. Older larvae migrate onshore and settle in coastal wetlands (mangroves, estuaries) during the juvenile stage, or occasionally enter freshwater lakes. Juveniles, then migrate into lagoons, lakes and shallow waters until they reach adolescence (24-45 cm fork length) before returning to the sea for further grown and sexual maturation, which they achieve at age 5.

Special Notes: Introduced, but not considered invasive.

Additional Fish Species

Invasive fish present on the Island of Guam according to Fishbase (Froese 2008)

Astronotus ocellatus (Oscar)

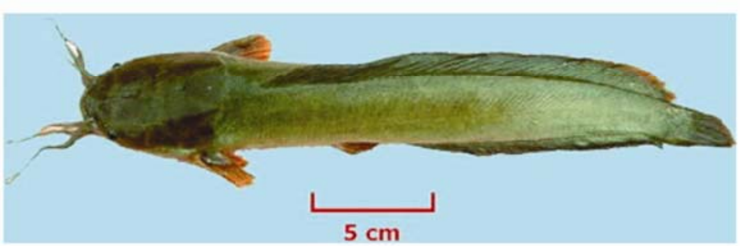
Betta Pugnax (Penang betta)

Cichla ocellaris (Peacock cichlid)

Cyprinus carpio carpio (Common carp)

Clarias batrachus (Walking catfish)

Xiphophorus hellerii (Green swordtail)



Clarias macrocephalus (Bighead catfish)

Species Name: ***Macrobrachium lar***

Family Name: Palaemonidae (long-arm shrimp)

Common Name: *Macrobrachium*, monkey river shrimp, Tahitian prawn

Photo:

Features: The largest *Macrobrachium* shrimp we found had a length of 10.3cm, the maximum length listed in the literature was a staggering 18.1cm. They all have front pincers, some of which can be extremely long. Note that these shrimp often lose their pincers when threatened or handled.

Where Found: We found *Macrobrachium* shrimp in each of the four undisturbed stream sites we surveyed including the stream in Tanapeg on the west side of the island. Southeast Asia is considered their primary origin.

How Introduced: *Macrobrachium lar* are believed to be native, but other species have the potential to be accidentally introduced via the local shrimp farm industry.

Ecology: Gravid females migrate to brackish water regions where Macrobrachium larvae pass through several life stages before returning to upper freshwater areas. Postlarvae and adults are omnivorous, eating algae, aquatic plants, mollusks, aquatic insects, worms, and other crustaceans.

Special Notes: *Macrobrachium rosenbergii,* if present, is an introduced species. More than 200,000 tons of *Macrobrachium rosenbergii* are produced annually via aquaculture worldwide.

Species Name: ***Palaemon concinnus***

Family Name: **Palaemonidae**

Common Name: *Mangrove Prawn*

Photo:

Features: These shrimp are much smaller than the *Macrobrachium* shrimp and they do not have pincers.

Where Found: This shrimp was only found in Lake Susupe, which is fitting due to its brackish nature. All of the shrimp sampled during the 2008 study are believed to be native.

How Introduced: Exported out of Taiwan, but may be Native

Ecology: They are filter-feeders, collector-gatherers and omnivorous scavengers. All these shrimp are amphidromous, with their larvae drifting downstream to the ocean, developing in the plankton, and migrating back into freshwater systems as juveniles. Some species appear to be more suited toward certain environmental conditions, but otherwise it appears that a variety of Atyid species can coexist within a single system (Leberer 2001).

Special Notes: There are 7 *Atyid* species native to Guam, but none are endemic.

Species Name: ***Caridina typus***

Family Name: Atyidae

Common Name: *Wild bee shrimp, or orange bee shrimp*

Photo:

Features: The *Atyid* shrimp are much smaller than the *Macrobrachium* shrimp and they do not have pincers.

Where Found: We found *C. typus* shrimp in each of the four undisturbed stream sites we surveyed including the stream in Tanapeg on the west side of the island.

How Introduced: Exported out of Taiwan, but may be Native

Ecology: They are filter-feeders, collector-gatherers and omnivorous scavengers. All these shrimp are amphidromous, with their larvae drifting downstream to the ocean, developing in the plankton, and migrating back into freshwater systems as juveniles. Some species appear to be more suited toward certain environmental conditions, but otherwise it appears that a variety of Atyid species can coexist within a single system (Leberer 2001).

Special Notes: There are 7 *Atyid* species native to Guam, but none are endemic.

Species Name: ***Chaunus (Bufo) marinus***

Family Name: Bufonidae

Common Name: Cane toad or Marine Toad

Photo:

Features: Female cane toads can reach 6 inches or more in length and can live up to 15 years in the wild. They can be a variety of colors, but they always have dry and warty skin with ridges above the eyes that run down the snout and a large parotoid gland behind each eye. Juveniles are much smaller, smoother and darker with smaller parotoid glands.

Where Found: Cane toads and/or tad poles were surveyed at the Kagman mitigation ditch site, the Costco marsh and most heavily at the marsh below the DPS gun range. The full range of this species should be considered CNMI wide.

How Introduced: The common name of "cane toad" is derived from the original purpose of using it to eradicate pests in sugar cane crops and may have been introduced to Saipan for the same purpose during Japanese occupation in the 1930's.

Ecology: Adult Cane Toads possess enlarged parotoid glands behind the eyes and other glands across the back. When threatened, the Cane Toad secretes a milky-white fluid known as bufotoxin from these glands. Bufotoxin contains components that are toxic to many animals. Adult cane toads are entirely terrestrial, venturing to fresh water to breed, and tadpoles have been found to only tolerate salt concentrations equivalent to 15% that of sea water.

Special Notes: The cane toad has poison glands, and the tadpoles are highly toxic to most animals if ingested.

Species Name: ***Trachemys scripta elegans***

Family Name: Emydidae

Common Name: Red-eared Slider Turtle

Photo:

Features: Red-eared Slider females can reach 12 inches in length and are most readily identified by the red bar behind each eye.

Where Found: Trachemys scripta elegans have been seen by DFW staff at Lake Susupe and in the pond areas of lower Kagman, but none were captured during the 2008 surveys.

How Introduced: Released from pet trade

Ecology: Red-eared Sliders are omnivores and eat a variety of animal and plant materials in the wild including, but not limited to fish, crayfish, carrion, tadpoles, snails, crickets, wax worms, aquatic insects and numerous aquatic plant species. They are almost entirely aquatic, but do leave the water to bask in the sun and lay eggs. A female might lay from two to thirty eggs, with larger females have the largest clutches. One female can lay up t five clutches in the same year and clutches are usually spaced twelve to thirty-six days apart.

Special Notes: The red-eared slider turtle is banned in Australia because of the threat the species poses to wildlife. Anyone who keeps or breeds red-eared slider turtles could face fines of more than $100,000 or five years' jail.

Frog Species

Established or potentially established population on the Island of Guam as of 2005 (Christy 2005)

Greenhouse Frog (*Euhyas planirostris*)

Eastern Dwarf Treefrog (*Litoria fallax*)

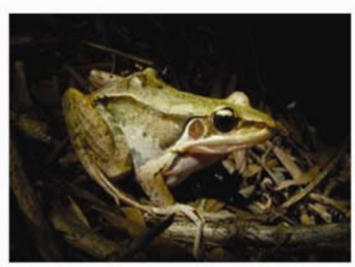
Crab-eating Frog (*Fejervarya cancrivorus*)

Marbled Pigmy Frog (*Microhyla pulchra*)

Indian Rice Frog (*Fejervarya limnocharis*)

Hong Kong Whipping Frog
(*Polypedates megacephalus*)

Barking Frog (*Hylarana guentheri*)



Gunther's Amoy Frog (*Rana guentheri*)

Reptile Species

Established or potentially established population on the Island of Guam as of 2005 (Christy 2005)

Chinese Striped-neck Turtle
(*Ocadia sinensis*)

Chinese Three-Keeled Pond Turtle
(*Chinemys revesii*)

Chinese Softshell Turtle (*Pelodiscus sinensis*)

Green Anole (*Anolis Carolinensis*)

Three-toed Box Turtle
(*Terrapene Carolina triunguis*)

Curious Skink (*Carlia ailanpalai or fusca*)

Common Snapping Turtle (*Chelydra serpentine*)

Brown Tree Snake (*Boiga iregularis*)

*Do not duplicate or distribute as some images may be under copyright

Species Name: **Planorbidae *sp.***
Family Name: Planorbidae
Common Name: Ramshorn snail

Photo:

Features: The term ramshorn snail is used in the aquarium trade to describe any kind of snail whos shell spiral forms tight whorls. Although most are extremely small, some may reach a size of two and a half centimeters (one inch).

Where Found: We found Planorbidae snails species at both marsh sampling sites and at Lake Susupe.

How Introduced: Native

Ecology: Their blood, like human blood–contains hemoglobin, which may lend these snails a bright reddish color. These ramshorn snails breathe air. Ramshorn snails generally will eat only the most delicate plants, preferring algae, uneaten fish food, and dead fish. Som varieties do particularly enjoy eating the leaves of stem plants. They lay eggs in globules, which tend to be brownish in color. The globules contain about a dozen or so eggs.

Special Notes: One should also be aware that red ramshorn snails are able to carry various parasitic flukes, which can be transmitted to fish, or humans

Species Name: **Thiarid *sp.***

Family Name: Thiaridae

Common Name: Thiarid snails

Photo:

Features: The title 'Thiarid snail' refers to all of the conical snail species observed in Saipan. They are typically quite small, averaging 20 to 30mm in length.

Where Found: We found Thiarid snails mostly in disturbed locations like Costco marsh and Lake Susupe, but they are also found at the relatively pristine site 007b, in upper Kagman. These snails completely carpet the substrate in Garapan slough

How Introduced: Some may be native, but most of the disturbed waterways are probably full of species released by aquarists.

Ecology: Many species of this family are quite tolerant of brackish water and prefer warmer temperatures and is resistant to low oxygen levels. They also tend toward burrowing and nocturnal activity.

Special Notes: 50°C is the lethal temperature for Thiarid snails to disinfect fishing gear and research equipment, which otherwise may inadvertently spread the snails to uninfested waters. These snails are also known to carry certain parasites which can be dangerous to humans

Species Name:	**Ampullariidae (*Asolene, Felipponea, Marisa, Pomacea, Pila*)**
Family Name:	Ampullariidae
Common Name:	Apple Snails

Photo:

Features: The title 'Thiarid snail' refers to all of the conical snail species observed in Saipan. The are typically quite small, averaging 20 to 30mm in length.

Where Found: Apple snails are believed to found island wide, but specimens were only surveyed at the Costco marsh and Lake Susupe.

How Introduced: Most likely these specimens were released by aquarists.

Ecology: The Ampullariidae are peculiar because they have gills and lungs, the mantle cavity bein divided to separate the two types of respiratory structures. It is part of the snail's natural behavior to leave the water when the food supply below the surface becomes inadequate Some apple snails deposit eggs above the waterline in calcareous clutches. This remarkable strategy of aquatic snails protects the eggs against predation by fish and othe aquatic inhabitants. Another anti-predator adaptation in the apple snail genera *Pomacea* and *Pila*, is the tubular siphon, used to breathe air while submerged, reducing vulnerability to attacking birds.

Special Notes: These snails can transfer parasites to humans if undercooked samples are eaten. Hawai'i experienced the introduction of *Pomacea* for culinary purposes, and its taro industry is now suffering because of it.

Appendix B – Field Data Sheet

Field Number: __________________________ Date:________________________

Locality

Island:____________________ Drainage: ____________________ Waterbody: ___________________

Nearest Primary Road: _____________________ Nearest Village: ______________________________

Site Access: _______________________________ GPS (LAT/LON): ________________________________

Directions from Primary Road: ____

____

Site Description

WaterBody: Freshwater_____ Brackish_____ Marine_____ Lentic____ Lotic______

Stream Order_______ Tail water_____ Canal______ Farm Pond_______ Reservoir________________

Lake_____ Backwater_______ Tidal_____ Swamp______ Other______ HUC______________________

Notes:____

Location Label on map =								
(Width)								
(Clarity)								
(Depth) R.	L. Bank	Middle	R. Bank	L. Bank	Middle	R. Bank	L. Bank	Middle

Notes:____

Canopy Cover Average %: ____Notes:___________

____

Aquatic Plant Cover (Plants/Algae/Other) Average %: ____

Notes: ____

Substrate Type: Natural ____________ Man-Made_____________ Steam Gradient: Flat________ Moderate__________

High________ Riparian Buffer:poor(<3x stream width) good(>3x stream width)

Notes: ____

Land Use Observations: Agriculture______Livestock______Forestry______Road_______Home site_____

Neighborhood______Industry______Waste Disposal_______ Natural_____ Recreation_______

Site Condition: Undisturbed_______ Disturbed_______ Highly Modified_________

Notes: ____

Quantitative Collection Information

Gear Type: Net______ Electricity________ Trap ________Notes: ______________________________

Backpack Operator(s): ____

Netter(s): ____ Dip net Mesh Size_________

Start Time: ________________ End Time: ________________ Shock Time: _______________________

Settings: Volts_________ Duty___________ Freq______________________

Observed Efficiency: Low________ Medium ________ High _________

Notes: ____

Ambient Conditions

Air Temperature: ______ Water Temperature: _____ pH_________________

Dissolved Oxygen: _________ Salinity: __________ Secchi: __________ Conductivity _______________

Water Level: Low _____ Normal______ Bank full ______ Flood_______ Sky Conditions: Clear _______

Partially Cloudy ______ Overcast______ Wind: Calm_____ Windy______ Gusts______

Tide: Incoming ______ Outgoing ______ Moon Phase: ____________ Water Surface: Smooth ______

Chop______ Advisory________

Site Sketch & Notes (no reverse side)

Appendix C – Lab Data Sheet

DFW FISHERIES – Invasive Fish – Lab Data Sheet (page-1)

Field Number:__________________________ Lab Date:________________

Page___ of___

Sample Method:_____________________

Species		***Total Length (mm)***	***Standard Length (mm)***	***Body Weight (g)***	***Comments / Photo ID***
1					
2					
3					
4					
5					
6					
7					
8					
9					
0					
1					

*Notes:*____

Measure Board used____

Scale used____

Specimen Live= ***L***, Specimen Dead=***D***, Specimen Frozen=**F**, Specimen Preserved=**P**

Appendix D – Site Photographs, Descriptions & Illustrations

002a - MCC Golf Course, Pond at Hole #6

15º15.750 N   145º47.690 W

Photo taken - 8/18/08

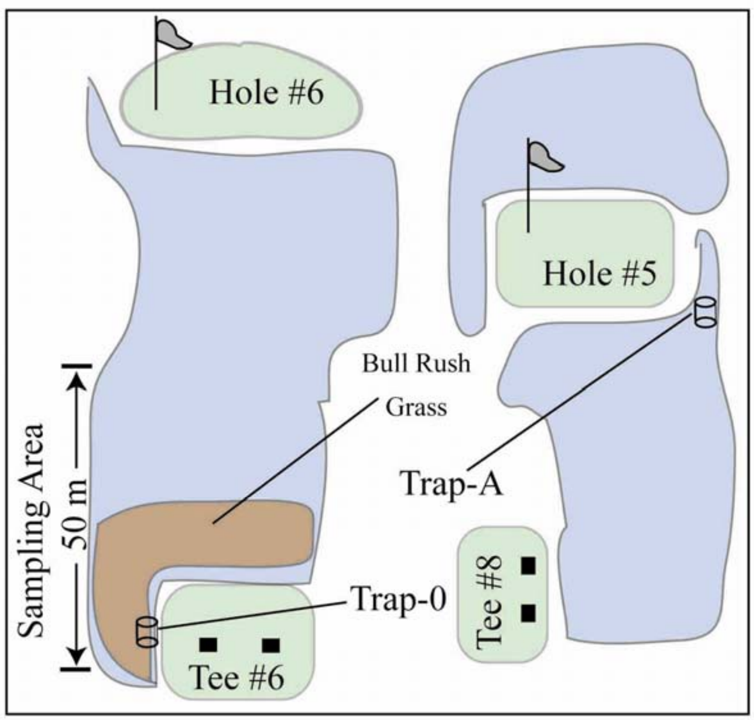
Site ID - 2a-81808

The sampling site is just west of the tee of Hole #6 at the MCC Golf Course.

The golf course has plans to remove all of the Tilapia at Hole #6 and drain the pond in an effort to remove all of the Bull Rush sometime in the near future.

* Tee locations based on Fall 2008

** Figures not drawn to scale



003a - DPS Gun Range, Marsh

15º14.270 N   145º47.373 W

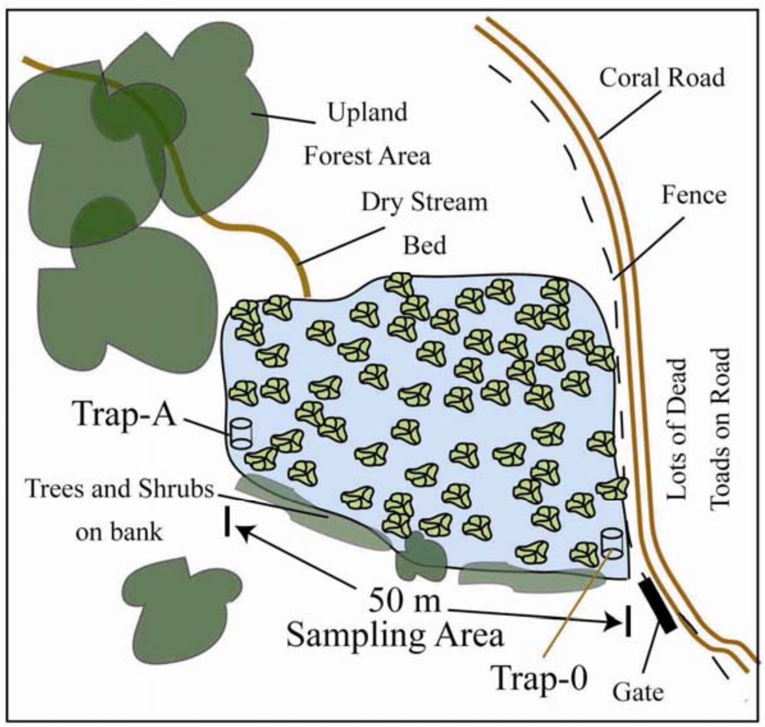
Photo taken - 8/18/08

Site ID - 3a-81808

The sampling site is just down the hill and across the street from the DPS gun range.

The marsh s almost completely covered in aquatic plants and it is difficult to say if water has always collected here, or if this marsh is an artifact of the road.

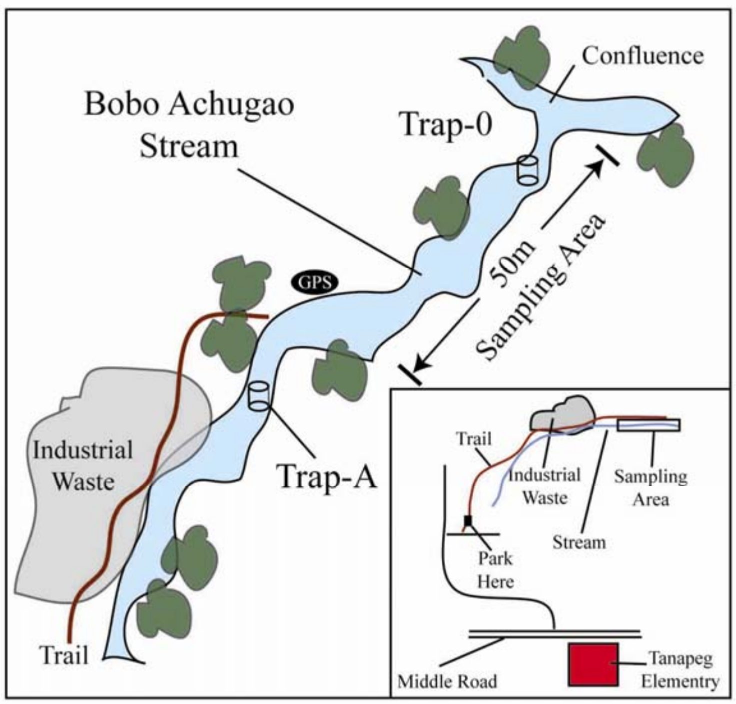
** Figures not drawn to scale



004a - Tanapeg, Bobo Achugao Stream

15º14.183 N   145º45.798 W

Photo taken - 8/13/08



Site ID - 4a-81308

The sampling site is up the hill from Tanapeg Elementry School. After you park there is about a 10 minute hike up a fairly well maintained trail, through a bunch of industrial waste and up to the confluence of 2 streams. The confluence markes the upper boundary of our sampling area.

** Figures not drawn to scale

005a - Jeffry's Beach Stream

15°12.970 N   145°46.772 W

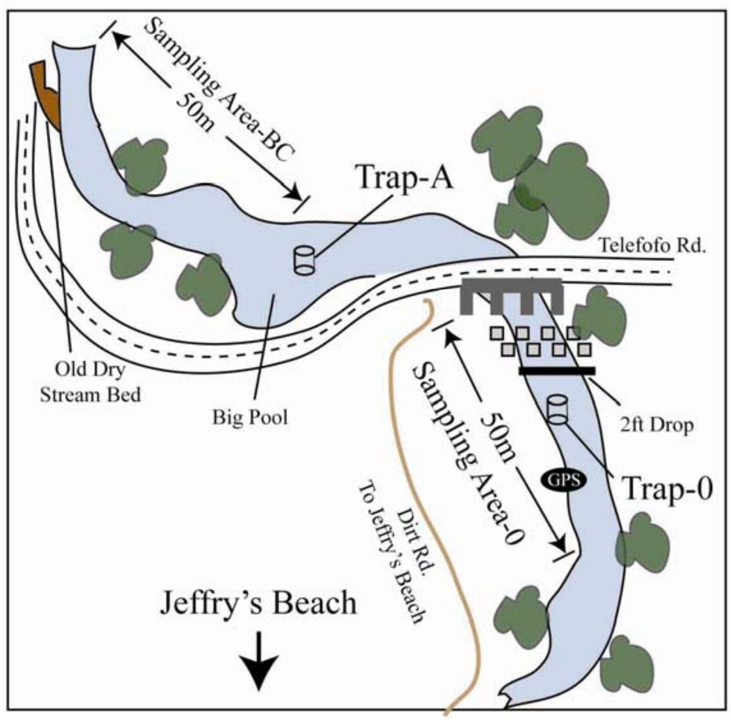
Photo taken - 8/16/08

Site ID - 5a-81608

The sampling site starts at the bridge adjacent to the road leading down to Jeffry's beach, before you reach the Kingfisher Golf Course.

A second diip net sampling was performed just up stream, starting at the top of the big pool.

** Figures not drawn to scale



005b - Tegeta's Stream, Upper

15º13.811 N   145º46.350 W

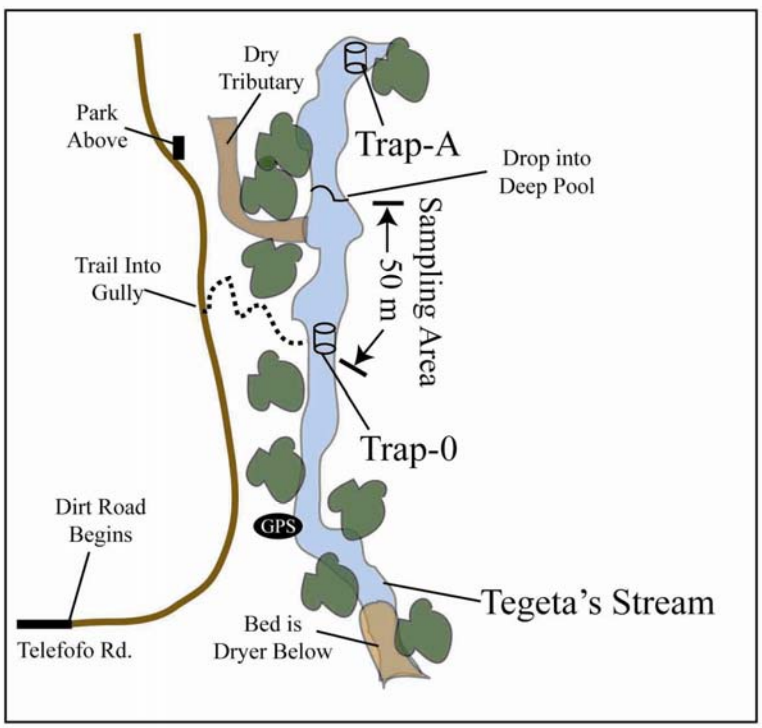
Photo taken - 8/19/08

Site ID - 5b-81908

The sampling site is up from the Kingfisher Gold Course. Follow Telefofo Rd. after it turns to dirt for about 1/4 mile. You will see a trail leading down into the gully on the right.

Park above and hike carefully down. The GPS units mark the bottom of the sample area, the dropoff and dry tributary mark the top.

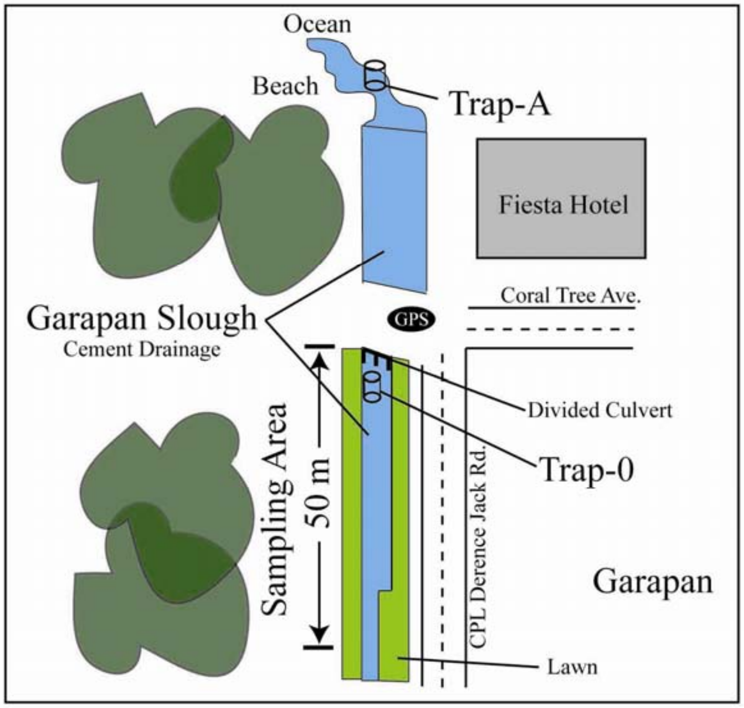
** Figures not drawn to scale



006a - Garapan Slough at Fiesta Hotel

15º12.785 N   145º42.992 W

Photo taken - 8/11/08



Site ID - 6a-81108

The sampling site is just south of the Fiesta Hotel, in the southwest corner of Garapan.

Ocean water flushes up into the slough during high tides and excessive storm drainage flows pass through this system during heavey rains.

** Figures not drawn to scale

006b - Garapan Slough at Hafa Adai Hotel

15º12.493 N   145º42.983 W

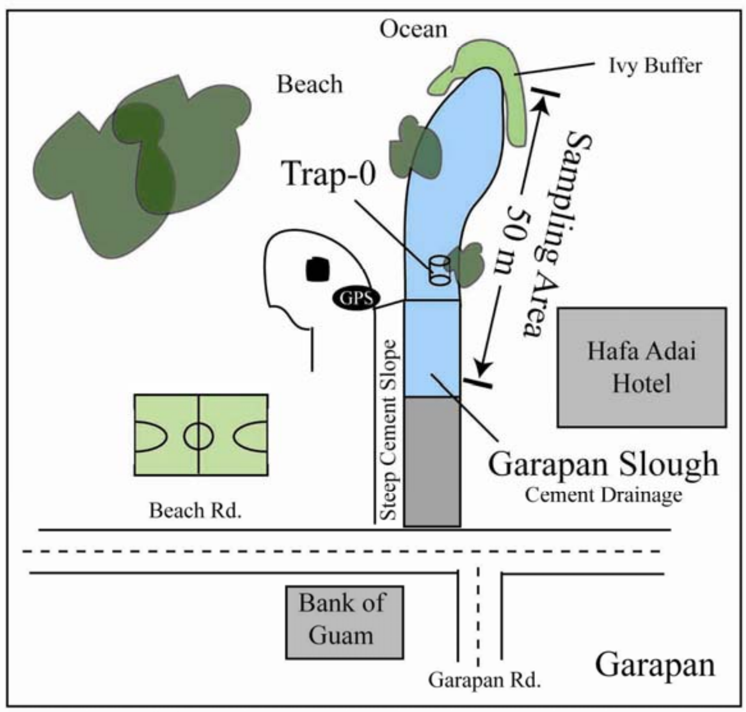
Photo taken - 8/12/08

Site ID - 6b-81208

The sampling site is just south of the Hafa Adai Hotel, just southwest of where Beach Rd. and Garapan Rd. meet.

A sand and Ivy burm prevents interaction with the ocean water unless the tide isvery high or there is a storm water flushing event.

** Figures not drawn to scale



007a - Kagman Mitigation Ditch

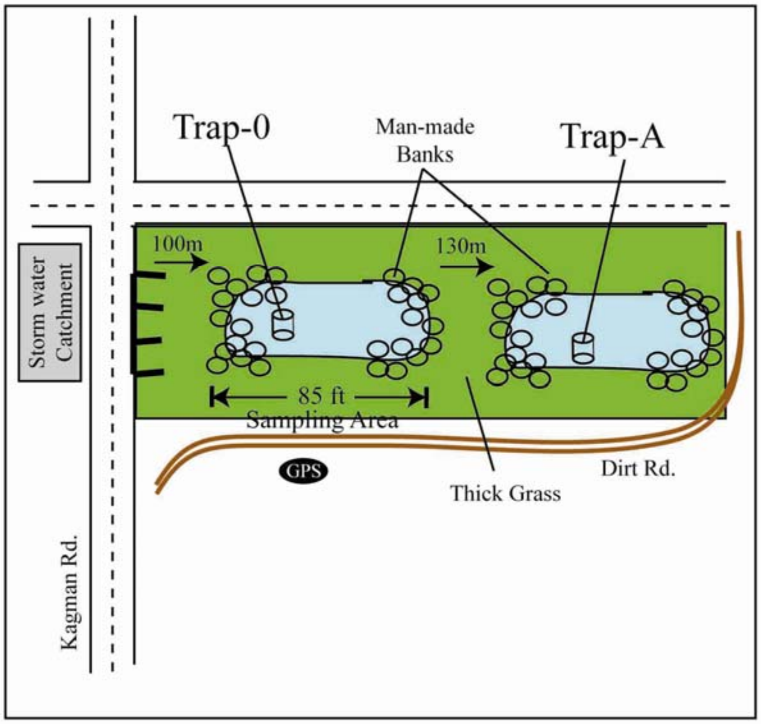
15º10.426 N 145º46.059 W

Photos taken - 8/15/08

Site ID - 7a-81508

The sampling site visible while driving down Kagman Rd. from the Mobile station. It is across from the new cement storm water catchment system.

** Figures not drawn to scale



007b - Kagman Shrine, Upper Sream

15º10.915 N   145º45.828 W

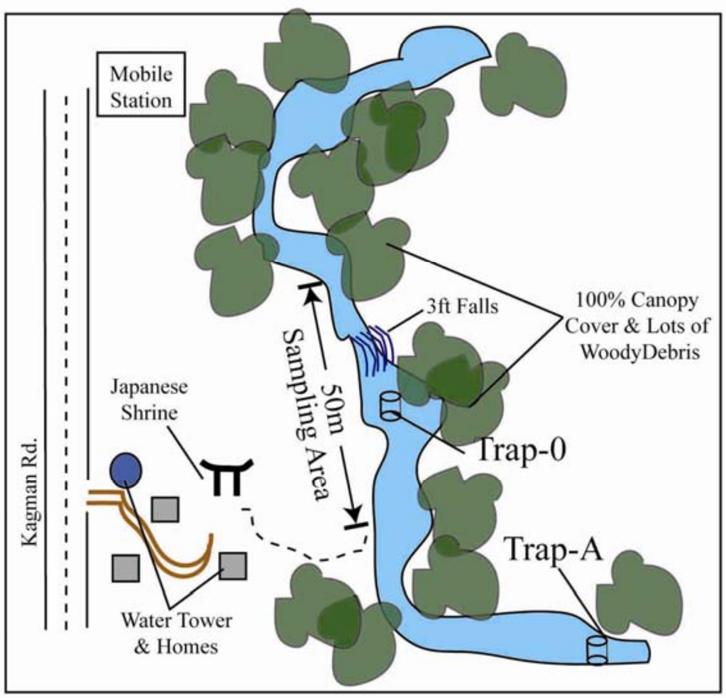
Photos taken - 8/15/08

Site ID - 7b-81408

To reach this sampling site you need to head down Kagman Rd. from the Mobile station and pull in to the first left at the water tank. Then you need to get permission from the land owner before heading down to the Japanese shrine.

From the shrine you head straight down the gully untill you reach the stream. This point marks the bottom of the sampling area.

** Figures not drawn to scale



009a - Lake Susupe

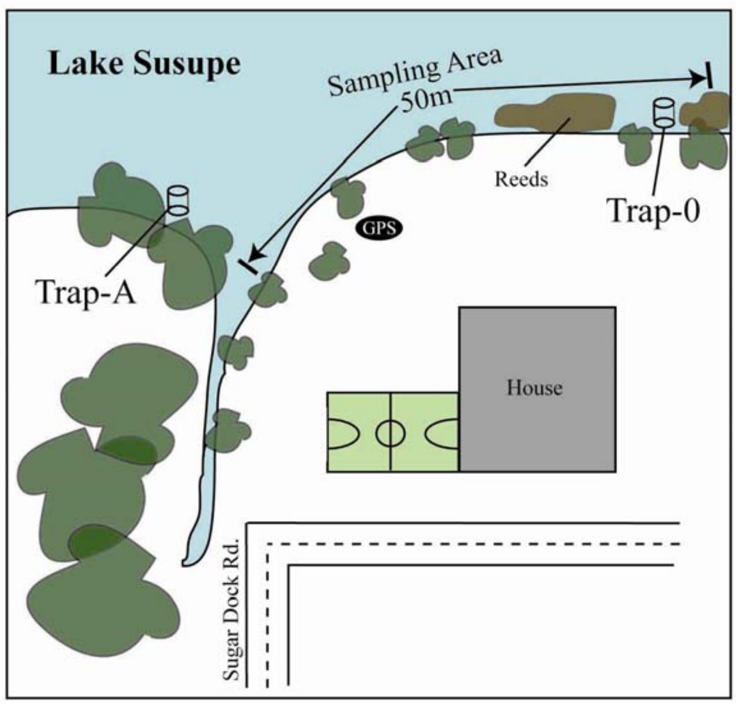
15º09.171 N   145º42.609 W

Photos taken - 8/13/08

Site ID - 9a-81308

Sampling was performed from the front yard of the house situated on the far West side of the lake. From Beach Rd. turn onto Sugar Dock Rd. towards the hills and follow the road until it takes a sharp right. The house is located at the bend in the road.

** Figures not drawn to scale



009b - Costco Marsh

15º10.227 N 145º42.833 W

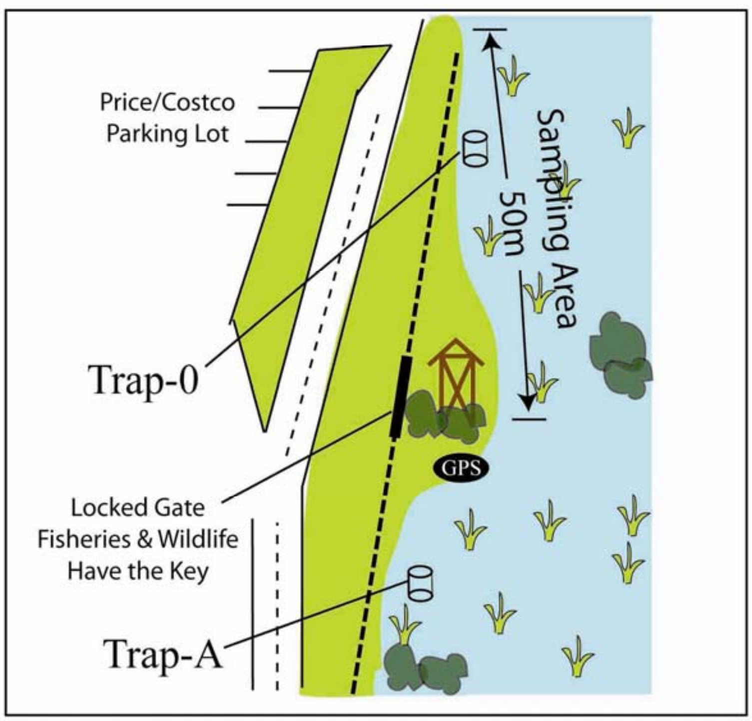
Photos taken - 8/15/08

Site ID - 9b-81508

This sampling site is just across from the Price/Costco parking lot. The sampling area begins just in front of the bird observation tower and extends north for 50 meters.

The dense aquatic plant cover made it difficult to catch any specimens though Tilapia were observed.

** Figures not drawn to scale



011a - COP Golf Course, Pond at Hole #5

15º07.181 N 145º41.785 W

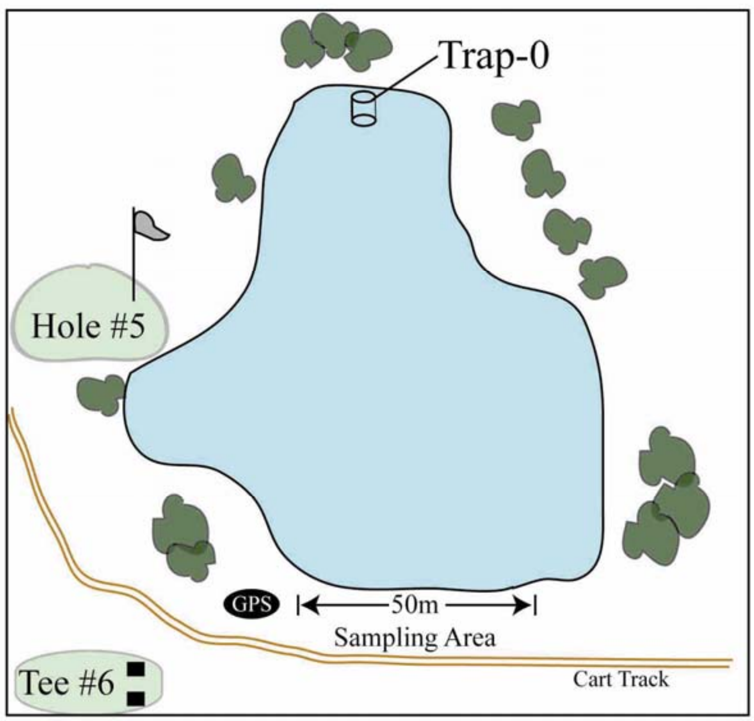
Photos taken - 8/17/08

Site ID - 11a-81708

This sampling site is just south of the green for hole #5 and east of the tee for hole #6, along the bank. The trap was set up across the pond.

The second trap was dropped into the pond between hole #15 and #16. That pond was dominated by very thick algae and very little water.

** Figures not drawn to scale



Appendix E – Source Site Conditions Data

Locality	Identification	Field Number	2a-81808	3a-81808	4a-81308	5a-81408-0	5b-81908	6a-81108
		Date	8/18/2008	8/18/2008	8/13/2008	8/16/2008	8/19/2008	8/11/2008
		Island	Saipan	Saipan	Saipan	Saipan	Saipan	Saipan
		Location	MCC Golf Coarse	DPS Gun Range	Up from Tanapag Elm.	Telefofo	Telefofo	Garapan
		Water Body	Pond	Marsh	Stream	Jeffrys Beach	Tegeta Stream	Drainage at S. of Fiesta
	GPS	Latitude (N)	15 15.750	15 14.27	15 14.183	15 12.970	15 13.811	15 12.785
		Longitude (E)	145 47.690	145 47.373	145 45.798	145 46.772	145 46.350	145 42.992
	Photos	Picture ID #1	2a-81808_MCCGolf-1	3a-81808_DPSRange-1	4a-81308_Tanapag-1	5a-81408-Jeffrys-1	5b-81908_TegetaStream-1	6a-81108_GaraFiesta-1
		Picture ID #2			4a-81308_Tanapag-2	5a-81408-Jeffrys-2	5b-81908_TegetaStream-2	6a-81108_GaraFiesta-2
Site Conditions	Sky	Clear	1					
		Partly Cloudy		1		1		1
		Overcast			1		1	
	Wind	Calm	1	1	1	1	1	1
		Windy						
		Gusty						
	Rain	Dry	1					
		Recent Rain		1	1			
		Currently Raining						
Site Description	Flow Type	Lotic	1	1				
		Lentic			1	1	1	1
	Water Type	Fresh		1	1	1	1	
		Brackish	1					1
		Marine						
	Stream Gradient	Flat	1	1		1		1
		Moderate			1		1	
		High						
	Coverage	Canopy Cover (%)	0	0	75	50	100	0
		Aquatic Plant Cover (%)	75	100	0	0	0	0
	Substrate Type	Natural			1	1	1	
		Man-made	1					1
		Uncertain		1				
	Site Condition	Undisturbed			1		1	
		disturbed		1		1		
		Highly Modified	1					1
	Riparian Buffer	Poor (<3xstream)	1					1
		Good (>3xstream)		1	1	1	1	
	Land Use Observations	Agriculture				1		
		Livestock		1				
		Mining / Quary	1					
		Forestry						
		Roads / Parking Lots		1		1		1
		Industry						1
		Homes						1
		Recreation	1					
		Natural		1	1	1	1	

	Identification	Field Number	2a-81808	3a-81808	4a-81308	5a-81408-0	5b-81908	6a-81108
Sample Location [0]	Clarity	Clear						
		Mostly Cear					1	
		Turbid Brown			1	1		
		Turbid Grey		1				1
		Turbid Green	1					
	Width & Depth	Width (in)	1080 x 3600	1800 x 1800	180	150	72	72est
		R. Bank (in)	12	na	4	5		
		L. Bank (in)	12	na	5	5		
		Middle (in)	38	36+	4	12	3	9
Sample Location [A]	Clarity	Clear						
		Mostly Cear					1	
		Turbid Brown			1	1		
		Turbid Grey		1				1
		Turbid Green	1					
	Width & Depth	Width (in)	1800 x 1800		148	222	122	96est
		R. Bank (in)	1		9	1		
		L. Bank (in)	1		3	1		
		Middle (in)	60+		9	2	8	11
Sample Location [B]	Clarity	Clear						
		Mostly Cear					1	
		Turbid Brown			1	1		
		Turbid Grey		1				1
		Turbid Green	1					
	Width & Depth	Width (in)	1800 x 3600		108	156	96	120est
		R. Bank (in)	12		9	3		
		L. Bank (in)	12		19	2		
		Middle (in)	60+		17	4	5	5
Water Chemistry	YSI Meter	Air Temp.						
		Water Temp.	32.28	29.2	25.84	26.72	25.32	32.62
		pH	7.35	5.9	8.02	7.21	7.04	7.41
		DO	129.3	49.1	79.4	73	38.8	33.3
		Salinity	7.32	0.05	0.21	0.13	0.24	15.5
		Conductivity	12.87	0.117	0.437	0.272	0.507	25.78
Collection Information	Net	Netter #1	JH	JH	JH	MCT	MCT	PJ
		Netter #2	PJ	PJ	PJ	JH	JH	JH
		Time (min each)	30	30	30	30	30	30
	Trap	Trap #1	1	0	1	1	1	1
		Trap #2	1	0	1	1	1	1
		Time (min each)	60	60	60	60	60	65
	Electro-Fishing	Fisher Name	na	PJ	JH	SCM	JH	PH
		Netter #1	na	JH	SM	MCT	MCT	SCM
		Netter #2	na	SCM	PJ	PJ	PJ	PH
		Shock Time (s)	na	175	525	430	274	NA
		Frequency	na	30	30	30	30	30
		Volts	na	400	400	300	200	400
		Duty Cycle	na	30	20	30	30	20
Other	Observations	Notes	Conductivity too high for Electro Fisher. Bigger fish were seen than were caught in dip net or trap. These Tilapia much healthier than COP Golfcourse	Lots of mating toads everywhere. Electro Fishing appeared to work on toads within the water but no other species were stunned.	Beautiful location	Up stream there seemed to be a recent washout and/or channeling that filled the stream with lots of mud	Water chemistry measures perfomed 1 day later (8/20/08)	We didn't know water Chemistry before we tried to Electro Fish. Also, water chemistry changes radically depending on the tide.
	3rd party input	Anecdotal Information	The pond will be fully cleared to remove the bull rush which has begun to clog it.		Eels have been seen in the reaches just above our sampling location by local trail runners (SH3)		A gobbie was spotted but not caught.	

Locality	Identification	Field Number	6b-81208	7a-81508	7b-81408	9a-81308	9b-81508	11a-81708
		Date	8/12/2008	8/15/2008	8/16/2008	8/13/2008	8/15/2008	8/17/2008
		Island	Saipan	Saipan	Saipan	Saipan	Saipan	Saipan
		Location	Garapan, Hafa Day Drainage	Kagman	Kagman Shrine	Lake Susupe	Costco Marsh	Coral Ocean Point Golf Coarse
		Water Body	Channel	Mitigation Ditch	Stream	Lake Susupe	Marsh	Pond (Hole #5)
	GPS	Latitude (N)	15 12.493	15 10.426	15 10.915	15 09.171	15 10.227	15 07.181
		Longitude (E)	145 42.983	145 46.059	145 45.828	145 42.609	145 42.833	145 41.785
	Photos	Picture ID #1	6b-81208_GaraHafa-1	7a-81508_KagDitch-1	7b-81408_KagShrine-1	9a-81308_LSusupe-1	9b-81508_Costco-1	11a-81708_COP-1
		Picture ID #2		7a-81508_KagDitch-2	7b-81408_KagShrine-2	9a-81308_LSusupe-2	9b-81508_Costco-2	11a-81708_COP-2
Site Conditions	Sky	Clear						1
		Partly Cloudy				1	1	
		Overcast	1	1	1			
	Wind	Calm	1	1	1	1	1	
		Windy						1
		Gusty						
	Rain	Dry						
		Recent Rain	1					
		Currently Raining			1			
Site Description	Flow Type	Lotic	1	1		1	1	1
		Lentic			1			
	Water Type	Fresh		1	1	1	1	1
		Brackish	1					
		Marine						
	Stream Gradient	Flat	1	1		1	1	1
		Moderate			1			
		High						
	Coverage	Canopy Cover (%)	25	0	100	50	0	0
		Aquatic Plant Cover (%)	0	0	0	75	100	0
	Substrate Type	Natural			1			
		Man-made	1	1			1	1
		Uncertain				1		
	Site Condition	Undisturbed			1			
		disturbed					1	
		Highly Modified	1	1		1		1
	Riparian Buffer	Poor (<3xstream)	1	1		1	1	1
		Good (>3xstream)			1			
	Land Use Observations	Agriculture		1				
		Livestock		1				
		Mining / Quary						
		Forestry						
		Roads / Parking Lots	1	1			1	
		Industry						
		Homes		1		1	1	
		Recreation	1			1		1
		Natural			1			

	Identification	Field Number	6b-81208	7a-81508	7b-81408	9a-81308	9b-81508	11a-81708
Sample Location [0]	Clarity	Clear			1			
		Mostly Cear					1	
		Turbid Brown	1	1		1		
		Turbid Grey						
		Turbid Green						1
	Width & Depth	Width (in)	109	288	108			5400x5400
		R. Bank (in)	4	4	2	36		na
		L. Bank (in)	6	5	0.5			na
		Middle (in)	4	38	2		16	30
Sample Location [A]	Clarity	Clear			1			
		Mostly Cear	1				1	
		Turbid Brown		1		1		
		Turbid Grey						
		Turbid Green						1
	Width & Depth	Width (in)	128	274	19			2700x2700
		R. Bank (in)	0.25	7	na	11		na
		L. Bank (in)	0.25	7	na			na
		Middle (in)	0.25	41	0.5		6	24
Sample Location [B]	Clarity	Clear			1			
		Mostly Cear					1	
		Turbid Brown				1		
		Turbid Grey						
		Turbid Green						
	Width & Depth	Width (in)			36			
		R. Bank (in)			na	11		
		L. Bank (in)			na			
		Middle (in)			5		14	
Water Chemistry	YSI Meter	Air Temp.						
		Water Temp.	29.45	32.04	26.67	33.03	29.95	34.19
		pH	7.72	8.93	7.88	7.93	7.39	8.97
		DO	66.8	154	98.2	74.9	22.4	141.2
		Salinity	5.71	0.19	0.49	3.25	0.24	3.43
		Conductivity	10.17	0.413	1.006	6.06	0.499	6.388
Collection Information	Net	Netter #1	JH	PJ	JH	PJ	MCT	JH
		Netter #2	PJ	JH	MCT	JH	JH	PJ
		Time (min each)	30	30	30	30	30	30
	Trap	Trap #1	1	1	0	1	1	1
		Trap #2	na	1	0	1	1	1
		Time (min each)	60	60	60	60	60	70
	Electro-Fishing	Fisher Name	na	NA	JH	JH	JH	SM
		Netter #1	na		MCT	SM	SM	JH
		Netter #2	na		PJ	PJ	MCT	PJ
		Shock Time (s)	na		147			30
		Frequency	na		30	30	30	na
		Volts	na		200	400	250	na
		Duty Cycle	na		30	20	30	na
Other	Observations	Notes	Conductivity too high for EF. This channel doesn't appear to connect with the ocean except in extreme weather.	Spot (A) marks the next pool down from the sample site. Nothing was found while netting in there.	Our sampling location could be actively harvested due to the ease of access.	In Fall 07 we attmpted to fish the lake with hook and line on a canoe and had no luck	Caught Tilapia Fall 07 and Saw them in Fall 08, but could not catch any.	Volt 100, Freq 20, D.cyc 30 failed to run, so Cond must be too high. (YSI later revealed high cond.)
	3rd party input	Anecdotal Information	Eels have been seen farther up the channel (across from Round 2) and there are lots of Tilapia and Molleys in that area as well.	We have a photo of a full groan Toad pulled from net location 2.	Fresh water eels have been reported in pools near this stream.	Tarpon, Milkfish and even some type of eel have reportedly been caught in the lake. Red Slider turtles have also been common here recently.	Caught Tilapia Fall 07 and Saw them in Fall 08, but could not catch any.	The fish from this pond seemed unhealthy and their guts split open prior to storage.

Appendix F – Source Lab Data

Locality	Method		Identification			Metrics				Other	
Field Number	Sample Method	Netter	Species Name	Sex	Species Descriptoin	Count	Total Length (mm)	Standard Length (mm)	Body Weight (g)	Notes	Photo ID #1
2a-81808	Dip Net	JH			Small Silver Tilapia	25	approx 25	approx 18	5.7	PR	2a_81808_Tilapia_net1
2a-81808	Dip Net	JH			Cone Snails	10	approx 10		1	PR	2a_81808_Snail_net1
2a-81808	Dip Net	PJ			Small Silver Tilapia	10	approx 25	approx 18	3.5	F	2a_81808_Tilapia_net2
2a-81808	Dip Net	PJ			Cone Snails	2	approx 10		<0.2	F	2a_81808_Snail_net2
2a-81808	Trap 0				Small Silver Tilapia	1	42	33	1.3	F	2a_81808_Tilapia_trap8
2a-81808	Trap 0				Small Silver Tilapia	1	40	29	1.1	F	2a_81808_Tilapia_trap8
2a-81808	Trap 0				Small Silver Tilapia	1	44	34	1.4	F	2a_81808_Tilapia_trap8
2a-81808	Trap 0				Small Silver Tilapia	1	40	30	1.2	F	2a_81808_Tilapia_trap8
2a-81808	Trap 0				Small Silver Tilapia	1	40	29	1.2	F	2a_81808_Tilapia_trap8
2a-81808	Trap 0				Small Silver Tilapia	1	35	25	0.7	F	2a_81808_Tilapia_trap8
2a-81808	Trap B				Small Silver Tilapia	1	52	39	2.3	PR	2a_81808_Tilapia_trap6
2a-81808	Trap B				black Tilapia	1	80	62	8	PR	2a_81808_Tilapia_trap6
2a-81808	Trap B				black Tilapia	1	82	62	8.9	F	2a_81808_Tilapia_trap6
2a-81808	Trap B				black Tilapia	1	66	48	4.8	F	2a_81808_Tilapia_trap6
2a-81808	Trap B				black Tilapia	1	72	52	6	F	2a_81808_Tilapia_trap6
2a-81808	Trap B				black Tilapia	1	52	39	2.3	F	2a_81808_Tilapia_trap6
3a-81808	Dip Net	JH			Bug	1	37		0.7	F	3a_81808_Bug_net
3a-81808	Dip Net	JH			Ramshorn Snail	10	4-15		2.9	F	3a_81808_Ramshorn_net
3a-81808	Dip Net	JH			Ramshorn Snail	All rest			177	F	
3a-81808	Dip Net	PJ			Ramshorn Snail	all			98	F	
4a-81308	Dip Net	PJ			Macrobrachium Shrimp	1	41	12	1.2	F	
4a-81308	Dip Net	PJ			Macrobrachium Shrimp	1	34	10	0.8	F	
4a-81308	Dip Net	PJ			Smaller shrimp (red heads)	8	17-24	5-7	1.9	F	
4a-81308	Dip Net	JH			Macrobrachium Shrimp	1	66	22	7.2	F	
4a-81308	Dip Net	JH			Macrobrachium Shrimp	1	46	15	2.2	F	
4a-81308	Dip Net	JH			Macrobrachium Shrimp	1	29	8	0.5	F	
4a-81308	Dip Net	JH			Macrobrachium Shrimp	1	28	7	0.4	F	
4a-81308	Dip Net	JH			Smaller shrimp (red heads)	13	13-26	4-7	1.5	F	
4a-81308	Trap B				Macrobrachium Shrimp	1	45	15	2	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	82	26	13.2	PR	81308_4a_shrimp_sp1
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	61	17	4.1	F	81308_4a_shrimp_sp1
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	57	18	5.1	PR	81308_4a_shrimp_sp1
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	60	18	4.4	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	66	20	5.8	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	62	21	5.3	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	51	15	3.6	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	53	17	3.2	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	55	17	3.9	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	31	8	0.7	F	
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	42	12	1.6	F	81308_4a_shrimp_sp2
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	37	11	1.1	F	81308_4a_shrimp_sp2
4a-81308	Electro Fish	SCM, PJ			Macrobrachium Shrimp	1	31	10	0.6	F	81308_4a_shrimp_sp2
4a-81308	Electro Fish	SCM, PJ			Smaller shrimp (red heads)	14	18-26	4-6	2.2	PR	81308_4a_shrimp_sp3
5a-81408-0	Trap 0										
5a-81408-0	Trap A										
5a-81408-0	Dip Net	MCT			Macrobrachium	1	14	46	2.4	F	81408_5a_Shrimp-Net0_sp1
5a-81408-0	Dip Net	MCT			Macrobrachium	1	14	47	2.4	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	13	45	1.8	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	13	41	1.5	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	14	45	1.5	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	12	40	1.4	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	11	35	1.1	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	10	30	0.5	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	8	25	0.4	F	
5a-81408-0	Dip Net	MCT			Macrobrachium	1	6	24	0.3	F	
5a-81408-0	Dip Net	JH			Tiny Shrimp	3		<5			81408_5a_Shrimp-Net0_sp3
5a-81408-0	Dip Net	JH			small fish	1	35	29	0.4	F	81408_5a_Net0-Gobie-1
5a-81408-0	Dip Net	JH			Macrobrachium	1	16	54	2	F	
5a-81408-0	Dip Net	JH			Macrobrachium	1	12	40	1.3	F	
5a-81408-0	Dip Net	JH			Macrobrachium	1	11	39	1.4	F	
5a-81408-0	Dip Net	JH			Macrobrachium	1	13	41	1.4	F	

5a-81408-0	Dip Net	JH		Macrobrachium	1	15	44	1.1	F	
5a-81408-0	Dip Net	JH		Macrobrachium	1	9	31	0.6	F	
5a-81408-0	Dip Net	JH		Macrobrachium	1	6	21	0.2	F	
5a-81408-0	Dip Net	JH		Macrobrachium	1	11	32	0.6	F	
5a-81408-0	Dip Net	JH		Macrobrachium	1	5	20	0.2	F	
5a-81408-0	Dip Net	JH		Little Red Shrimp	1	6	22	0.2	F	
5a-81408-0	Dip Net	JH		Little Red Shrimp	1	5	21	0.1	F	
5a-81408-0	Electro Fish	MCT, PJ	kuhlia Repestris	Rock Flagtail	1	22	19	<0.1	F	81608_5a_EF_Flagtail-1
5a-81408-0	Electro Fish	MCT, PJ	kuhlia Repestris	Rock Flagtail	1	22	18	<0.1	F	
5a-81408-0	Electro Fish	MCT, PJ		Gobbie	1	40	32	0.6	PR	81608_5a_Gobie-Ef0
5a-81408-0	Electro Fish	MCT, PJ		Gobbie	1	45	36	0.7	PR	
5a-81408-0	Electro Fish	MCT, PJ		Gobbie	1	42	31	0.5	PR	
5a-81408-0	Electro Fish	MCT, PJ		Gobbie	1	34	28	0.2	F	
5a-81408-0	Electro Fish	MCT, PJ		Gobbie	1	38	31	0.4	gut open)	
5a-81408-0	Electro Fish	MCT, PJ		Gobbie	1	35	27	0.3	gut open)	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	25	70	9.2	PR	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	25	69	7.9	F	81408_5a_shrimp_All-EF0
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	19	61	5.3	F	81408_5a_shrimp_Big-EF0
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	21	69	6.9	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	20	65	6.8	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	15	47	2.9	PR	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	19	56	4.3	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	15	52	3.2	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	18	54	3.8	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	13	49	3	F	81408_5a_shrimp_Mid-EF0
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	14	45	2.7	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	18	55	2.9	mooshed)	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	16	50	2.9	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	15	46	2.5	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	15	50	3	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	16	54	3.9	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	15	45	2.2	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	14	43	2.2	F	81408_5a_shrimp_SM-EF0
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	13	41	1.7	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	15	46	2.3	PR	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	13	42	1.7	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	13	42	1.6	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium	1	14	45	2	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium (medium)	18	<13	<46	28.3	F	
5a-81408-0	Electro Fish	MCT, PJ		Macrobrachium (small)	14	<10	<35	9.9	F	
5a-81408-0	Electro Fish	MCT, PJ		Little Red Shrimp	3	<8	<25	0.4	F	81408_5a_shrimp_SM-EF0-Sp2
5a-81408-BC	Dip Net	PJ		Macrobrachium	1	13	42	1.7	F	
5a-81408-BC	Dip Net	PJ		Macrobrachium	1	12	42	1.9	F	
5a-81408-BC	Dip Net	PJ		Macrobrachium	1	11	37	1.3	F	
5a-81408-BC	Dip Net	PJ		Macrobrachium	1	12	44	1.6	F	
5a-81408-BC	Dip Net	PJ		Macrobrachium	1	10	31	0.7	F	
5a-81408-BC	Dip Net	PJ		Macrobrachium	1	10	31	0.4	F	
5a-81408-BC	Dip Net	PJ		Macrobrachium	4	<10	<30	0.7	F	
5a-81408-BC	Dip Net	JH		Macrobrachium	1	17	51	3.4		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	15	49	2.5		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	15	42	2		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	13	44	1.6		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	13	42	1.5		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	14	42	1.1		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	11	36	0.9		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	10	36	0.7		
5a-81408-BC	Dip Net	JH		Macrobrachium	1	10	32	0.6		
5a-81408-BC	Dip Net	JH		Macrobrachium	10	<10	<30	3		
5b-81908	Dip Net	MCT		Macrobrachium	1	35	92	16.7	F	81908_5b_Shrimp1_Net1
5b-81908	Dip Net	MCT		Macrobrachium	1	24	74	10.9	F	81908_5b_Shrimp1_Net1
5b-81908	Dip Net	MCT		Macrobrachium	1	21	65	7.4	F	81908_5b_Shrimp1_Net1
5b-81908	Dip Net	MCT		Macrobrachium	1	19	54	4.2	F	81908_5b_Shrimp2_Net1
5b-81908	Dip Net	MCT		Macrobrachium	1	17	52	3.3	F	81908_5b_Shrimp2_Net1
5b-81908	Dip Net	MCT		Macrobrachium	1	16	50	3.2	F	81908_5b_Shrimp2_Net1
5b-81908	Dip Net	MCT		Macrobrachium (sm	26	<10	<30	8.8	F	81908_5b_Shrimp3_Net1

5b-81908	Dip Net	MCT			Small red shrimp	30	<8	<20	3.8	F	81908_5b_Shrimp4_Net1
5b-81908	Dip Net	MCT			Small red shrimp	**70**	<8	<20	8.9	**erpolated #)**	
5b-81908	Dip Net	JH			Macrobrachium	1	22	62	6	F	
5b-81908	Dip Net	JH			Macrobrachium	1	15	47	2.7	F	
5b-81908	Dip Net	JH			Macrobrachium	1	16	49	3.2	F	
5b-81908	Dip Net	JH			Macrobrachium	1	12	36	1.2	F	
5b-81908	Dip Net	JH			Macrobrachium (sm	11	<10	<30	3.2	F	
5b-81908	Dip Net	MCT			Small red shrimp	**44**	<8	<20	5.6	**erpolated #)**	
5b-81908	Trap 0				Macrobrachium	1	25	74	10.1	F	
5b-81908	Trap 0				Macrobrachium	1	21	65	6.6	F	
5b-81908	Trap 0				Macrobrachium	1	19	60	5.3	F	
5b-81908	Trap 0				Macrobrachium	1	18	52	3.2	F	
5b-81908	Trap 0				Macrobrachium	1	15	37	1.7	F	
5b-81908	Trap 0				Macrobrachium	1	14	41	1.7	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	37	103	27.2	PR	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	28	81	14.7	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	25	77	13.1	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	25	79	11.3	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	24	72	9.5	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	20	64	5.9	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	22	67	7.2	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	22	65	5.9	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	27	77	9.7	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	22	69	8.4	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	22	68	7.7	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	27	70	7.4	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	19	60	5.4	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	22	70	7.5	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	20	56	4.1	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	19	55	3.6	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	17	50	3.2	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	20	59	4	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	17	51	3	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	19	56	3.9	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	14	45	1.9	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	14	44	1.8	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	13	41	1.5	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	14	43	1.8	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	10	35	1	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	12	39	1.2	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	10	32	0.9	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	14	42	1.5	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	1	11	39	1.2	F	
5b-81908	Electro Fish	MCT, PJ			Macrobrachium	29	<10	<35	11.1	F	
5b-81908	Electro Fish	MCT, PJ			Small red shrimp	50	<5	<20	5.6	PR	
5b-81908	Electro Fish	MCT, PJ			Small red shrimp	**468**	<5	<20	52.4	**erpolated #)**	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	71	54	4.2	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	56	44	2.4	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	87	66	7.8	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	71	55	4.3	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	74	53	4.6	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	74	56	4.9	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	55	43	2	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	59	45	2.7	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	64	50	2.9	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	61	45	2.7	F	
6a-81108	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	50	39	1.6	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	61	50	3.6	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	64	51	3.9	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	57	45	2.5	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	71	59	5.2	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	66	55	4.2	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	57	46	2.9	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	54	43	2	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	67	54	4.7	F	

6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	62	48	3.3	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	1	60	47	3.2	F	
6a-81108	Trap 0		Poecilla latpinna	f	Sailfin Molley	8	60ish	45ish	19.1	F	
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	55	42	2.4	F	
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	47	38	1.2	F	
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	48	37	1.2	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	27			23.8	re Females than males???)	
6a-81108	Dip Net				Tilapia	1	118	91	31.8	P	81108_6a_Tilapia_net
6a-81108	Dip Net				Tilapia	1	88	76	13	P	
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	63	51	3.3	P	81108_6a_Molley_net
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	70	55	4.6	F	
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	69	56	3.9	F	
6a-81108	Dip Net		Poecilla latpinna	m	Sailfin Molley	1	37	30	0.5	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	62	51	4.1	P	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	61	51	3.7	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	56	45	2.4	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	61	48	3.1	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	57	48	3.2	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	50	38	1.9	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	51	41	1.8	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	45	37	1.3	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	45	36	1.4	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	1	41	31	1.1	F	
6a-81108	Dip Net		Poecilla latpinna	f	Sailfin Molley	30	<40	<30	17.5	F	
6a-81108	Dip Net				Juv. Milk??	1	33	24	0.3	P	81108_6a_JuvmilkQ_net
6a-81108	Dip Net				Juv. Milk??	1	35	25	0.3	F	
6b-81208	Trap 0		Megalops Cyprinoides		silver and robust	1	151	112	32.1	PR	6b_81208_tarpon_trap
6b-81208	Trap 0		Chanos chanos		silver and streamlined	1	89	65	5.2	PR	6b_81208_milkfish_trap
6b-81208	Trap 0		Chanos chanos		silver and streamlined	1	93	68	6.3	PR	6b_81208_milkfish_trap
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	76	56	5.2	PR	6b_81208_sailfin-M2_trap
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	91	65	8.6	PR	6b_81208_sailfin-M1_trap
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	75	54	4.8	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	79	57	6.1	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	65	48	4	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	59	44	3	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	65	47	3.8	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	67	49	4	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	70	50	3.9	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	65	47	3.7	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	67	50	3.9	F	
6b-81208	Trap 0		Poecilla latpinna	m	Sailfin Molley	1	59	44	3	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	53	41	2.8	PR	6b_81208_sailfin-F1_trap
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	73	56	5.8	PR	6b_81208_sailfin-F2_trap
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	61	50	3.4	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	61	48	4	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	67	50	4.7	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	68	52	4.7	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	71	56	5.6	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	60	48	3.5	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	59	46	3.1	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	75	58	6.6	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	60	46	3.9	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	55	43	3	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	59	46	3.5	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	58	45	2.8	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	58	44	3.2	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	61	50	3.6	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	60	49	3.5	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	59	45	3.5	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	60	47	3.9	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	55	43	2.9	F	
6b-81208	Trap B		Poecilla latpinna	f	Sailfin Molley	1	56	42	2.8	F	
6b-81208	Dip Net	PJ	Megalops Cyprinoides		Indo Pacific Tarpon	1	152	109	35.2	F	
6b-81208	Dip Net	PJ	Chanos chanos		Milkfish	1	96	66	7.4	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	60	48	3.4	F	

6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	64	52	4	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	61	49	3.1	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	69	55	4.5	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	60	47	3	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	64	50	3.6	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	52	44	2.7	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	51	41	2	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	56	46	2.6	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	1	59	46	2.8	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	m	Sailfin Molley	8			24.3	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	62	48	3.8	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	62	49	4.2	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	56	45	3	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	55	45	2.8	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	55	44	3.2	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	54	44	2.6	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	59	50	3.8	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	59	48	3.3	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	42	34	1.2	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	49	35	2	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	1	55	47	3	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	f	Sailfin Molley	25	45-55	35-50	73.3	F	
6b-81208	Dip Net	PJ	Poecilla latpinna	j	Sailfin Molley	17	<35	<27	10.4	F	
6b-81208	Dip Net	PJ			Cone snail	1	<10		na	F	
6b-81208	Dip Net	JH	Chanos chanos		Milkfish	1	90	66	5.2	F	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	36	30	0.5	PR	6b_81208_JuvMilkQ_net
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	32	26	0.3	PR	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	35	28	0.4	PR	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	38	32	0.5	PR	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	33	18	0.3	PR	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	32	15	0.3	F	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	32	15	0.2	F	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	35	30	0.4	F	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	34	26	0.4	F	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	35	27	0.4	F	
6b-81208	Dip Net	JH			Silver, Juv Milk ?	1	33	27	0.4	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	69	54	4.1	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	62	49	3.1	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	62	49	3.3	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	62	49	3.3	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	50	40	1.6	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	58	48	2.3	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	67	55	3.7	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	56	47	2.7	F	
6b-81208	Dip Net	JH	Poecilla latpinna	m	Sailfin Molley	1	56	47	2.6	F	
6b-81208	Dip Net	JH	Poecilla latpinna	f	Sailfin Molley	1	55	45	239	F	
6b-81208	Dip Net	JH	Poecilla latpinna	f	Sailfin Molley	1	57	46	3.1	F	
6b-81208	Dip Net	JH	Poecilla latpinna	f	Sailfin Molley	1	51	42	2.2	F	
6b-81208	Dip Net	JH	Poecilla latpinna	f	Sailfin Molley	1	50	40	1.9	F	
6b-81208	Dip Net	JH	Poecilla latpinna	f	Sailfin Molley	1	55	44	2.9	F	
6b-81208	Dip Net	JH	Poecilla latpinna	f	Sailfin Molley	28	55	45	87.5	F	
6b-81208	Dip Net	JH	Poecilla latpinna	j	Sailfin Molley	59	<40	<35	33.9	F	
6b-81208	Dip Net	JH			Cone Snail	1	<5		na	F	
7a-81508	Dip Net				Tad Pole	16	<15			F	
7a-81508	Dip Net				Bug	3	15			FP	81508_7a_bugs1_net2
7a-81508	Dip Net				Tad Pole	10	<10			F (decomposing)	
7a-81508	Dip Net				Bug1	1	15			P	81508_7a_bugs1_net1
7a-81508	Dip Net				Bug2	1	13			P	
7a-81508	Dip Net				Bug3	1	10			P	
7a-81508	Dip Net				Bug4	7	<5			P	81508_7a_bug2_net1
7b-81408	Dip Net	MCT			Little Red Shrimp	All	<15	<5	10.6	F	
7b-81408	Dip Net	MCT			Cone shape Snail	1	37	na	na	PR	
7b-81408	Dip Net	MCT			Cone shaped sp2	1	11	na	na	PR	7b_81408_snail_sp4_net
7b-81408	Dip Net	JH			Macrobrachium Shrimp	1	31	9	0.7	F	
7b-81408	Dip Net	JH			Little Red Shrimp	All	<15	<5	15.2	F	

7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	60	19	5.2	PR	7b_81408_shrimp_sp1_ef
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	60	19	4.8	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	55	18	3.9	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	59	19	4.8	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	56	20	4.6	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	50	16	3	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	44	14	2	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	44	15	1.8	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	45	14	2.2	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	45	14	2.1	F	
7b-81408	Electro Fishing	MCT, PJ		Macrobrachium Shrimp	1	29	9	0.6	F	
7b-81408	Electro Fishing	MCT, PJ		Little Red Shrimp	30	<15	<5	3.7	F	7b_81408_shrimp_sp2_ef
7b-81408	Electro Fishing	MCT, PJ		Little Red Shrimp	All rest	<15	<5	21.4	F	
9a-81308	Trap 0			Tilapia	1	70	55	6.5	PR	81308_9a_Tilapia_sp2-trap
9a-81308	Trap 0			Tilapia	1	70	54	6.7	PR	81308_9a_Tilapia2_sp2-trap
9a-81308	Trap 0			Tilapia	1	59	45	3.2	F	
9a-81308	Trap 0			Tilapia	1	50	40	2.2	F	
9a-81308	Trap 0			Tilapia	1	43	34	1.2	F	
9a-81308	Trap 0			Tilapia	1	47	36	1.6	F	
9a-81308	Trap 0			Tilapia	1	40	33	1.4	F	
9a-81308	Trap 0			Tilapia	1	42	32	1.3	F	
9a-81308	Trap 0			Tilapia	1	42	33	1.2	F	
9a-81308	Trap 0			Tilapia	1	36	28	0.8	F	
9a-81308	Trap 0			Tilapia	1	40	32	1	F	
9a-81308	Trap 0			Tilapia	1	39	30	1.1	F	
9a-81308	Trap 0			Tilapia	1	39	30	0.9	F	
9a-81308	Trap 0			Tilapia	1	39	30	0.9	F	
9a-81308	Trap 0		m	Sailfin Molly	1	52	40	1.4	F	
9a-81308	Trap 0		f	Sailfin Molly	1	50	38	1.9	F	
9a-81308	Dip Net	PJ		Mosquito Fish	1	31	28	0.4	PR	81308_9a_Mosqfish_net
9a-81308	Dip Net	PJ		Mosquito Fish	1	31	28	0.2	PR	
9a-81308	Dip Net	PJ		Mosquito Fish	1	30	28	0.3	R	
9a-81308	Dip Net	PJ		Mosquito Fish	1	32	28	0.3	PR	
9a-81308	Dip Net	PJ		Mosquito Fish	21	<30	<28	2.7	F	
9a-81308	Dip Net	PJ		Cone Snails	6	<7			F	81308_9a_Snail_sp2_net
9a-81308	Dip Net	PJ		Little Red head Shrir	24	<15	<5	2.5	PR	81308_9a_Shrimp_sp4_net
9a-81308	Dip Net	PJ		Apple Snail	32			empty	F	81308_9a_Applesnail2_net
9a-81308	Dip Net	PJ		Tilapia	1	52	43	1.9	F	
9a-81308	Dip Net	PJ		Tilapia	5	<30	<25	1.5	F	
9a-81308	Dip Net	JH		Tilapia	1	60	46	3	F	
9a-81308	Dip Net	JH		Tilapia	1	42	32	0.9	F	
9a-81308	Dip Net	JH		Tilapia	6	<40	30	3.4	F	
9a-81308	Dip Net	JH		Little Red head Shrir	21	<15	<5	3.2	F	
9a-81308	Dip Net	JH		Mosquito Fish	122	<30	<25	15.4	F	
9a-81308	Dip Net	JH		Ram Snail	2	<5			F	
9a-81308	Dip Net	JH		Cone Snails	62	<10		3.4	F	
9b-81508	Dip net			Apple Snail	1		30	11.1	PR	81508_9b_Applesnail_net
9b-81508	Dip net			Mixed Snails	14		<5	0.7	PR	81508_9b_Snail_Sp1-Sp2
9b-81508	Dip net			Tad Poles	4		<25	0.2	F	81508_9b_tadpoles_net
9b-81508	Dip net			Bug	1		<10		F	81508_9b_bug_sp1_net
9b-81508	Dip net			Bug	1		<10		F	
9b-81508	Dip net			Ram Snail	3		<10		PR	
9b-81508	Dip net			Snail	5		<10	0.2	PR	81508_9b_Snail_Sp3_net
9b-81508	Dip net			Apple Snail	1		30	empty	F	
9b-81508	Dip net			Apple Snail	1		25	5.3		
9b-81508	Dip net			Apple Snail	1		33	10.2	PR	
11a-81708	Trap 0			Tilapia	1	55	42	2.6	PR	81708_11a_tilapia_sp4
11a-81708	Trap 0			Tilapia	1	50	39	1.9	PR	81708_11a_tilapia_sp4
11a-81708	Trap 0			Tilapia	1	46	33	1.6	PR	81708_11a_tilapia_sp4
11a-81708	Trap 0			Tilapia	1	47	34	1.6	F	
11a-81708	Trap 0			Tilapia	1	46	35	1.4	F	
11a-81708	Trap 0			Tilapia	1	49	37	1.8	F	
11a-81708	Trap 0			Tilapia	1	45	33	1.3	F	
11a-81708	Trap 0			Tilapia	1	49	35	1.3	, no gut	
11a-81708	Trap 0			Tilapia	1	49	35	1.7	, no gut	

11a-81708	Trap 0			Tilapia	1	48	35	1.6	, no gut	
11a-81708	Trap 0			Tilapia	1	49	36	1.7	, no gut	
11a-81708	Trap 0			Tilapia	1	48	34	1.2	, no gut	
11a-81708	Dip Net	PJ		Tilapia	1	38	29	0.8	F	
11a-81708	Dip Net	JH		Tilapia	1	104	81	14.5	PR	81708_11a_Tilapia_sp1
11a-81708	Dip Net	JH		Tilapia	1	90	68	9.9	F	
11a-81708	Dip Net	JH		Tilapia	1	65	50	5.6	F	
11a-81708	Dip Net	JH		Tilapia	1	58	43	2.4	F	81708_11a_Tilapia_sp2
11a-81708	Dip Net	JH		Tilapia	1	58	42	2.3	F	81708_11a_Tilapia_sp2
11a-81708	Dip Net	JH		Tilapia	1	60	44	3.2	F	81708_11a_Tilapia_sp2
11a-81708	Dip Net	JH		Tilapia	1	45	35	1.6	F	81708_11a_Tilapia_sp3
11a-81708	Dip Net	JH		Tilapia	1	42	33	1.1	, no gu	81708_11a_Tilapia_sp3
11a-81708	Dip Net	JH		Tilapia	1	44	32	1.4	, no gu	81708_11a_Tilapia_sp3

Appendix G – FWS-FIS2C01 Principles & Techniques of Electrofishing

Offered to CNMI Fisheries through the USFWS via the DOI LEARN Management Portal.

Online course details as of 2/17/2009:

FWS-FIS2C01 Principles & Techniques of Electrofishing

Vendor Information: LCMS (FWS-FIS2C01)

Course Code: FWS-FIS2C01

Duration: 24 H

Instructor/Technician: ROXANNE MAY (roxanne_may@fws.gov)

Course Description: This course illustrates how basic principles of electricity are applied to improve electrofishing results. The goals of this course are to (1) present a framework for increasing the efficiency and standardization of electrofishing through a working knowledge of electric circuit and field theory, power transfer and standardization, system components, gear types, electrode design, and sampling considerations, (2) provide safety training, and (3) promote the awareness of and methods to minimize electrofishing-induced fish trauma. Other knowledge/skills gained include the ability to make simple trouble-shooting checks, estimate capabilities of equipment, understand equipment power output characteristics, compensate for the effects of water conductivity on catchability and battery discharge time, and plan experiments to determine effective waveforms and power required for capturing specific species and size classes.

Categories: Natural Resource Management , Online Training Course

Course Objectives: Second Contact: Alan Temple(304)876-7440

Course Tuition: $0

Prerequisite Courses: None

Appendix H – Bishop Museum gene sequence report

PRELIMINARY REPORT

Confirming the identification of freshwater invasive fish species from CNMI using molecular analysis

Prepared for:
Division of Fish and Wildlife
Saipan
Commonwealth of the Northern Mariana Islands

Prepared by:
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[1]Pacific Biological Survey
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December, 2009
Contribution No. 2009-00? to the Pacific Biological Survey

Confirming the identification of freshwater invasive fish species from CNMI using molecular analysis

Introduction

It has long been recognized that DNA sequence diversity can be used to discriminate between species. Recent efforts have focused on developing a database of a single gene sequence, the mitochondrial gene cytochrome *c* oxidase subunit 1 (CO1), which is believed sufficient to differentiate the vast majority of animal species (e.g., Hebert *et al*., 2003; Ward, *et al.*, 2005). This process is commonly referred to as barcoding. The mitochondrial cytochrome *b* (cyt*b*) gene has frequently been used in molecular phylogeny studies, and can also be used for species identification (e.g., Parson *et al*., 2000, Hsieh *et al*., 2001, Tobe *et al*., 2009). GenBank (http://www.ncbi.nlm.nih.gov/Genbank/) is the NIH genetic sequence database, consisting of more than 100 billion publicly available DNA sequences. This resource can be used to search for DNA sequences similar to that of an unknown specimen using *blast* algorithms.

Very little is known of the species that inhabit the freshwater habitats of the CNMI. An extensive survey of freshwater interstitial streams on Saipan (McKagan et al., 2008) found seven native species and eight species of introduced fish, but were unable to confirm the identification of many of the species due to their size and morphological similarity between species. Here we use molecular barcoding techniques to help with species identification.

Materials and Methods

Sample collection

Samples were collected from freshwater systems on Saipan, CNMI (McKagan *et al*., 2008), frozen, and transported to the Pacific Center for Molecular Biodiversity, Bishop Museum for processing (Table 1). Upon thawing, muscle tissue was sampled and preserved in a salt-saturated solution of 20% dimethyl sulfoxide-EDTA (DMSO). Voucher specimens have been temporarily stored at -20C. Voucher DNA and tissues are housed at -80C in the Pacific Center for Molecular Biodiversity, Bishop Museum (PCMB 4840-4877).

DNA Extraction

Genomic DNA was extracted from approximately 25 mg DMSO-preserved muscle tissues using a DNeasy Blood and Tissue Kit (Qiagen Inc.) following the recommended protocol. The complete mitochondrial cytochrome *b* (cyt*b*) gene (approx. 1,200 bp) of each sample was amplified via polymerase chain reaction (PCR) using the primers GLU-L 5'TGA TAT GAA AAA CCA TCG TTG-3' (Palumbi *et al*., 1991) and H15915 5'-ACC TCC GAT CTY CGG ATT ACA AGA-3' (Aoyama *et al*., 2001). Approximately 655bp were amplified from the 5' region of the cytochrome *c* oxidase subunit 1 (CO1) gene were amplified via PCR using the primers FishF1 5'-TCA ACC AAC CAC AAA GAC ATT GGC AC-3' and FishR1 5'-TAG ACT TCT GGG TGG CCA AAG AAT CA-3' or FishR2 5'-ACT TCA GGG TGA CCG AAg AAT CAG AA-3' for samples PCMB 4848 and 4874 (Ward *et al*., 2005). Reactions were performed in a 50 μL solution containing 10 ng genomic DNA, 400 μM of each dNTP, 1.5 units Taq DNA polymerase (D4545, Sigma Chemical), 2 mM $MgCl_2$, each primer at 1 μM, and 1x PCR buffer. PCR cycling parameters were 94 C (1 min), 50 C (1 min), and 72 C (1 min) repeated for 35 cycles with a final extension of 72 C (5 min). PCR product was gel extracted using QIAQuick Gel Extraction Kit (Qiagen Inc.). Cycle sequencing of

100 fmol double-stranded PCR product was carried out with the forward primer (GLU-L) for cyt*b*, and both the forward and reverse primers for COI using a CEQ DTCS Quick Start Kit (Beckman-Coulter) following the recommended protocol. The products sequenced on a CEQ8000 genetic analysis system. Sequence data were subjected to nucleotide megablast (high similarity) search (http://www.ncbi.nlm.nih.gov/BLAST/) in order to identify the best taxon match for the resultant sequence for each specimen.

Results & Discussion:

Five of the specimens had 99-100% match for both the cytb and COI sequences within GenBank, namely PCMB 4840, 4846 and 4847 (Chanos chanos), PCMB 4842 (Eliotris acanthopoma), PCMB 4845 (Megalops cyprinoides), and PCMB 4848 (Gambusia affinis) (Table 1). PCMB 4841, preliminarily identified only as a Goby, had a 98% (cytb) and 99% identity with Genbank sequences for Stiphodon elegans Appendix 1). Stiphodon elegans and Megalops cyprinoides have been previously reported as native to the CNMI (McCagan et al., 2008). Chanos chanos and Gambusia affinis are introductions to the CNMI, and have been previously recorded from the islands. Eleotris acanthopoma, is recorded as native to Guam, Palau, and the Western Pacific (FishBase, 2009), and would be expected to also be native in Saipan's freshwater ecosystems.

Specimens PCMB 4846 and 4847 were originally identified as a mullet species (Table 1). Molecular analysis, however, determined the two specimens to be Chanos chanos, and a secondary inspection of morphological characters of the voucher specimens indicated that while the specimens superficially resembled mullets, they lacked the diagnostic characteristics of the Mugilidae (A. Suzumoto, pers. comm., 2009).

Specimens PCMB 4859 and 4866 were preliminarily identified as Poecilia reticulata (Table 1). Both specimens had identical cytb and COI sequence data, and this confirmed the samples to be species in the genus Poecilia. However, no match to species level could be confirmed, most likely due to an absence of sequence data for the unknown species having been submitted to GenBank. COI and cytb sequence data were available for Poecilia reticulata, but the Saipan specimens had significantly different sequence data (see Appendix 2).

The three tilapia species identified in this study were Oreochromis species (Table 1, Appendix 3). Two of the three species had 100% match for the COI gene as Oreochromis mossambicus (PCMB 4874 and 4877). PCMB 4872, however, had 99% identity match with Sarotherodon galilaeus for the cytb gene, and 99% identity match for Oreochromis niloticus for the COI gene. This discrepancy between the two gene regions is unclear, but may be due to misidentification within the GenBank database: the COI gene submissions may be more reliable due to the strict identification protocols now required for barcoding projects in order to generate a standardized reference library (see Fish-Bol, http://www.fishbol.org/). Historically, the CNMI had aquaculture farms featuring tilapia (O. niloticus and O. mossambicus) (McKagan et al., 2008). Hybrids of O. mossambicus x O. niloticus are possible, but hybridization among species can not be recognized with the molecular techniques used in this study. Mitochondrial DNA is maternally inherited, and any hybrid or subsequent generation would have the maternal species DNA only.

References:

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Ward, R.D., Zemlak, T.S., Innes, B.H., Last, P.R. & Hebert, P.D.N. 2005. Barcoding Australia's fish species. Philosophical Transactions of the Royal Society of London B 360, 1847–1857.

Table 1: Specimens analyzed in this project. Details for the collection sites can be found in McCagan *et al.* (2008). Species names in bold indicate a high probability in the maximum identity columns of genus and/or species match.

PCMB number	Collection site	Preliminary identification	cyt*b* maximum identity	COI maximum identity
4840	6B	*Chanos chanos*	100% ***Chanos chanos*** (700bp) 84% *Nemacheilus putaoensis*	100% ***Chanos chanos*** (655 bp) 84% *Barbonymus gonionotos*
4841	5A	Goby	98% ***Stiphodon*** *elegans* (400 bp) 85% *Gillichthys* sp. 85% *Rhinogobius* sp.	99% ***Stiphodon*** *elegans* (626 bp) 87% *Sicyopterus lagocephalus* 86% *Gnatholepis* sp.
4842	6B	*Eliotris* c.f. *acanthopoma*	100-99% ***Eleotris acanthopoma*** (600bp) 98% *Eleotris sandwicensis* 84% *Eleotris melanosoma* 84% *Eleotris fusca*	99% ***Eleotris acanthopoma*** (644 bp) 99% *Eleotris sandwicensis* 86% *Eleotris picta*
4845	6B	*Megalops cyprinoides*	99% ***Megalops cyprinoides*** (414 bp) 89% *Megalops atlanticus*	99% ***Megalops cyprinoides*** (470 bp) 82% *Pervagor melanocephalus*
4846	6A	Mullet c.f. *Liza vaigiensis*	100% ***Chanos chanos*** (500 bp) 84% *Alosa pseudoharengus*	100% ***Chanos chanos*** (642 bp) 83% *Barbonymus gonionotus*
4847	6A	Mullet	No data.	99% ***Chanos chanos*** (458 bp)
4848	9A	*Gambusia* sp.	100-99% ***Gambusia affinis*** (700bp) 92% *Gambusia vittata* 91% *Gambusia atrora*	No data.
4859	6A	*Poecilia reticulata*	97% ***Poecilia*** *latipinna* (500 bp) 94% *Poecilia latipunctata* 92% *Poecilia gillii* 85% *Poecilia reticulata*	96% ***Poecilia*** *petenensis* (649 bp) 95% *Poecilia mexicana*
4866	6B	*Poecilia reticulata*	97% ***Poecilia*** *latipinna* (500 bp) 94% *Poecilia latipunctata* 92% *Poecilia gillii* 85% *Poecilia reticulata*	94% ***Poecilia*** *petenensis* (553 bp) 93% *Poecilia mexicana*
4872	9A	Tilapia	99% ***Sarotherodon*** *galilaeus multifasciatus* (600bp) 98% *Sarotherodon linnelii*	99% ***Oreochromis*** *niloticus* (600 bp) 99% *Oreochromis aureus* 98% *Sarotherodon galilaeus*
4874	11A	Tilapia	No data	100% ***Oreochromis mossambicus*** (400 bp)
4877	2A	Tilapia	95% ***Oreochromis*** *karongae* (370 bp) 95% *Oreochromis malagarasi* 95% *Oreochromis tanganicae* 94% *Oreochromis mossambicus*	100-94% ***Oreochromis mossambicus*** (636 bp) 95% *Oreochromis urolepis* 94% *Oreochromis niloticus*

Appendix 1: Mitochondrial cytochrome *b* sequence data for *Stiphodon elegans* specimen included in this study (PCMB 4841), and data from Genbank. Dashes indicate an identical nucleotide match with *S. elegans*.

```
             ....|....| ....|....| ....|....| ....|....| ....|....|
                     10         20         30         40         50
S. elegans   AAATTGCAAA TCACGCACTA GTTGACCTCC CTGCCCCTTC AAATATTTCT
4841         ---------- ---------- ---------- ---------- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                     60         70         80         90        100
S. elegans   GCATGATGAA ACTTTGGCTC CCTTCTAGGA CTCTGCCTTG GTGCCCAAAT
4841         ---------- ---------- ---------- ---------- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                    110        120        130        140        150
S. elegans   TGTCACTGGG CTATTTCTTG CAATACACTA TACCTCTGAC ATTGCCACAG
4841         ---------- ---------- ---------- ---------- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                    160        170        180        190        200
S. elegans   CTTTCTCATC TGTTGCACAC ATTTGCCGTG ATGTTAACTT TGGCTGACTA
4841         ---------- ---------- ---------- ----C----- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                    210        220        230        240        250
S. elegans   ATCCGGAACA TACATGCTAA TGGTGCCTCC TTCTTCTTTA TTTGCATTTA
4841         ---------- ---------- ---------- ---------- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                    260        270        280        290        300
S. elegans   CCTGCACTTA GGGCGAGGCC TTTATTATGG CTCATACCTT TACAAAGAAA
4841         -------G-- ---------- -----A---- --------C- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                    310        320        330        340        350
S. elegans   CATGAAACAT TGGTGTAGTT CTACTACTAC TTGTAATAAT AACTGCCTTT
4841         ---------- ---------- ---------- ---------- ----------

             ....|....| ....|....| ....|....| ....|....| ....|....|
                    360        370        380        390        400
S. elegans   GTAGGCTATG TTCTCCCCTG AGGACAAATA TCCTTCTGAG GGGCCACAGT
4841         ---------- ---------- ---------- ---------- ----------
```

Appendix 2: Mitochondrial cytochrome *b* sequence data for *Poecilia* (sailfin molly) species included in this study (PCMB 4859 & 4866), and data from Genbank for *Poecilia reticulata* (the preliminary species identification), and *P. latipinna* species (most closely matching species). Dashes indicate an identical nucleotide match with *P. latipinna*.

```
              ....|....| ....|....| ....|....| ....|....| ....|....|
                      10         20         30         40         50
P. reticulata --------G- -------C-- ----G-C--- ---------- -A--AA-A--
P. latipinna  CACCCCCTCT TAAAAATTGC AAACAATGCA CTAGTAGACC TCCCCGCCCC
4866          ---------- ---------- ----G----- ---------- ----------
4859          ---------- ---------- ----G----- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                      60         70         80         90        100
P. reticulata -C-A--T--T --A------- ----T----- A--T--C--- ---T------
P. latipinna  CGTCAACATC TCCGCCTGAT GAAACTTTGG CTCCCTACTA GGACTATGCC
4866          ---------- ---------- ---------- ---------- ----------
4859          ---------- ---------- ---------- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     110        120        130        140        150
P. reticulata --G-T----- ----T----- --T------- ---------- ---T------
P. latipinna  TCATCGCCCA AATCCTAACC GGCTTATTTT TAGCAATACA CTACACCTCT
4866          -A-------- ---------- ---------- ---------- ----------
4859          -A-------- ---------- ---------- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     160        170        180        190        200
P. reticulata --T--T--T- ---------- ---C---G-- ---------- -------A--
P. latipinna  GACATCTCCA TAGCATTCTC ATCTGTAACC CACATTTGTC GAGATGTTAA
4866          -----T---- ---------- -------G-- --T------- ----------
4859          -----T---- ---------- -------G-- --T------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     210        220        230        240        250
P. reticulata T--T------ --T--T---- -C--A--C-- T--T--A--- -----G--T-
P. latipinna  CTACGGATGA CTCATCCGCA ATATGCATGC CAACGGGGCC TCCCTATTCT
4866          ---------- ---------- ---------- ---T--A--- ----------
4859          ---------- ---------- ---------- ---T--A--- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     260        270        280        290        300
P. reticulata -C--T---C- ----C-G--- ---------- -AT------- T--G------
P. latipinna  TTATCTGCAT CTACTTACAT ATTGGACGAG GCCTATACTA CGGTTCCTAC
4866          ---------- ---------- ---------- ---------- ----------
4859          ---------- ---------- ---------- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     310        320        330        340        350
P. reticulata C-G-T----- -G-------- ------T--A --C--AT-T- –T--A-----
P. latipinna  TTATACAAAG AAACATGAAA CATTGGCGTT ATTCTCCTAC TACTTGTTAT
4866          ---------- ---------- ---------- ---------- ----------
4859          ---------- ---------- ---------- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     360        370        380        390        400
P. reticulata ---------- --C------- –T--A----- ---------- ----------
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P. latipinna  AATAACTGCT TTTGTAGGAT ACGTTCTCCC ATGAGGACAA ATATCCTTCT
4866          ---------- ---------- -T-------- ---------- ----------
4859          ---------- ---------- -T-------- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     410        420        430        440        450
P. reticulata ----T--A-- ------T--- --T-----A- ---------- C---A-----
P. latipinna  GAGGCGCCAC TGTAATCACC AACCTCCTCT CTGCTGTACC TTACGTAGGC
4866          ---------- ------T--- --T------- ---------- ----------
4859          ---------- ------T--- --T------- ---------- ----------

              ....|....| ....|....| ....|....| ....|....| ....|....|
                     460        470        480        490        500
P. reticulata --TG-C---- ---------- ---------- --------A- -------A--
P. latipinna  GACACTCTCG TCCAATGAAT CTGAGGGGGA TTTTCAGTTG ACAACGCTAC
4866          --------T- ---------- ---------- ---------- ----------
4859          --------T- ---------- ---------- ---------- ----------
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