

Husbandry Guidelines for the Brown Banded Bamboo Shark



Photo courtesy of Kristen Witcomb

Chiloscyllium punctatum

(Chondrichthyes: Hemiscylliidae)

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DISCLAIMER

These husbandry guidelines we produced by the author has part assessment for the completion of Certificate III in Captive Animals, at TAFE NSW- Western Sydney Institute, Richmond College, N.S.W. Australia. As such, care should be taken in the interpretation of information therein, as attention but no responsibility is assumed for any loss or damage that may result from the use of these guidelines. Husbandry guidelines are 'works in progress' and thus enhancements to this work is invited and encouraged.

OCCUPATIONAL HEALTH AND SAFETY RISKS

There are a number of Occupational Health and Safety concerns that are confronted when housing any species, and in particular sharks. These can result from not only direct contact with the animal, but also in the maintenance of the aquaria. Safety standards must be adhered to when performing water quality and life support system checks. This includes that Material Safety Data Sheets are kept within 3 m of the chemicals being employed and any standard operating procedures for the life support system used is correctly followed. Furthermore, many aquaria which display sharks (such as the brown-banded bamboo shark, *Chiloscyllium punctatum*) use SCUBA or surface supply to perform essential husbandry tasks such as glass cleaning and siphoning of the substrate. Each institution is required to provide provisions and standard operating procedures to ensure the health and safety of all divers, support staff and animals that will be involved. Aquaria are encouraged to develop and implement a dive program, complying with the appropriate government regulations and industry standards. Furthermore, it is highly recommended that inductions into diving in individual exhibits are conducted and pre-dive meetings are held to determine the roles of individuals involved and any changes to the general routine set out in the dive program. Finally, how a diver should react to any behavior displayed by sharks should be communicated to and clarified with all individuals involved in the dive to standardise responses.

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1 Introduction

The brown-banded bamboo shark (*Chiloscyllium punctatum*) is a member of the Chondrichthyes class, jawed fish with paired fins, paired nares, a 2-chambered heart and cartilaginous skeletons. They are further classified as sharks within the Elasmobranch subclass. Sharks, in the modern sense, are typically branded as apex predators that knowingly hunt humans. The largest shark, the whale shark, *Rhincodon typus*, can reach lengths of approximately 12m yet feeds on items as small as plankton. Of over 400 extant species of shark, commonly only four are known to attack humans, and these are more misidentification on the shark's part in recognising human swimmers as seals. Even with such a bad reputation, adults and children alike swarm to aquariums and zoos worldwide to encounter these amazing creatures.

The brown-banded bamboo shark is a particularly hardy species and bodes well in captivity. What makes the species even more popular is its ability to be successfully housed with a wide variety of aquatic animals from larger giant shovelnose rays (*Glaucostegus typus*) to an array of small tropical fish. Furthermore, housing *C. punctatum* allows for further research into the not only such an unknown species, but also into little known areas in the group such as parthenogenesis with the publication of potential 'virgin births' in a number of species of sharks, including a close relative of the brown-banded bamboo shark, the white-spotted bamboo shark, *Chiloscyllium plagiosum*.

C. punctatum juveniles present an attractive display, small with beautiful markings, that allow aquarists to educate the public that sharks are not all the threat that the media makes them out to be, by allowing parents and children up close to these shy, misunderstood creatures. Education through captive institutions is a positive step forward to enlighten the public on the conservation efforts required to ensure the survival of this magnificent group of animals and that fearing them, rather than just being cautious, is not necessary. However, fear of sharks from beach goers due to 'Jaws' is not the only risk to the group. Shark finning has become a major industry which between 73-100 million sharks of varying species fall prey to annually (D. Cosgrave, *pers. comm.*). Not only is the industry inhumane (many fisherman cut the fins off alive sharks and throw the torso, still living, back into the ocean where they ultimately drown or die of blood loss), it is ignorant of the role these predators, no matter their size, play in the oceanic ecosystems they inhabit.

1.1 ASMP Category

Not applicable.

1.2 IUCN Category

C. punctatum is ranked as near threatened on the IUCN red list. It fails to meet the criteria for classification as Vulnerable due to insufficient data.

1.3 EA Category

No information could be located at this point in regards to *C. punctatum* EA category.

1.4 NZ and PNG Categories and Legislation

No information could be located at this point to indicate there is specific legislation regarding *C. punctatum*.

1.5 Wild Population Management

Management of *C. punctatum* numbers is not all a natural process. Disease and death from larger predators such as shark rays and lemon sharks all contribute to maintaining the carrying capacity of an area; however, hunting for the aquarium trade and shark-fin industry also contribute to numbers of wild brown-banded bamboo sharks, though not necessarily in a positive way. Exact numbers lost to both industries is unknown as most are taken illegally and/or not identified by species.

1.6 Species Coordinator

There is none listed for this species.

1.7 Studbook Holder

There is none listed for this species.

2 Taxonomy

2.1 Nomenclature

| | |
|----------------|--|
| Class | Chondrichthyes (Subclass Elasmobranchii) |
| Order | Orectolobiformes |
| Family | Hemiscyllidae |
| Genus | <i>Chiloscyllium</i> |
| Species | <i>C. punctatum</i> |

2.2 Subspecies

There are no recognised subspecies at this time.

2.3 Recent Synonyms

Chiloscyllium griseum (non Müller & Henle, 1838) (misapplied name)

Chiloscyllium hasselti (non Bleeker, 1852) (misapplied name)

Chiloscyllium indicum (non Gmelin, 1879) (misapplied name)

Chiloscyllium margaritiferum Bleeker, 1863 (synonym)

Chiloscyllium plagiosum (non Anon., 1830) (misapplied name)

Hemiscyllium punctatum (Müller & Henle, 1838) (synonym)

Hemiscyllium punctatum (Müller & Henle, 1838) (synonym)

Scyliorhinus russellianus Blainville, 1816 (ambiguous synonym)

Scyllium punctatum Kuhl & van Hasselt, 1823 (ambiguous synonym)

Squalus russellianus Blainville, 1816 (ambiguous synonym)

2.4 Other Common Names

There are a number of other common names that refer to *Chiloscyllium punctatum* other than the brown-banded bamboo shark. These include the brown-spotted catshark, grey carpet shark and the spotted catshark. The suffix catshark is a common addition due to the small 'whiskers' that develop on the snout. Grey carpet shark is perhaps the most suited common name, especially when discussing adults, as only juveniles possess the banding pattern referred in the common name brown-banded bamboo shark.

3 Natural History

The brown-banded bamboo shark is a hardy species from the Class Chondrichthyes. Chondrichthyes are cartilaginous fish which include sharks, rays, skates and chimaeras. This group has its origin in the Devonian period and evolutionarily speaking are curious specimens. Considering this ancient group is derived from ancestors with well-developed bones, it is surprising that Chondrichthyes are characterised by cartilaginous skeletons with some calcification, but have no bone present. Their well developed sensory organs, powerful jaws and adept swimming musculature have ensured their survival and dominance in the aquatic environment.

Chondrichthyes can be broken into two subclasses, Elasmobranchii (sharks, rays and skates) and Holocephali (chimaeras). The Elasmobranchii consists of 13 extant orders, numbering approximately 937 species (Hickman *et al.* 2008). Brown-banded bamboo sharks are members of the Order Orectolobiformes. Orectolobiformes are known as the carpet sharks due to many of their members have patterning reminiscent of carpets. The order is relatively small with only seven families representing approximately 40 species ranging from the ornate wobbegong (*Orectolobus ornatus*) to the whale shark (*Rhincodon typus*). The brown-banded bamboo shark is a member of the family Hemiscylliidae (the bamboo sharks) which divides into two genres, *Hemiscyllium* and *Chiloscyllium*. These genus' represent 11 species of typically smaller sharks, all species averaging less than 150cm in length.

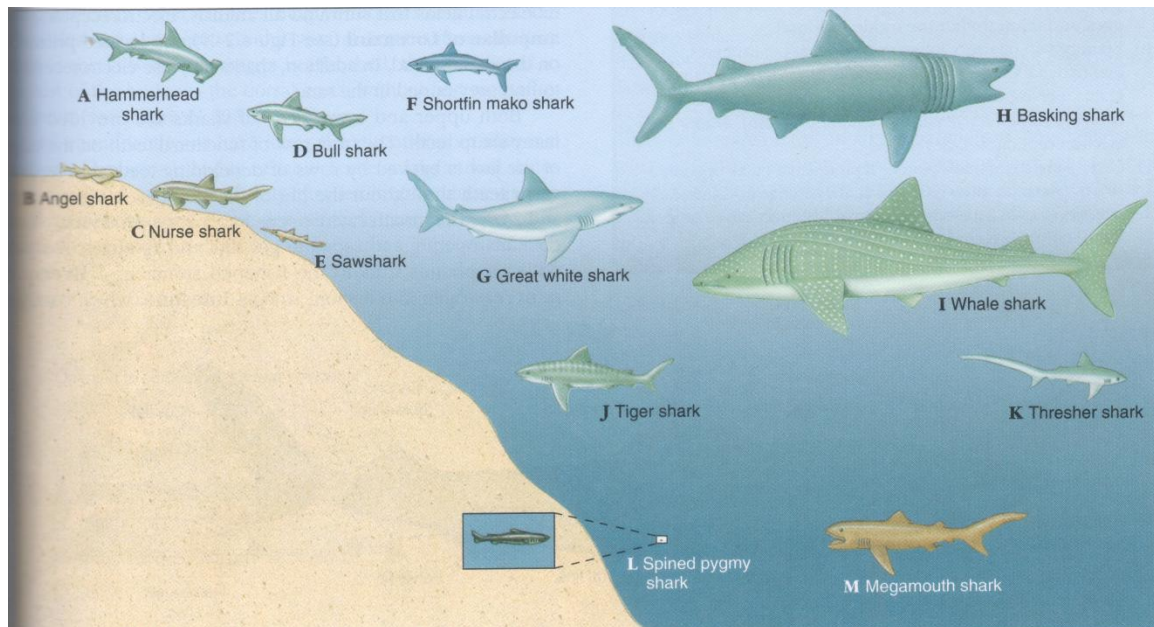


Figure 1 Diversity of sharks present in the subclass Elasmobranchii; A hammerhead shark, *Sphyrna*; B angel shark, *Squatina*; C nurse shark, *Ginglymostoma cirratum*; D bull shark, *Carcharhinus leucas*; E sawshark, *Pristiophorus*; F shortfin mako shark, *Isurus oxyrinchus*; G great white shark, *Carcharodon carcharias*; H basking shark, *Cetorhinus maximus*; I whale shark, *Rhincodon typus*; J tiger shark, *Galeocerdo cuvier*; K thresher shark, *Alopias vulpinus*; L spiny pygmy shark, *Squaliolus laticaudus*; and M megamouth shark, *Megachasma pelagios*. Taken from Hickman *et al.* 2008, p. 521.

3.1 Morphometrics

3.1.1 Mass And Basic Body Measurements

Wild specimens of *C. punctatum* have been known to reach lengths of 117cm (Bennett and Kyne, 2003). In captivity, the brown-banded bamboo shark can grow up to 144cm.

3.1.2 Sexual Dimorphism

Sexual dimorphism is not clearly evident based on size. However, as with other Chondrichthyes, sexual dimorphism is evident as males possess claspers. Claspers are formed from the posterior portion of the pelvic fins which serve as an intromittent organ for semen direction into the female's cloaca.

3.1.3 Distinguishing Features

Brown-banded bamboo sharks possess slender bodies with concave posterior margined dorsal fins and an elongated and thick precaudal tail. The body lacks a lateral dermal ridge. No colour patterns are observed in the adult form, just a solid variation of grey-brown. The juveniles are distinct with dark transverse banding across their pale form which fades to the adult form.

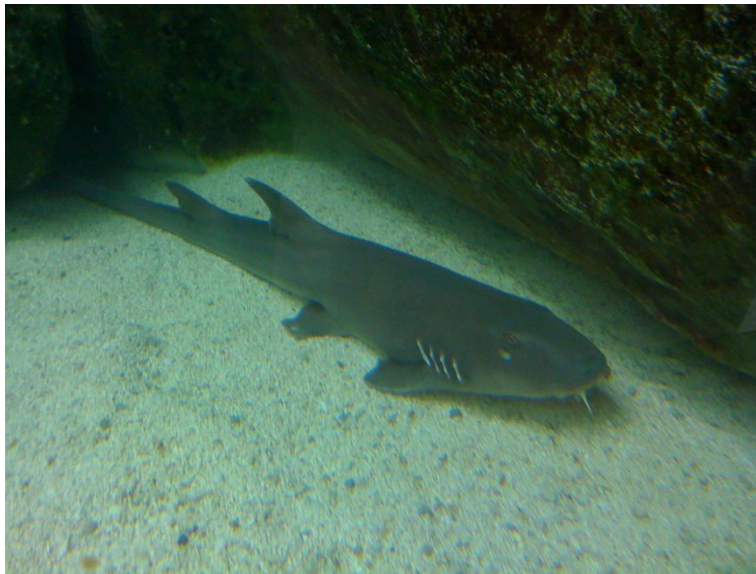


Figure 2 Adult form of *C. punctatum*. Photo courtesy of Kristen Witcomb.



Figure 3 Juvenile form of *C. punctatum*. Bands start a very dark brown and fade to this paler caramel before completely disappearing in the adults. Photo courtesy of Kristen Witcomb.

3.2 Distribution and Habitat

The brown-banded bamboo shark is a widely distributed tropical species found on the northern half of Australia and off the coast of other Asia-Pacific countries including Cambodia, China, India, Indonesia, Japan, Malaysia, Papua New Guinea, Philippines, Singapore, Taiwan, Thailand and Vietnam.

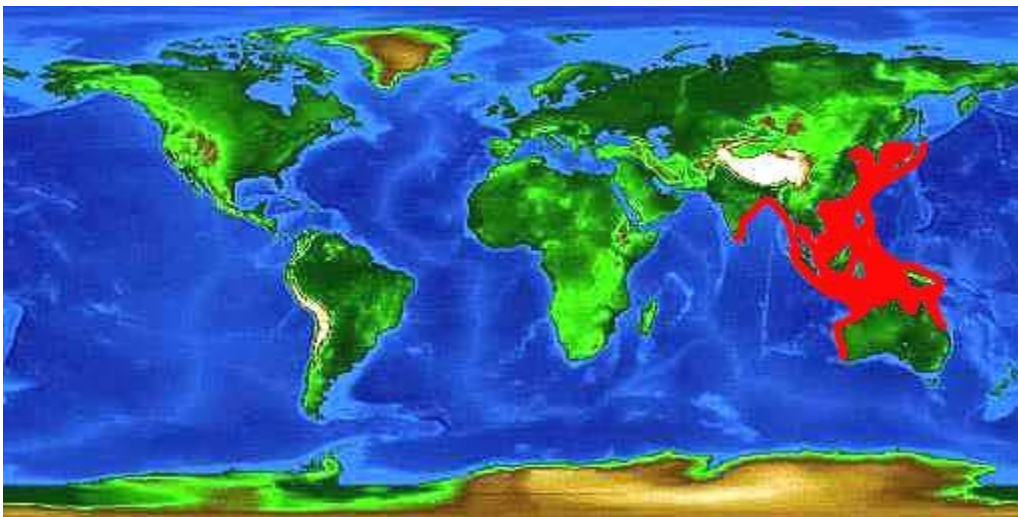


Figure 4 Photo courtesy of Ichthyology Department, FLMNH.

C. punctatum is found on coral reefs, sand and sand/mud substrates throughout its range. It can tolerate severe environmental hypoxia (low oxygen levels), one reason this species is favoured in captivity. It prefers to hide in crevices during the day being a nocturnal feeder. The banding pattern found on juvenile's further helps it camouflage with the coral based surroundings.

3.3 Conservation Status

The species is listed as near threatened due to insufficient data for upgrading it to vulnerable. Research into *C. punctatum* populations is necessary as the species is common in by-catch, threatened by overfishing for human consumption or the display-aquarium trade, and also habitat degradation and loss.

3.4 Longevity

3.4.1 In the Wild

An approximate life span of 25 years is given for the brown-banded bamboo shark, however further research into wild populations is necessary (Bester, Unknown).

3.4.2 In Captivity

In captivity the longevity reflects that of their wild counterparts.

3.4.3 Techniques Used to Determine Age in Adults

Growth in elasmobranchs is typically characterised by the von Bertalanffy growth function (VBGF) in the following form:

$$L_t \text{ or } W_t = L_{\text{inf}} \text{ or } W_{\text{inf}} \left[1 - e^{-(k(\text{age} + t_0))} \right] \quad (\text{Mohan } et \text{ al. } 2004)$$

where,

L_t or W_t = length or weight at time t ;

L_{inf} or W_{inf} = asymptotic (maximum) length or weight;

k = growth coefficient;

age = years; and

t_0 = theoretical age at which the animal was size 0.

Furthermore, a general estimate of sexual maturity can be assessed using the colouration and patterning between the juvenile and adult forms of *C. punctatum*.

4 Housing Requirements

4.1 Exhibit/Enclosure Design

It is of great importance that any exhibit be designed specifically for the species and individuals being housed. If this essential concept is ignored, the animal's basic physical and behavioural requirements potentially may not be successfully met.

The Exhibited Animals Protection Act (amended 2004) states that exhibits should be designed to provide for the basic requirements of each species being exhibited (Part 2, Clause 5, Section 12). Furthermore, Clause 5, Section 3 (EAPA, amended, 2004) states that all keepers must possess the following:

- 'a) understanding the basic biological, behavioural, nutritional and environmental requirements of the animals in the exhibitors care and how this relates to their care in captivity;
- b) demonstrating good maintenance and husbandry of the exhibitors enclosures and animals with an understanding of hygiene, cleanliness and neatness in regard to enclosures, equipment and feed;
- c) renovating enclosures as required;
- d) appropriately transporting animals within and outside the institution;
- e) training new staff in the management of species displayed, or kept for display, within the collection; and
- f) maintaining enclosure security.'

Furthermore, in terms of enclosure construction (Part 5, Clause 9, EAPA, amended 2004) it is necessary that the enclosure minimises predator, pest and wild animal entry. It must also be in sufficiently good repair to ensure animal containment and safety for the animals, staff and the public. Additionally, the enclosure must be constructed to minimise the risk of injury to the animal and the risk to staff and public, if they follow the instructions of all appropriate signage. Finally, the risk of escapement must be minimised through construction and the positioning or removal of vegetation or other materials.

4.2 Holding Area Design

The EAPA (amended 2004) specifies that any species not covered by species-specific guidelines have a holding area that must be in length at least 3 times the individual's length and in breadth at least 1.5 times the individual's length. Due to the species being nocturnal, it is also necessary for there to be adequate protection for any individuals to hide. For smaller individuals and juveniles, piping cut in half length ways has been a suitable shelter (pers. obs.). Furthermore, there must be adequate protection from the

weather and allow safe access for keepers with no blind spots in the enclosure (DPI 2004). Being an aquatic species, adequate heating and ozone must be incorporated into the design.

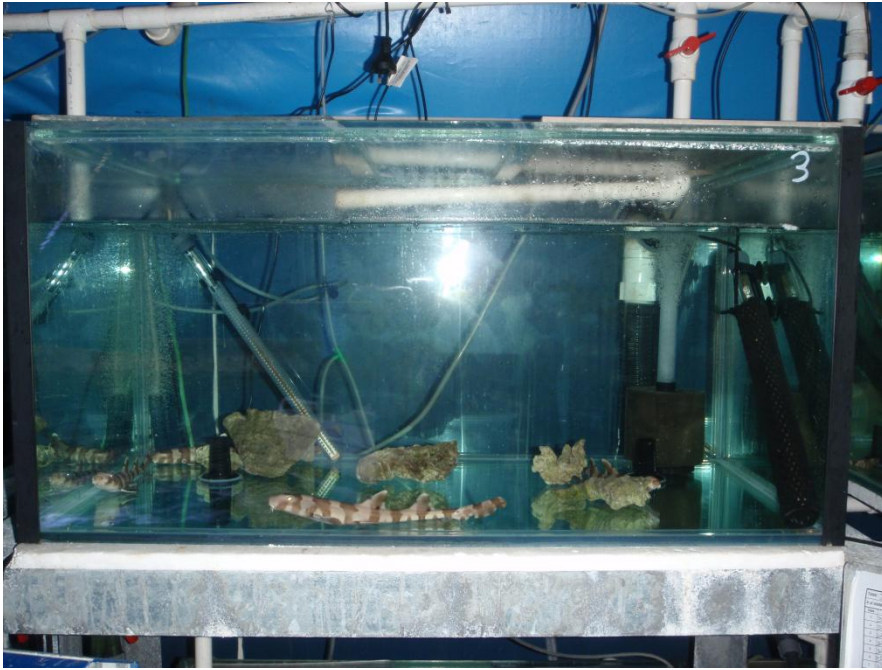


Figure 5 Photo courtesy of Kristen Witcomb. Bollards for shelter are clearly visible in a Sydney Aquarium off display housing tank for juvenile *C. punctatum*.

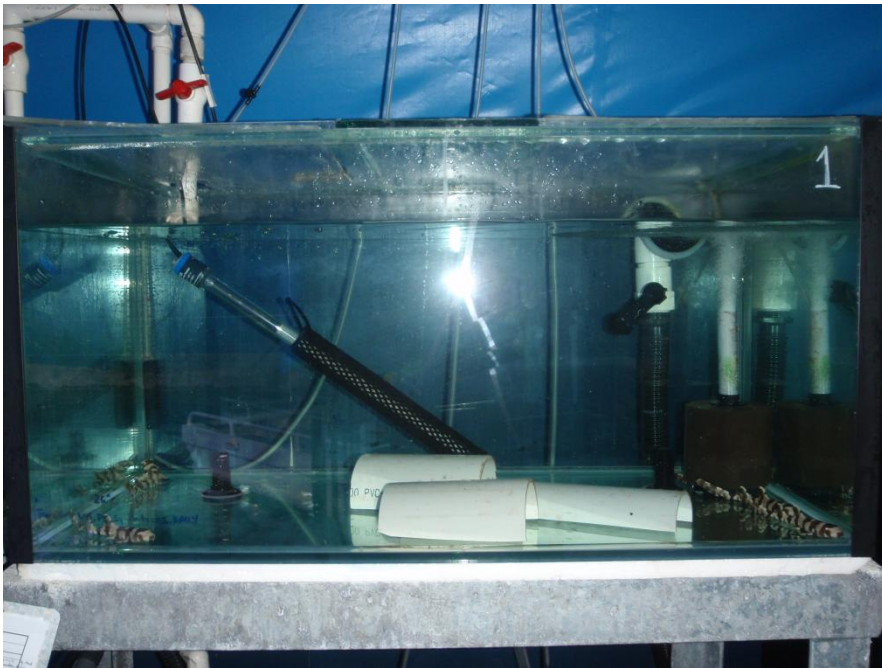


Figure 6 Photo courtesy of Kristen Witcomb. PVC piping halved lengthways for shelter is clearly visible in a Sydney Aquarium off display housing tank for juvenile *C. punctatum*.

4.3 Spatial Requirements

Minimum standards for keeping *C. punctatum* dictate that the size and shape of the enclosure must provide freedom of movement, both horizontally and vertically (DPI 2004). It must allow for an animal to avoid, or withdraw from, contact with other animals and permit exercise and behavioural enrichment. Each individual must also be provided with sufficient space to enable it to take exercise and be protected from undue dominance and conflict from other animals (DPI, 2004).

4.4 Position of Enclosures

The enclosure must be constructed in such a way as to minimise the entry of predators and pests of the animals in the enclosure (DPI, 2004). Sufficient filtration and temperature regulation systems for pools housing brown banded bamboo sharks must be provided. For convenience and cost efficiency, such equipment should be located in close proximity to the pool, easily accessible and not in direct sunlight.

4.5 Weather Protection

Sufficient shaded, covered or sheltered areas must be provided to protect the animals from adverse ambient conditions; such causes of conditions include, but are not limited to, weather, sunlight or artificial lighting, glare or other environmental factors including wind, rain and extremes in temperatures (DPI, 1994; DPI, 2004).

4.6 Temperature Requirements

C. punctatum is a tropical species and thus the water temperature must be regulated. In general, a range between 24°C-27°C is suitable for both juveniles and adults (pers. obs.). Furthermore, the air temperature in indoor enclosures must be controlled so the animals do not suffer from heat or cold, with rapid changes being avoided (DPI, 1994).

4.7 Substrate

Pools should be constructed from materials that are durable, water tight, non-porous, non-toxic and easily cleaned and disinfected (DPI 1994). In holding pools and small aquaria with juveniles no substrate as such is required (pers. obs.). Substrate materials such as coarse sand and small to medium pebbles are suitable as brown banded bamboo sharks are bottom dwellers living in coastal waters and tidal pools.

4.8 Nestboxes and/or Bedding Material

No nest boxes are required for *C. punctatum*. The species is oviparous, and it is recommended that eggs be removed from on display enclosures and separated from other individuals in holding tanks to be monitored.

4.9 Enclosure Furnishings

Enclosures should include naturalistic furniture and items to encourage natural behaviour (DPI 2004). Bare and/or sharp projections and edges, loose air or water hoses, cables or restraining nets and fences in poor repair are hazardous to marine individuals and are to be avoided in all aquaria (DPI 1994). No objects, furniture, apparatus, decoration, plants or other items which could interfere with the welfare of the animals or the efficient husbandry shall be kept or allowed to remain in the immediate surroundings of the aquaria (DPI, 1994). Sufficient cover, including items such as bollards or piping halved lengthways, is also required (pers. obs.). These furnishings should be stable features as individuals are capable of moving and tipping the objects. No nesting materials are needed for this species. The inclusion of aquatic plants is not necessary. Some plants and corals can sting the sharks (juveniles are more susceptible than adults) and if left decomposing, can adversely affect water quality.

5 General Husbandry

5.1 Hygiene and Cleaning

Particulate animal and food waste, trash or debris that enters the pool must be removed as often as possible to maintain high water quality levels and to prevent health hazards (DPI, 1994). The walls and floor of the aquaria shall be cleaned as often as necessary to maintain proper water quality. F10 and Animal House disinfectant products have been found to be successful (pers. obs.; MSDS attached in Appendix). All boots, aprons, food buckets and receptacles must be kept clean (DPI 1994). The configuration of a pool shall provide for ease of cleaning, draining and maintenance of adequate water quality (DPI, 1994).

Cleaning regime

Nesting material and branches are not required for brown banded bamboo shark exhibits. Particulate animal and food waste, trash or debris, should be removed on a daily basis. Water quality parameters must be measured at least twice daily: pH (should average 7.9-8.4), temperature (24°C - 27°C) and salinity (27.5-32ppt). Bromine, nitrate, nitrite, ammonia and alkalinity levels should also be tested once per week. Furthermore, algae and other debris must be removed from viewing areas such as glass and acrylic. For large aquaria, three times weekly is appropriate as it is necessary to dive clean. For smaller aquaria, it may be necessary more often but not to the same extent as for larger exhibits, through the use of scrubbing pads on extendable poles. The substrate must also be cleaned regularly. In large aquaria, whilst one diver is cleaning the glass/acrylic, another diver can be gravel siphoning the substrate a small section at a time. In small tanks, a bell and hose or airline is sufficient to siphon debris from the bottom.

Pest Control Maintenance

Being an aquatic species, the number of pest species affecting *C. punctatum* is limited. Two pests that can impact on the brown banded bamboo shark include *Aiptasia* spp. and rodents.

Aiptasia spp. are highly undesirable in any aquarium tank. They stress coral and are capable of stinging juvenile sharks, fish and invertebrates. The genus is also known to settle and grow on the gills of many aquatic species making breathing difficult. They enter the tanks through the live rocks and kelp that is put on display for aesthetic qualities. *Aiptasia* spp. are also capable of coming into the exhibit through make-up water if it comes directly from the ocean. To eliminate the pest, manual removal from the gills with fine tweezers is required. Alternate solutions that are also employed include the introduction of Peppermint Shrimp (*Lysmata* spp.) which feed on *Aiptasia* spp. polyps and also an increase in the salinity level of a tank, especially before a turnover of species in an exhibit/tank.

Rodents are not directly a pest to any aquatic species including the brown banded bamboo shark, but can cause a problem with the electrical circuits which power the Life Support System (LSS) for the species. Without equipment such as filters and ozone, it would be impossible to sustain tanks, especially large oceanarium. Rodents tend to be

attracted to warm areas and are quite capable of chewing through power cords and other electrical equipment, causing malfunctions in the LSS and jeopardising the lives of all species in the tank/s affected. Regular maintenance and checks of bait stations around the LSS and also around the facility itself is necessary.

5.2 Record Keeping

Record keeping is an important part of the animal industry. Records can aid in the identification of any abnormal behaviour, regular health issues and more. In many institutions, the use of daily record sheets for each tank is employed to ensure all important data is maintained in a clear and concise manner. These sheets include the date and a space for any comments which include but is not limited to, food distributed, if taken/refused, temperature recording, LSS check-offs, any unusual behaviour or visual observations of the animals within the tank, any maintenance such as backwashing of filters, siphoning, algae cleans or any other task performed to ensure the upkeep of the tank. Additionally, animal counts where necessary, treatments administered (which should also be recorded on a treatment sheet which is recommended to be created when given a medication to administer) and any other note of importance should also be recorded on these daily records. It is a useful tool furthermore to let staff not usually caring for a tank know if there is anything specific required (for example, writing on the next day not to feed a particular individual). The information kept on file in each institution for an individual should accompany the individual if it is ever transferred to another facility (EAPA, amended, 2004).

5.3 Methods of Identification

Identifying sharks can be difficult. Keepers tend to be able to identify their animals by sight from familiarity with the animals in their care. Certain scars, colouration and other marks can determine an individual. Microchipping is a quite definitive form of identification, however, in large oceanariums finding an individual when the species likes to hide, let alone being able to scan an individual, is not a simple task.

5.4 Routine Data Collection

Routine data collection should be common place in any captive animal facility. The more data recorded on an individual, the better the care the animal can receive. Any data recorded provides a written record of their history in captivity and is a valuable source of information, especially when institution transfers occur. Records are bestow a wealth of knowledge, including a database of information on health problems, veterinary treatments and procedures, growth and development, feeding patterns and reproductive activity among many other husbandry aspects.

Unlike many terrestrial species, routine data collection on weight and length is not common place in their aquatic counterparts. Concise records on juveniles or sick animals in particular on treatments administered and any changes in physical appearance or behaviour are important to record. Furthermore, food consumption is a good indicator of animal health, thus it is important to note what was fed, if it was taken, the quantity taken

and who fed the individual should be recorded. Time of day (especially if multiple feeds are offered daily) is noteworthy on records.

Data collection sheets can allow for quick referencing and are generally in a form easy to read by any keepers, even if they aren't dealing with the animal on a day-to-day basis. A general example is included below, however, institutions will have their own versions which will likely vary but still record the same general information.

| | | | |
|-----------------------------|---|------------------|---------------|
| Species | <i>bamboo shark</i> | Sex | <i>0.1</i> |
| I.D. | <i>CPUN021</i> | Enclosure | <i>OC4 Q5</i> |
| Distinguishing marks | | | |
| | | | |
| Date | Comment | Initial | |
| <i>12/5/12</i> | <i>moved in from OC2</i> | <i>KW</i> | |
| <i>13/5/12</i> | <i>offered mince on fingertip at 11.10am, refused KW, offered at 3.15pm peeled prawn piece, taken</i> | <i>KW</i> | |
| | | | |

Figure 7 Example data record sheet (example data in italics).

6 Feeding Requirements

6.1 Diet in the Wild

The brown banded bamboo shark is a carnivorous species, more specifically though, a portion of its diet deems it a piscivore. In the wild, populations of these sharks will typically eat mostly invertebrates and crustaceans. Small fish may also be preyed upon by larger juveniles and adults.

The species is a demersal one and tends to inhabit coastal areas and tidal pools, including the continental shelf in tropical regions and thus, there is slight seasonal variability depending on prey populations (Daley *et al.* 2002). Though the diet primarily remains the same, the portion that each group makes up of the diet can vary. Due to this species being commonly kept in both private and public aquaria, more is known on this species diet or prey portions percentages in captivity.

6.2 Captive Diet

The brown-banded bamboo shark's captive diet similarly reflects that of its wild diet. A variety of squid, prawns, mussels and small marine fish such as whitebait can be offered. The size of the individual will determine the size of the food able to be offered.

Table 1 Feed table for items fed at Sydney Aquarium, Australia

| Food item | Preparation | Age of individual to be fed |
|--|---------------------------|---|
| Prawns | defrosted, heads removed | adults, juveniles (may need to be cut into smaller pieces where necessary) |
| Whitebait | defrosted | adults, juveniles |
| Small squid | defrosted | adults, juveniles (cut into small pieces or tentacles only used for smaller individuals) |
| Mussels | defrosted | adults, juveniles (cut into small pieces and rims used for small animals) |
| Mince (mixture of mussels, whitebait and prawns) | defrosted, finely chopped | juveniles (for younger individuals it must be fine, for older individuals coarsely chopped is suitable) |

Note: Fort Worth Zoo houses a male brown-banded bamboo shark which is fed crab and shrimp twice a week (Matthews, Unknown). Food provided should be similar to its wild diet, but can vary across facilities due to access to food sources. Furthermore, seasonability is not a primary issue in captive environments as conditions are monitored and controlled.

When it comes to quantity of food items, some discretion on the keeper's part is required. A small amount of mince (the size of a five cent piece) is quite sufficient for newly hatched pups, offered twice daily. As they grow, pups require larger food portions but less often. At approximately 20cm, small pieces of mussel or whole whitebait can be offered every second day, offering between 2-4 pieces depending on the individual is suitable. As an adult, a varied diet occurs. This species is typically kept in large oceanariums where bulk feeds occur and individuals are not specifically fed a certain quantity. When the animal is hungry, it will emerge during feeding and take what they require. However, if an adult is held in quarantine where it is easy to monitor food intake, 2-4 pilchards/red spot whiting/small squid can be offered in any variation of number (though pilchards should be used sparingly as they are typically fatty, unless the individual is underweight one in a feed is suitable) every second day. If it is necessary to medicate an individual daily, this food should be split so the weekly total is the same as if it were fed every second day.

Table 2 An example feeding schedule for a healthy adult brown-banded bamboo shark.

| Day | Pilchard | Red Spot Whiting | Small Squid | Mussel | Prawn |
|------------------|-----------------|-------------------------|--------------------|---------------|--------------|
| Monday | 1 | 3 | - | - | 3 |
| Tuesday | - | - | - | - | - |
| Wednesday | - | 2 | 2 | 2 | - |
| Thursday | - | - | - | - | - |
| Friday | 1 | - | 2 | - | 2 |
| Saturday | - | - | - | - | - |
| Sunday | - | - | - | - | - |

Freezing and Thawing

Unless the species is housed near a fishing port with a reliable intake of feed items, it will be necessary to bulk buy and freeze whole items. To reduce the chance of transferring parasitic infections via diet, all items are recommended to be thoroughly frozen for at least 36 hours prior to thawing for feeding (Janse *et al.* 2004). Furthermore, freezing minimises deterioration as a result of physical and biochemical changes, and halts microbial activity. A freezing rate of between 0.15-5.00 cm h⁻¹ has been shown to be adequate and show no changes in quality (Keizer, 1995). To prevent surface dehydration and freezer burn from low humidity conditions in freezers, all food items should be stored in air tight containers or thoroughly wrapped in plastic bags.

Thawing should take place in a refrigerator, once food items have been removed from the freezer. Closed containers should be utilised to prevent bacterial contamination. Thawing should take place overnight, where only the quantity of food required for the next day is removed to be thawed. If before use further thawing is necessary, although not preferable, standing room temperature water can be used, however, it should be only for a minimal amount of time and food items should not be left in water for prolonged periods of time to minimise nutrient loss. At Sydney Aquarium, a mixture of water of 1/3

saltwater to 2/3 freshwater is used in the mornings to finish defrosting of the day before's breakout of frozen items (pers. obs.).

Once defrosted, food should not be re-frozen a second time. All food, if refrigerated, should be fed out within a 24 hour period after its initial removal from the freezer. After such a time, all products should be discarded.

As with any diet preparation, proper hygiene procedures should be adhered to at all times. To prevent bacterial growth all equipment, work areas and sinks should be thoroughly cleaned with hot water and disinfectant after use. It is recommended to only use disinfectants that do not leave a residue on preparation surfaces (Janse *et al.* 2004).

6.3 Supplements

It is debatable as to whether or not to provide supplements to captive shark species. If whole food items (for example, whole fish, including the internal organs) are provided, it is not necessary to supplement the diet (A. Wilkes, *pers. comm.*). Feeding only parts of the fish, squid, etc, diminishes the nutritional value of the diet.

6.4 Presentation of Food

The age of the individual being fed is a determining factor in the presentation of food. In general, adults and older juveniles are able to be scatter fed. Simply, the diet can be thrown into large oceanariums or placed into small aquaria. Ensuring that it sinks, brown-banded bamboo sharks can forage the substrate imitating natural strategies. It is preferable to feed the sharks in the late afternoon as the species is nocturnal. However, in most public aquaria this is not feasible. Sydney Aquarium has housed both juveniles and adults. The adults on public display are in multi-species tanks and are fed throughout the day with scatter feeds. Typically, this is daily where the feed is made up and either split into two feeds distributed at different times or fed in one large quantity. The juveniles are fed slightly differently.

Housed off exhibit in small holding aquaria, depending on the age of the individuals will determine the best method of feeding. As the species is bred on site, newly hatched offspring are not accustomed to feeding on dead food. In the wild, it is innate to hunt for moving food items. Therefore, for the first few weeks after hatching, it is necessary to wiggle small pieces of food in front of the juvenile's heads, tickling the tip of the snout with the food, to mimic live food prey. This can be done by hand or a pair of long tweezers. Sydney Aquarium aquarists of found that squid tentacles, small whitebait, the rim of mussels and minced prawn, whitebait and mussels are the best for this process (A. Wilkes, *pers. comm.*). This process should be done a minimum of 2-3 times daily as juveniles have fast metabolisms and small stomachs. Slowly, the juveniles can be weaned off of 'live-imitated' food pieces to scatter feeds of pieces or mince.

For both adults and juveniles, food must sink to the bottom of the tank. Brown-banded bamboo sharks are bottom-dwellers and will generally not venture too higher in the water to feed (pers. obs.). Furthermore, being nocturnal, it may be necessary for less

acclimatised individuals to have food offered in the darker and more shaded areas of the tanks to increase the chances of feeding successfully.

If it is necessary to medicate an individual, even in large oceanariums, stick feeding is quite successful with minimal conditioning required for the animal to take food.

7 Handling and Transport

7.1 Timing of Capture and Handling

As with all sharks, brown-banded bamboo sharks are highly prone to capture myopathy and should thus be handled as minimal as possible. Being a nocturnal species, during the day the species is quite sluggish and it is best for on display individuals to be captured prior to the public arriving. In the morning is the best time for capture and transport to allow monitoring throughout the day.

7.2 Catching Bags

No catching bags are required for the brown-banded bamboo shark.

7.3 Capture and Restraint Techniques

One method used to capture brown-banded bamboo sharks is targeting by hand nets. In small tanks, this is quite simple. Minimising stress is of great importance, therefore one swift movement should be utilised. Another technique is without any equipment and capturing the individual with a trained aquarist's hands. The species is considerably small and generally only moved when a juvenile. A firm grasp with two hands, one on the upper part of the body and one on the lower part (just before the tail starts) is sufficient to capture and temporarily restrain this species. As previously mentioned, sharks are prone to capture stress and thus restraint should be minimised. Once caught it should immediately be placed in the awaiting transport container, tub or plastic bag.

7.4 Weighing and Examination

It is uncommon for aquaria to weigh sharks (A. Wilkes, *pers. comm.*). As part of the daily routine, observational checks on the health of individuals should be conducted. Visual checks are recommended over examinations where restraint is necessary.

7.5 Release

If transported in a bag, the bag can be slowly lowered into the new water bottom, slowly raising a corner to allow the shark to slowly move out into the tank. If transported in a large tub or container, the shark will need to be caught, typically by hand, and lifted into its new housing. In large aquaria, a suitable hideout should be within close proximity to the release point to allow for cover once released.

7.6 Transport Requirements

7.6.1 Box Design

The container must be water proof. If transported in a bag (Figure 1), the outer container must be crush proof, constructed of materials such as wood, fibreboard or similar (IATA, 2009). The inner surface must be smooth and free of abrasions and projections. It must

also be leak proof or lined with plastic. The inner container must be a strong plastic bag with full width opening at the top. It must be deep enough to allow that the portion above water be twisted and doubled over in order to be secured by an elastic band, wire or metal strip. It is also preferable that it be placed in a second bag in case of breakage or leakage. In the bag, there should be 1/3 water to 2/3 oxygen with the shark being able to move freely.

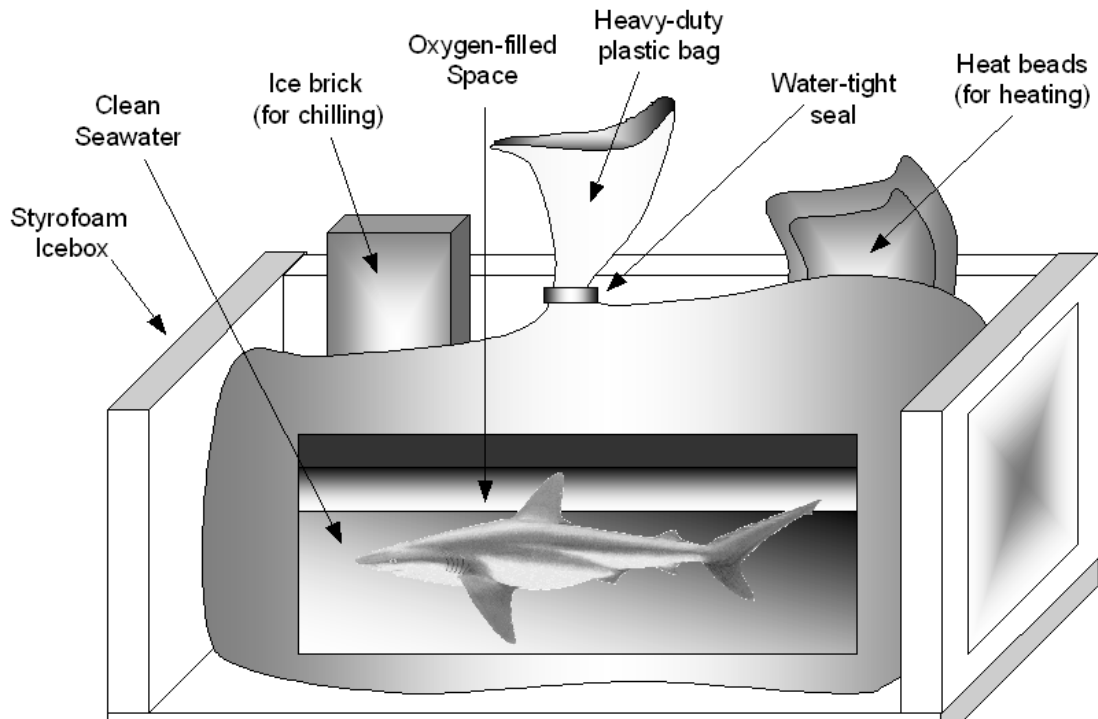


Figure 8 Example of a transport container when the individual is in a plastic bag. It is not always necessary to incorporate an ice brick or heat beads for brown-banded bamboo sharks. Taken from Smith *et al.* 2004.

For larger individuals, a tub may need to be employed, as seen in Figure 2. The tub must be slightly longer than the individual being transported to allow the individual to completely turn around in any direction. If the tub is too small, the shark will not be able to move. This can be hazardous to the health of the individual as it can cause lactic acid to build up (G. Cordey, *pers. comm.*). A 100L round tub is typically suitable for this species. Depending on the length of transportation, an air pump may be required and should be firmly attached to the top of the lid, which needs to be sealed.

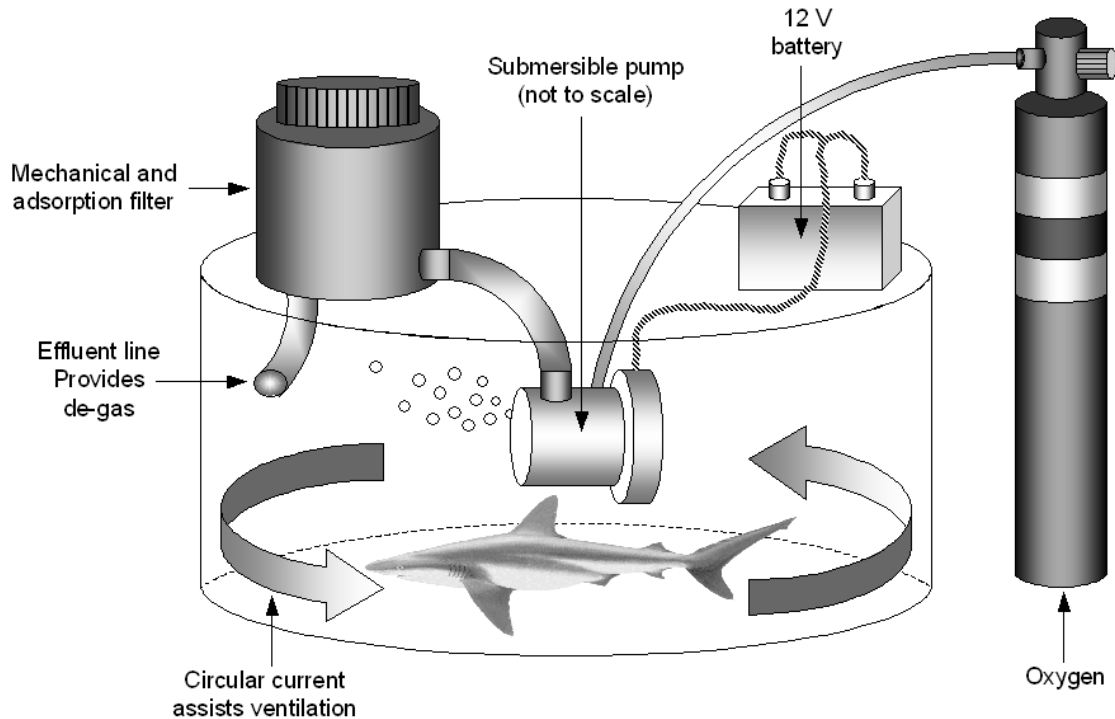


Figure 9 Transport container when individual is directly in the tub. It is not always necessary to attach a filter, submersible pump and oxygen tank. For short journeys, filling the airspace with compressed oxygen or attaching an air pump is sufficient. Taken from Smith *et al.* 2004.

All outer containers or tubs should be opaque and present a dark environment which typically has a calming effect on animals. Additionally being a nocturnal species, the brown-banded bamboo shark is light sensitive further requiring the need for a dark transport environment.

7.6.2 Furnishings

No furnishings are required for transport. Brown-banded bamboo sharks are typically strong and can move objects that are unstable. Furthermore, any movement of the container can result in any furnishings harming the shark such as being crushed.

7.6.3 Water and Food

Individuals should be starved for 1-2 days prior to transport. This time can vary depending on digestion rates of individuals. No food is required during transport. Feeding on arrival is encouraged. Being an aquatic species, only the saltwater used to transport the individual is required.

7.6.4 Animals per Box

For this species, it is preferable to transport one individual if bagged (A. Wilkes, *pers. comm.*). Depending on the length of transport time, small juveniles in a sufficient sized tub can be transported in small numbers.

7.6.5 Timing of Transportation

The extremes of midnight and midday during winter and summer respectively should be avoided. It is preferable to move this species during the afternoon (A. Wilkes, *pers. comm.*).

7.6.6 Release from Box

See 7.5 above.

8 Health Requirements

8.1 Daily Health Checks

Daily health checks whilst cleaning, feeding and life support system checks will aid in the maintenance of a healthy shark. Distant observations are useful. Any signs of trauma, such as scratches or bite marks, should be noted and treated if severe enough. It is not uncommon for intraspecific and interspecific interactions to result in some minor lacerations that do not need treatment; however, they should be noted and kept a close eye on to prevent infection occurring or them getting worse.

Any signs of disease should also be recorded, the veterinarian notified (if an on-site one is available) and monitored closely. This can include unusual behaviour, food consumption changes and lesions or similar markings that cannot be attributed to interspecific or intraspecific interactions.

8.2 Detailed Physical Examination

It is very important in treatment to have early diagnosis of any abnormalities. Records need to be kept on each illness that includes:

- Individual identification
- Initial signs
- Results of a physical examination
- Results of tests performed (including serology and blood analysis, cultures and faecal exams)
- Any progression of the abnormalities or further changes that could be related

8.2.1 Chemical Restraint

Anaesthetising a shark is still in its infancy. An elasmobranch may be anaesthetised using tonic immobility ('hypnosis') or a suitable immersion or injectable anaesthetic (Stamper, 2004). A combination of methods can result in a smoother process with reversal agents on hand to ease the recovery process or to end the anaesthesia prematurely.

Immersion or inhalation anesthesia has the advantage of being safe to deliver and easily modified through addition or dilution. However, the use of immersion drugs in large bodies of water is typically not practical or economically feasible.

Injection anesthesia can allow animals to be captured in large exhibits with less staff and employee time. Delivery can be achieved by hand injection, pole syringe, Hawaiian sling, or remotely, via a dart gun (Harvey *et al.* 1988). Intravenous, intraperitoneal or intramuscular injections are preferred.

Individuals can react variably to an anaesthetic. Individual size and weight, age, stress, disease status, body temperature, liver and kidney function, injection site and reaction with non-target tissues are just a number of factors that can affect an animal under anaesthesia (Stamper, 2004). Close monitoring of a specimen prior, during and after any anaesthesia is necessary. Ventilation rate, heart rate and where possible blood gas and lactate levels should be recorded throughout the procedure and monitored closely.

Potential anaesthetic drugs for immersion and injectable techniques are listed below. It is important to remember that as this procedure is still in its primacy, that other drugs may be more suitable and doses will vary by the aforementioned factors.

Immersion anaesthetics

- Benzocaine
- Etomidate or metomidate
- Halothane-oxygen-nitrous oxide
- Oxygen
- Quinaldine
- Tricaine Methane Sulfonate (MS-222)
-

Injectable anaesthetics

- Alfaxalone-alfadolone
- Azaperone
- Carfentanil citrate
- Detomidine hydrochloride
- Ethanol
- Ketamine hydrochloride
- Medetomidine
- Propofol (note this has been successfully used in *Chiloscyllium plagiosum*, Mitchell *et al.* 2001)
- Teletamine
- Sodium pentobarbital
- Xylazine

Before administering any drugs however, it is strongly recommended to consult a veterinarian, particularly one with elasmobranch experience. Over- or under-dosing an individual can yield highly undesirable results.

Table 3 The various stages of anaesthesia, note that not all individuals will exhibit all stages or will to differing degrees. Taken from Stamper, 2004.

| Stage | Plane | Description | Corresponding Behavioural response |
|---------|-----------|---------------------|---|
| Stage 0 | | Normal | Swimming actively, reactive to external stimuli, muscle tone and equilibrium normal. |
| Stage 1 | | | Subjective in nature. Disorientation. |
| | Plane 1 | Light sedation | Voluntary swimming continues; slight loss of reactivity to visual and tactile stimuli; respiratory rate, equilibrium, and muscle tone normal. |
| | Plane 2 | Deep sedation | Voluntary swimming stopped; total loss of reactivity to visual and tactile stimuli; slight decrease in respiratory rate; equilibrium normal; muscle tone slightly decreased; still responds to positional changes. |
| Stage 2 | Plane 1 | Light narcosis | This stage is also known as the excitement phase. There is a loss of consciousness and subsequent excitement (uninhibited action, uncoordinated movements, struggling, exaggerated response to painful stimuli, and spinal reflexes). Efforts to right self, muscle tone decreased, and still weakly responds to positional changes. Respirations can be irregular. |
| | Plane 2 | Deep narcosis | Ceases to respond to positional changes; decrease in respiratory rate to approximately normal; total loss of equilibrium; no efforts to right self; muscle tone decreased; some reactivity to strong tactile and vibration stimuli; suitable for external sampling (e.g., gill biopsy). |
| Stage 3 | | | Four planes with increasing depression of respiration, circulation, protective reflexes, and muscle tone. |
| | Plane 1 | Light anesthesia | Total loss of muscle tone; responds to deep pressure; further decrease in respiratory rate; suitable for minor surgical procedures. |
| | Plane 2-4 | Surgical anesthesia | Respiratory rate very low; heart rate slow. |
| Stage 4 | | Medullary collapse | Represents complete respiratory arrest. Cardiac arrest will ensue unless anesthetic regime is not modified. |

8.2.2 Physical Examination

Measurements of morphometric parameters can be taken (these can include but are not limited to total length, fork length, precaudal length, girth and eye to eye length). Weighing is not a general occurrence of display animals. Macroscopic examination of the shark is also an informative procedure. A systematic approach to this is started at the head, nostril, eyes, mouth and gills and move posteriorly. Any abnormalities observed should be recorded and discussed to find the appropriate action required.

Respiration rate can also be monitored. If necessary, blood samples can be drawn. Samples can be taken from larger juveniles and adults adjacent to the insertion of either the dorsal fin or the ventral midline. For ventral samples, the ventral surface can be exposed by lifting the caudal fin (Violetta, 2004). Needle gauge and syringe size should be determined on the size of the shark.

8.3 Routine Treatments

No routine treatments for bamboo sharks are administered on a regular basis. Maintenance of a high standard of water quality, following quarantine procedures before introducing new individuals to an exhibit and a balanced diet is sufficient.

8.4 Known Health Problems

There are a number of diseases common to elasmobranchs. However, few have been documented in *C. punctatum*. Goiter, burns and tuberculosis are the most typical health problems bamboo sharks will encounter in captivity.

Goiter

Goiter is the enlargement of the thyroid gland, essentially located in the middle of the lower jaw muscles. Starting as a small lump, it can develop to a size that potentially will prevent the shark eating, leading to starvation and death if left untreated. It is caused by an iodine deficiency in the diet (Crow, 2004). Whilst taking months to develop, a goiter takes just as long to reduce in size. A simple iodine supplement can be provided at the first signs of a goiter developing, continuing with the treatment until its disappearance.

Burns

Typically, brown-banded bamboo sharks have a limited sense of temperature changes. Thus, burns resulting from individuals resting on heaters can cause health problems (A. Elzer, *pers. comm.*). A simple solution to prevent this occurrence is placing the heaters higher in the tanks. Being a bottom-dweller, it is unlikely an animal will encounter a heater for long enough for serious burns to occur. Casings or having the heaters behind backdrops or within the plumbing system outside the tank will also reduce the risk.

Tuberculosis

A bacterial infectious disease, tuberculosis is present in humans and animals. The cause of (fish) tuberculosis is the bacterium *Mycobacterium marinum*. Signs an individual may be infected includes scale loss, lesions, colour loss and condition loss (Aquatic Community, 2004). Treatment is virtually impossible and thus prevention is the best method. Known tanks within an aquarium that have tuberculosis present should be provided with their own equipment (such as nets) to prevent spread between tanks. Thoroughly washing hands with alcohol foam and saltwater can also reduce the chance of spread between exhibits and from aquarists being infected. If infected individuals are euthanised due to becoming undesirable aesthetically, the entire exhibit should be cleaned meticulously with bleach and dried before being restocked to prevent the bacterium re-infecting new individuals.

8.5 Quarantine Requirements

Quarantine is an important tool for the prevention of disease transmission. It should be imposed any time a new animal is transferred to the wild, from the wild and between institutions. It allows for disease detection and also recovery periods and acclimatisation following transport.

A 30 day quarantine period is recommended with standard health checks being performed to ensure no transfer of disease occurs. Standard quarantine conditions are necessary such as isolation from other individuals and separate filtration from the main display water systems. The extent of diagnostic testing such as blood analysis, cultures, faecal examinations, etc, to be performed should be determined by the discretion of the individual institution.

9 Behaviour

9.1 Activity

Being a nocturnal species, the brown-banded bamboo shark has limited day time activity. The day usually involves resting in dark places such as caves, crevices, under rocks and other shaded areas. Juveniles are also known to hide among corals as due to their colour banding they camouflage well. At night, these sharks will hunt for food. Their diet consists of species such as squid, shrimp, small fish and other benthic organisms. They are capable of surviving extreme hypoxia (low-oxygen levels) making them a hardy species (Bester, Unknown).

9.2 Social Behaviour

Minimal information is known about the social organisation of this species. In general, it is thought to be a solitary species (Bester, Unknown), coming together to reproduce. It has been observed in captivity to have minimal inter- and intra-species interaction with tank mates (pers. obs.).

9.3 Reproductive Behaviour

No known courtship displays between males and females has been observed in the brown-banded bamboo shark. As with most species of shark however, a sign that a female will possibly soon lay eggs is bite marks on her body (N. Weller, *pers. comm.*). During mating, the male is required to insert one of his claspers, located on the inner side of his pelvic fin, into the female's genital opening (cloaca). In order to achieve this, the male uses his mouth to hold on to areas such as her gill slit or pectoral fin; these 'love bites' can be observed on mated females. Once mated with, the female lays a group of elongated, flattened eggs. These then attach to rocks, inside crevices, etc with filamentous material. The developing embryo feeds exclusively on the yolk sac until they hatch. In captivity, the eggs take between 4-6 months to hatch, with the time varying with temperature. The young are around 13-17cm when they emerge from the pod-like eggs and possess a distinct banding pattern, giving the name brown-banded bamboo shark. Once hatched, the juveniles are on their own, with no parental care exhibited.

9.4 Bathing

Being an aquatic species, even though it is possible for brown-banded bamboo sharks to survive a considerable amount of time out of water, without a saltwater environment, the shark will perish.

9.5 Behavioural Problems

No known serious behavioural problems are present in the brown-banded bamboo shark. They are small enough for trained aquarist's to handle without mechanical aid. They tend not to consistently move and will settle in dark places in the tank.

9.6 Signs of Stress

Indicators of stress include:

- Inappetence
- Expulsion of eggs by females
- Weight loss
- Injury from inter- or intra-species interaction



Figure 10 Injury sustained by a brown-banded bamboo shark, potentially from a shark ray (*Rhina ancylostoma*). Photo courtesy of Kristen Witcomb

9.7 Behavioural Enrichment

Enrichment strategies that may be used to stimulate natural behaviours in *C. punctatum* include:

- Adding extra substrate to allow for hibernation/aestivation displays
- Ensure tank is as large as possible
- Construct natural bollards, crevices, etc that allow the individuals to hide and be on display

- Vary feeding schedules and diet
- House with other specimens to simulate competition behaviour during feeds (monitor body condition to ensure all are having at least some access to food)
- Swap animals over between enclosures to provide new areas to explore or rearrange bollards, mock rocks, etc to create a new environment in the same tank

9.8 Introductions and Removals

No introduction or removal periods/procedures are necessary with *C. punctatum*. It is not a species with a highly developed social structure such as in primates and moving individuals will thus not cause tension between individuals. The only thoughts for the introduction of individuals is to ensure that the tank will not become overcrowded by any introductions as this can cause problems. Additionally, taking into account the size of individuals (small juveniles will find it difficult to compete with mature adults for food and require smaller food particles and more consistent feeds) being housed together. Lastly, performing the introduction early in the day allows for a longer monitoring period by staff post-introduction.

9.9 Intraspecific Compatibility

The brown-banded bamboo shark is quite compatible of being housed with its own species. As long as there is sufficient space (i.e. the tank is not overcrowded), hiding places and food being supplied then there will be no problems housing large numbers of this species together. However, size of individuals should be considered in terms of food competition and diet.

9.10 Interspecific Compatibility

C. punctatum can be comfortable housed with a wide variety of fish, sharks, rays, mammals and reptiles with no evident problems (pers.obs.). However, there are some species which are prone to bite and subsequently injure even mature brown-banded bamboo sharks. Shark rays (*R. ancylostoma*) and Lemon sharks (*Negaprion brevirostris*) for example are just two species that have been known to bite brown-banded bamboo sharks, with a worst case scenario of mortally wounding the individuals. Some bites are small and need no medical attention or just a short quarantine period to allow the injury to heal, but in some cases a bite is severe enough to cause death.

9.11 Suitability to Captivity

This species is highly suitable to captivity. It can be kept in private collections and on public display. With temperature control, good water quality, sufficient space and food, brown-banded bamboo sharks will thrive in captivity and require no human intervention to readily reproduce. This high suitability can lead to excess juveniles where methods such as sex separation need to be employed to reduce the reproduction rate.

10 Breeding

10.1 Mating System

Observing mating systems in sharks is often difficult. The mating system observed for brown-banded bamboo sharks is polygamous. It is thought for *C. punctatum* that females will mate with males until she realises she is holding eggs (N. Weller, 2011, *pers. comm.*). Once these eggs are deposited, it is assumed she will mate again with further males and continue the cycle as long as the optimal breeding conditions are maintained.

10.2 Ease of Breeding

The brown-banded bamboo shark readily breeds with little effort needed as long as ample food is supplied and water quality and housing is adequate.

10.3 Reproductive Condition

Males mature at 68 to 76 cm TL, females at about 63 cm TL (Compagno 2001).

10.3.1 Females

To reproduce females must first reach maturity which is age and size related at approximately 63cm total length (Bennett and Kyne, 2003). The female must also have a healthy body condition to be able to provide the nutrients and energy to develop healthy eggs and offspring. In captivity, this is dependent on aquarists maintaining a high standard of care and holding animals in their optimal conditions especially breeding individuals.

10.3.2 Males

Males too must also reach maturity before breeding which is age and size related also (68-76cm total length (Bennett and Kyne, 2003)). Seeing as though males are required to hold on to the female during mating, males must also have a peak body condition to have the opportunity to mate every season. In captivity, this is dependent on aquarists maintaining a high standard of care and holding animals in their optimal conditions especially breeding individuals.

10.4 Techniques Used to Control Breeding

The easiest method to control breeding of *C. punctatum* is to house males and females separately. Being housed in aquaria, there tends to be, especially with larger exhibits, the ability to do this. This method is the most effective without jeopardising future reproductive capabilities by other means. As long as no individuals are missed due to this species tending to like hiding, the method is encouraged. However, if mating does occur, the eggs can simply be removed if they are not desired and disposed of correctly, disallowing the eggs to hatch.

10.5 Occurrence of Hybrids

No known hybrids of this species have been recognised though little data from wild populations is known. It is highly possible that a hybrid specimen has not been discovered due to the difficulty in obtaining information from aquatic species, especially nocturnal ones.

10.6 Timing of Breeding

Eggs are generally laid between late July and February with mating occurring between July and September (Harahush *et al.* 2007); however, if temperature and photoperiod are monitored, the species is capable of breeding year round. There is also the potential for parthenogenesis to occur. Furthermore, females in the related epaulette shark (*Hemiscyllium ocellatum*) have the ability to store sperm to fertilise the ova for up to several months after mating and it is possible that the same scenario can occur in brown-banded bamboo sharks.

10.7 Age at First Breeding and Last Breeding

As previously discussed, breeding is not age related but size related.

10.8 Ability to Breed Every Year

This species has the ability to breed every year once they have reached maturity.

10.9 Ability to Breed More than Once Per Year

This species can breed multiple times per year under the optimal conditions.

10.10 Nesting, Hollow or Other Requirements

C. punctatum requires no nest or hollow. However, some objects (bollards, tunnels, crevices, etc.) are necessary for egg attachment to encourage natural reproductive behavior.

10.11 Breeding Diet

No change during breeding is required in terms of diet from the maintenance diet.

10.12 Incubation Period

Eggs should be kept in a smaller tank (3-4 foot tanks are suitable) with a temperature similar to that in which the eggs were originally laid. Due to higher temperatures increasing the rate of development of pups in eggs, incubation is between 4-6 months. Sydney Aquarium maintains eggs at 25.5-27.0°C with eggs hatching at around 3.5-4.5 months. Garner (2003) found a 12% decrease from 115 to 101 days incubation when temperature was raised from 24°C to 27°C whilst Michael (2001) observed a 27% decrease for the same temperature increase.

10.13 Clutch Size

A female is capable of laying between 2-3 eggs at a time. Harahush *et al.* (2007) found that females laid on average 115 eggs per season, of which approximately 33% were viable.

10.14 Age at Weaning

This species requires no weaning. From the time they hatch, *C. punctatum* pups are on their own.

10.15 Age of Removal from Parents

As with most oviparous shark species, being there no parental care, eggs should be removed from the parent tank as soon as they have been discovered to minimise the chance the eggs are damaged and allow the eggs to hatch safely without the possibility of being eaten due to the large size difference between the pups and most other species the brown-banded bamboo shark is housed with.

10.16 Growth and Development

Embryonic development

Table 4 Embryonic development in *Chiloscyllium punctatum* (adapted from Harahush *et al.* 2007)

| Stage | DPD | Embryonic size | Comments |
|-----------------|----------|----------------|---|
| Early embryonic | 9 | | germinative disc first visible to naked eye |
| | 18 | 2mm | irregular shape and motionless on side |
| | 23 | 6.30 ± 2.00mm | upright and motionless in yolk sac |
| | 27 | 11.34 ± 6.43mm | first signs of motility, 4 chambered heart pumping blood |
| | 30 | 13.55 ± 7.39mm | numerous blood vessels running through body |
| Pre-hatching | 35 | 22.42 ± 7.00mm | clear amniotic fluid dissolved, bottom edge of egg case weaken and allows seawater to enter and circulate in the eggs |
| | 53 | 38.25 ± 4.70mm | signs of pigmentation, external filamentous gills have emerged from gill slits |
| | 60 | 50mm | the medial finfold is replaced by adult-like dorsal, anal, pectoral and pelvic fins |
| Late embryonic | 82 | | pigmentation visible, fully formed mouth regularly opens and closes |
| | 90 | >80mm | banding present, nostrils and barbells are developed |
| Hatching | 153 ± 13 | 192 ± 9mm | yolk completely internalized and occupies entire pouch in egg case |

Growth rate

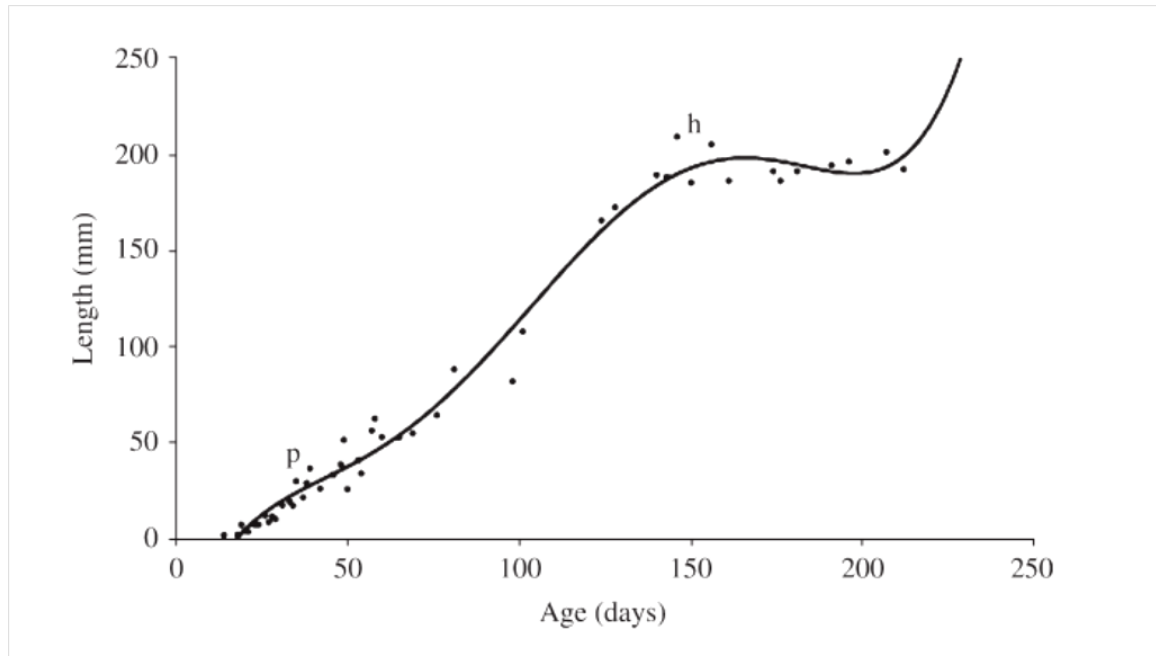


Figure 11 Growth rate of *Chiloscyllium punctatum*, showing growth pre- (p) and post- hatching (h) from Harahush *et al.* 2007.

11 Artificial Rearing

11.1 Incubator Type

A glass tank with good filtration, aeration and temperature control with a powerhead for circulation can work successfully and is fairly simple to find the components in the workplace and set up.

11.2 Incubation Temperature and other variables

Temperature should be maintained between 21-25°C (determined by the temperature of where the eggs were obtained, or slightly warmer to increase the developmental rate). Salinity should be 31-35ppt (salt water) with a 12 hr light: 12 hour dark light cycle.

11.3 Desired % Egg Mass Loss

No information relating to desired % egg mass loss could be located at this time.

11.4 Hatching Temperature

Temperature for the duration of egg incubation should be maintained consistently through to post hatching and growth outside of the egg.

11.5 Normal Pip to Hatch Interval

‘Pipping’ is not a shark egg characteristic and therefore irrelevant. However, it should be noted that during the pre-hatching stage (from approximately 35 post deposition), the bottom edge of the egg case weakens and the marginal seals (the respiratory fissures) open, allowing the entry of sea water (Harahush *et al.* 2007). Subsequent circulation within the egg case then occurs.

11.6 Diet and Feeding Routine

Post hatch, juveniles are reasonably weak and survive on the remainder of the yolk sac which has been internalised (Harahush *et al.* 2007). Harahush *et al.* (2007) notes that at UnderWater World, Sunshine Coast (Queensland, Australia) offered finely cut squid, fish and prawns 10 days post hatching and left the food in the tank for 5 minutes. All uneaten food was then removed. Feeding usually began between 14-21 days post hatching. If concern arises at lack of appetite, small pieces of food items (including minced prawn, whitebait and mussels) can be held directly in front of the mouth to entice the juvenile into feeding.



Figure 12 Young pup removed from an oceanarium at Sydney Aquarium, the egg was not found and put into a quarantine tank yet the juvenile survived. Photo courtesy of Kristen Witcomb.

11.7 Specific Requirements

The most obvious specific requirement for juvenile *C. punctatum* is the immersion in saltwater being an aquatic species. As previously mentioned in Housing Requirements, a temperature range between 24-27°C, with adequate shelter such as a hide and/or a visual barrier to minimise stress in pups is required. Ample space to display natural behaviours should additionally be provided.

11.8 Data Recording

A daily record sheet should be attached to the tank with the date the eggs went in and where they came from, with temperature and LSS checks recorded in the morning and the afternoon. The hatching date should be recorded and then any food items offered and whether or not they were eaten (individuals should be identified for feeding). Any changes (number of juveniles, feeding patterns etc) should also be recorded.

11.9 Identification Methods

The banding on juveniles is distinct like a fingerprint and can be used for identification purposes. Furthermore, depending on the age of the juveniles, size can be useful.

11.10 Hygiene

Hygiene is important as with any tank. Filters should be checked to be functioning at maximum capacity and cleaned when necessary. Post hatching when food is being offered, all uneaten material should be removed and detritus siphoned out as regularly as required (daily or twice daily is best). Food preparation and hygiene should be carried out as for adults (refer to Sections 5.1 and 6.2).

11.11 Behavioural Considerations

Adults prefer to hide in crevices and coral overhangs during the day and this should be replicated for juveniles. Pipes halved lengthways are suitable. If the area housing the juveniles is frequented regularly, covering $\frac{3}{4}$ of the side of the tank with a dark material (for example black corflute) will reduce stress responses.

11.12 Weaning

No weaning is required in *C. punctatum*.

12 Acknowledgements

I would like to extend thanks to Sydney Aquarium, for the experience provided in working with both juvenile and adult brown-banded bamboo sharks. The entire curatorial team, inclusive but not limited to those listed in the references for personal communications, aided in furthering my understanding of the behaviour, physiology and captive management of the species among guidance in the production of these guidelines.

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14 Glossary

Parthenogenesis: the production of fertile eggs (i.e. eggs that will successfully hatch a health pup) by a female without fertilisation from a male in sexual reproductive species.

15 Appendix

| Page 1 of 2 | | | | | | | | | |
|---|--|------------|----------------|-----------------------|------|-----------|------|--|---------|
| MATERIAL SAFETY DATA SHEET | | | | | | | | | |
| COMPANY DETAILS AUSTRALIAN DISTRIBUTOR: COMPANY: Chemical Essentials (Pty) Ltd Address: 13 Abella Str, Doncaster East, Victoria 3111 Emergency Telephone number: +03 9841 9901 Fax: +03 9841 9909 | MANUFACTURER: Health and Hygiene (Pty) Ltd P O Box 347, Sunninghill 2157, South Africa. Tel: +27 11 474-1668 Fax: +27 11 474-1670 e-mail: info@healthandhygiene.co.za | | | | | | | | |
| IDENTIFICATION | | | | | | | | | |
| PRODUCT NAME: F10 SUPER CONCENTRATE DISINFECTANT | UN Number: None D G Class: None Hazchem code: None Poisons Schedule: 5 | | | | | | | | |
| HAZARDOUS ACCORDING TO CRITERIA OF WORKSAFE AUSTRALIA IN THE PACK CONCENTRATE ONLY (eyes and skin irritant) | | | | | | | | | |
| USE: Biodegradable multi purpose Disinfectant for all hard surfaces, equipment and airspaces | | | | | | | | | |
| PHYSICAL DESCRIPTION/PROPERTIES | | | | | | | | | |
| Appearance: Clear, colourless liquid, with a slight natural odour. Boiling Point: 110°C Vapour Pressure: Not known Specific Gravity: 1.00 Flash Point: Not flammable Flammability Limits: Not flammable Solubility in water: Soluble | | | | | | | | | |
| INGREDIENTS | | | | | | | | | |
| | <table border="0"> <thead> <tr> <th style="text-align: left;">CAS Number</th> <th style="text-align: left;">Quantity (w/w)</th> </tr> </thead> <tbody> <tr> <td>Benzalkonium Chloride</td> <td>5.4%</td> </tr> <tr> <td>Biguanide</td> <td>0.4%</td> </tr> <tr> <td>Ingredients not determined to be hazardous</td> <td>to 100%</td> </tr> </tbody> </table> | CAS Number | Quantity (w/w) | Benzalkonium Chloride | 5.4% | Biguanide | 0.4% | Ingredients not determined to be hazardous | to 100% |
| CAS Number | Quantity (w/w) | | | | | | | | |
| Benzalkonium Chloride | 5.4% | | | | | | | | |
| Biguanide | 0.4% | | | | | | | | |
| Ingredients not determined to be hazardous | to 100% | | | | | | | | |
| HEALTH HAZARD INFORMATION | | | | | | | | | |
| HEALTH EFFECTS: Acute SWALLOWED: Low. Substantial ingestion may cause irritation to mouth, throat and digestive tract. EYE: Low. Will cause irritation but not serious damage. SKIN: Low. Concentrate may act as mild degreasant to sensitive skin. INHALED: Low. No significant hazard. | | | | | | | | | |
| Chrono INHALED: Low. No significant hazard | | | | | | | | | |
| FIRST AID | | | | | | | | | |
| SWALLOWED: DO NOT induce vomiting. Give milk or water to drink. Seek medical advice where necessary. EYE: Rinse eyes with water. Seek medical advice where necessary. SKIN: Wash affected area with soap and water. INHALED: Non-toxic. Avoid long term inhalation of neat liquid. Remove to fresh air. | | | | | | | | | |
| FIRST AID FACILITIES: Contact a doctor or Poison Information Centre (phone 131126) | | | | | | | | | |
| ADVICE TO DOCTOR: Treat symptomatically | | | | | | | | | |

F10 SUPER CONCENTRATE DISINFECTANT

PAGE 2 OF 2

PRECAUTIONS FOR USE

EXPOSURE LIMITS: No data found
Engineering controls: None required
PERSONAL PROTECTION: Not required
FLAMMABILITY: Not Flammable

SAFE HANDLING INFORMATION

Storage and Transport: Store below 30°C in dry conditions
SPILLS AND DISPOSAL: Soak up on an inert material e.g. dry earth and dispose of in an area approved by local authority by-laws. Flush small spills with copious amounts of water
FIRE/EXPLOSION HAZARD: The product is not flammable or explosive.
OTHER INFORMATION: Ensure good industrial hygiene.
DO NOT mix with soaps or other chemicals.

CONTACT POINT: Managing Director, +03 9841 9901
Chemical Essentials Pty Ltd

KEEP OUT OF THE REACH OF CHILDREN

Issue number: 2
Issue Date: August 2004



Glason - The Better Way of Doing Things!

Air-tech ANIMAL HOUSE 1
This revision issued: August 08

Material Safety Data Sheet

SECTION 1 - IDENTIFICATION OF CHEMICAL PRODUCT AND COMPANY

Statement of Hazardous Nature

This product is classified as: Hazardous according to the criteria of NOHSC Australia.

Not a Dangerous Good according to the Australian Dangerous Goods (ADG) Code.

Glason Specialised Services Pty Ltd
24 The Ridge, Narara
NSW 2250

Telephone: 02 4323 7792
Fax: 02 4325 7900

Substance: Blend of detergent and modifier.
Trade Name: Air-Tech Animal House
Product Use: Anionic surfactant - detergent powder.
Creation Date: May, 2003
Revision Date: September, 2009

Section 2 - Composition/Information on Ingredients

| Ingredients | CAS No | Conc. % | TWA (mg/m ³) | STEL (mg/m ³) |
|---------------------------------|------------|---------|--------------------------|---------------------------|
| Sodium dodecylbenzenesulfonate | 25155-30-0 | >60 | not set | not set |
| Other non hazardous ingredients | secret | to 100 | not set | not set |

This is a commercial product whose exact ratio of components may vary slightly. Minor quantities of other non hazardous ingredients are also possible.

The TWA exposure value is the average airborne concentration of a particular substance when calculated over a normal 8 hour working day for a 5 day working week. The STEL (Short Term Exposure Limit) is an exposure value that should not be exceeded for more than 15 minutes and should not be repeated for more than 4 times per day. There should be at least 60 minutes between successive exposures at the STEL. The term "peak" is used when the TWA limit, because of the rapid action of the substance, should never be exceeded, even briefly.

Section 3 - Hazards Identification

Risk Phrases: R22, R36. Harmful if swallowed. Irritating to eyes.

Safety Phrases: S20, S39. Safety Phrases are: When using, do not eat or drink. Wear eye/face protection.

SUSDP Classification: None allocated.

ADG Classification: None allocated. Not a Dangerous Good.

UN Number: None allocated

Emergency Overview

Physical Description & colour: White to Ivory coloured flaked solid

Odour: No odour

Major Health Hazards: harmful if swallowed.

Potential Health Effects

Inhalation

Short term exposure: Available data indicates that this product is not harmful. In addition product is unlikely to cause any discomfort or irritation.

Long Term exposure: No data for health effects associated with long term inhalation.

Skin Contact:

Short term exposure: Available data indicates that this product is not harmful. It should present no hazards in normal use. However product is believed to be mildly irritating, but is unlikely to cause anything more than mild transient discomfort.

Long Term exposure: No data for health effects associated with long term skin exposure.

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Eye Contact:

Short term exposure: This product is severely irritating to the eyes. It will cause intense discomfort such as severe pain, copious watering and redness of the eyes. Effects will last long after exposure has ceased, and in severe exposure, permanent effects such as corneal damage or blindness can occur.

Long Term exposure: No data for health effects associated with long term eye exposure.

Ingestion:

Short term exposure: Available data shows that this product is harmful, but symptoms are not available. This product is unlikely to cause any irritation problems in the short or long term.

Long Term exposure: No data for health effects associated with long term ingestion.

Carcinogen Status:

NOHSC: No significant ingredient is classified as carcinogenic by NOHSC.

NTP: No significant ingredient is classified as carcinogenic by NTP.

IARC: No significant ingredient is classified as carcinogenic by IARC.

Section 4 - First Aid Measures

General Information:

You should call The Poisons Information Centre if you feel that you may have been poisoned, burned or irritated by this product. The number is 13 1126 from anywhere in Australia (0800 764 766 in New Zealand) and is available at all times. Have this MSDS with you when you call.

Inhalation: First aid is not generally required. If in doubt, contact a Poisons Information Centre or a doctor.

Skin Contact: Blot or brush away excess chemical. Wash gently and thoroughly with water (use non-abrasive soap if necessary) for 10 minutes or until chemical is removed. Under running water, remove contaminated clothing, shoes and leather goods (e.g. watchbands and belts). If irritation persists, repeat flushing and obtain medical advice.

Eye Contact: Quickly and gently blot or brush product away. Flush the contaminated eye(s) with lukewarm, gently flowing water until the product is removed or until irritation has ceased, while holding the eyelid(s) open. Obtain medical advice if irritation becomes painful or lasts more than a few minutes.

Ingestion: If swallowed, do NOT induce vomiting. Wash mouth with water and contact a Poisons Information Centre, or call a doctor.

Section 5 - Fire Fighting Measures

Fire and Explosion Hazards: There is a slight risk of an explosion from this product if commercial quantities are involved in a fire.

Fire decomposition products from this product may be toxic if inhaled. Take appropriate protective measures.

Extinguishing Media: Preferred extinguishing media are carbon dioxide, dry chemical, foam, water fog.

Fire Fighting: If a significant quantity of this product is involved in a fire, call the fire brigade.

Flash point: Not flammable.

Upper Flammability Limit: No data.

Lower Flammability Limit: No data.

Autoignition temperature: No data.

Flammability Class: No data.

Section 6 - Accidental Release Measures

Accidental release: In the event of a major spill, prevent spillage from entering drains or water courses. Wear full protective clothing including face mask, face shield and gauntlets. All skin areas should be covered. See above under Personal Protection regarding Australian Standards relating to personal protective equipment. Suitable materials for protective clothing include rubber, PVC. Stop leak if safe to do so, and contain spill. Sweep up and shovel or collect recoverable product into labelled containers for recycling or salvage, and dispose of promptly. Can be slippery on floors, especially when wet. Recycle containers wherever possible after careful cleaning. After spills, wash area preventing runoff from entering drains. If a significant quantity of material enters drains, advise emergency services.

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This material may be suitable for approved landfill. Ensure legality of disposal by consulting regulations prior to disposal. Thoroughly launder protective clothing before storage or re-use. Advise laundry of nature of contamination when sending contaminated clothing to laundry.

Section 7 - Handling and Storage

Handling: Keep exposure to this product to a minimum, and minimise the quantities kept in work areas. Check Section 8 of this MSDS for details of personal protective measures, and make sure that those measures are followed. The measures detailed below under "Storage" should be followed during handling in order to minimise risks to persons using the product in the workplace. Also, avoid contact or contamination of product with incompatible materials listed in Section 10.

Storage: Store packages of this product in a cool place. Make sure that the product does not come into contact with substances listed under "Materials to avoid" in Section 10. Check packaging - there may be further storage instructions on the label.

Section 8 - Exposure Controls and Personal Protection

The following Australian Standards will provide general advice regarding safety clothing and equipment:

Respiratory equipment: AS/NZS 1715, Protective Gloves: AS 2161, Industrial Clothing: AS2919, Industrial Eye Protection: AS1336 and AS/NZS 1337, Occupational Protective Footwear: AS/NZS2210.

Exposure Limits **TWA (mg/m³)** **STEL (mg/m³)**
Exposure limits have not been established by NOHSC for any of the significant ingredients in this product.

Ventilation: No special ventilation requirements are normally necessary for this product. However make sure that the work environment remains clean and that dusts are minimised.

Eye Protection: Eye protection such as protective glasses or goggles is recommended when this product is being used.

Skin Protection: You should avoid contact even with mild skin irritants. Therefore you should wear suitable impervious elbow-length gloves and facial protection when handling this product. See below for suitable material types.

Protective Material Types: We suggest that protective clothing be made from the following materials: rubber, PVC.

Respirator: If there is a significant chance that dusts are likely to build up in the area where this product is being used, we recommend that you use a suitable Dust Mask.

Section 9 - Physical and Chemical Properties:

| | |
|---|--|
| Physical Description & colour: | White to Ivory coloured flaked solid |
| Odour: | No odour |
| Boiling Point: | No specific data. Expected to decompose before boiling. |
| Freezing/Melting Point: | No specific data. Solid at normal temperatures. |
| Volatiles: | No specific data. Expected to be low at 100°C. |
| Vapour Pressure: | No data. Expected to be low at normal room temperatures. |
| Vapour Density: | No data. |
| Specific Gravity: | No data. |
| Water Solubility: | Approx 10% by weight. |
| pH: | No data. |
| Volatility: | No data. |
| Odour Threshold: | No data. |
| Evaporation Rate: | No data. |
| Coeff Oil/water distribution: | No data. |
| Autoignition temp: | No data. |

MATERIAL SAFETY DATA SHEET

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Material Safety Data Sheet

Section 10 - Stability and Reactivity

Reactivity: This product is unlikely to react or decompose under normal storage conditions. However, if you have any doubts, contact the supplier for advice on shelf life properties.

Conditions to Avoid: None known.

Incompatibilities: strong oxidising agents.

Fire Decomposition: Carbon dioxide, and if combustion is incomplete, carbon monoxide and smoke. Oxides of sulfur (sulfur dioxide is a respiratory hazard) and other sulfur compounds. Most will have a foul odour. Water. Carbon monoxide poisoning produces headache, weakness, nausea, dizziness, confusion, dimness of vision, disturbance of judgment, and unconsciousness followed by coma and death.

Polymerisation: This product is unlikely to undergo polymerisation processes.

Section 11 - Toxicological Information

Local Effects:

Target Organs: There is no data to hand indicating any particular target organs.

Classification of Hazardous Ingredients

| Ingredient | Risk Phrases |
|---|--------------|
| No hazardous ingredients present in hazardous concentrations. | |

Section 12 - Ecological Information

This product is biodegradable. It will not accumulate in the soil or water or cause long term problems.

Section 13 - Disposal Considerations

Disposal: Containers should be emptied as completely as practical before disposal. If possible, recycle containers either in-house or send to recycle company. If this is not practical, send to a commercial waste disposal site. This product should be suitable for landfill. However, check with local Waste Disposal Authority before sending there. Note that product properties may have been changed in use, significantly altering its suitability for landfill. Please do NOT dispose into sewers or waterways.

Section 14 - Transport Information

ADG Code: This product is not classified as a Dangerous Good. No special transport conditions are necessary unless required by other regulations.

Section 15 - Regulatory Information

AICS: All of the significant ingredients in this formulation are to be found in the public AICS Database.

MATERIAL SAFETY DATA SHEET

Issued by: Glason Specialised Services Pty Ltd

Phone: 02 4323 7782



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Air-tech ANIMAL HOUSE 1
This revision issued: August 08

Material Safety Data Sheet

Section 16 - Other Information

This MSDS contains only safety-related information. For other data see product literature.

Acronyms:

| | |
|----------------|---|
| ADG Code | Australian Code for the Transport of Dangerous Goods by Road and Rail |
| AICS | Australian Inventory of Chemical Substances |
| CAS number | Chemical Abstracts Service Registry Number |
| Hazchem Number | Emergency action code of numbers and letters that provide information to emergency services especially firefighters |
| IARC | International Agency for Research on Cancer |
| NOHSC | National Occupational Health and Safety Commission |
| NOS | Not otherwise specified |
| NTP | National Toxicology Program (USA) |
| R-Phrase | Risk Phrase |
| SUSDP | Standard for the Uniform Scheduling of Drugs & Poisons |
| UN Number | United Nations Number |

THIS MSDS SUMMARISES OUR BEST KNOWLEDGE OF THE HEALTH AND SAFETY HAZARD INFORMATION OF THE PRODUCT AND HOW TO SAFELY HANDLE AND USE THE PRODUCT IN THE WORKPLACE. EACH USER MUST REVIEW THIS MSDS IN THE CONTEXT OF HOW THE PRODUCT WILL BE HANDLED AND USED IN THE WORKPLACE.
IF CLARIFICATION OR FURTHER INFORMATION IS NEEDED TO ENSURE THAT AN APPROPRIATE RISK ASSESSMENT CAN BE MADE, THE USER SHOULD CONTACT THIS COMPANY SO WE CAN ATTEMPT TO OBTAIN ADDITIONAL INFORMATION FROM OUR SUPPLIERS
OUR RESPONSIBILITY FOR PRODUCTS SOLD IS SUBJECT TO OUR STANDARD TERMS AND CONDITIONS, A COPY OF WHICH IS SENT TO OUR CUSTOMERS AND IS ALSO AVAILABLE ON REQUEST.

Please read all labels carefully before using product.

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