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Protocols for capturing and tagging juvenile white sharks in near-shore waters

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Introduction

This document has been drafted specifically with respect to the capture and tagging of juvenile white sharks for the purpose of attaching satellite tracking tags and/or intra-peritoneal insertion of acoustic tags (via surgery). It details the procedures involved, the identified risks and the control measures in place to minimise those risks. It recognises that the capture and tagging of juvenile white sharks is a potentially dangerous procedure and that staff undertaking such activities require specific instructions and guidelines to ensure safe and successful operations.

All tagging of white sharks requires current permits from the relevant State and/or Commonwealth agencies and procedures are required to be approved by an independent Animal Ethics Committee.

1.1 Staff

Tagging and handling sharks requires a certain level of physical fitness. It is therefore imperative that staff are fit and healthy - as a minimum, staff should be able to pass the equivalent of a diving medical and be fit for at sea duties.

1.2 Instructions to staff

All staff undertaking the capture and tagging procedure are assigned specific tasks for the process and are briefed on both the overall procedure as well as those specific to their assigned tasks. These briefings are given prior to undertaking the work and may include video footage of the capture and tagging process. CSIRO maintains a video library of catching and tagging sequences for reference and training.

Briefings are held prior to each capture and debriefings are held after each capture. This ensures that the process is adaptive and that any issues arising, or improvements to the procedures can be openly discussed, agreed and incorporated if necessary.

The number of sharks captured per day will vary depending on the availability of sharks, the environmental conditions on the day and the physical state of the team. Searching for and capture of sharks in the near-shore waters is both physically and mentally demanding. It is imperative that the Field Leader and Vessel Skipper recognise the limitations of the team, particularly towards the end of the day when all team members tire. In general, juvenile white sharks in near-shore are less than 3.0 m total length (TL) and the capture and handling gear is designed for sharks of this size. The capture of and handling of sharks up to 3.5 m is possible with the gear provided but sharks at these larger sizes are more challenging and time consuming to handle. The decision to capture any shark will be based on the status of the team (taking into account their level of tiredness), the environmental conditions (swell, wind, and temperature), remaining daylight period available and the size of the sharks involved.

1.3 Vessel(s)

Capture of sharks requires one or two vessels depending on their size and capabilities. Vessels operating in the surf zone require a high level of manoeuvrability and vessels less than 7 m are recommended. Vessels such as Stabi-Craft or rigid-hull inflatables are suitable for such operations. Capture, tagging and release operations may proceed from the same vessel provided there is sufficient space and stability to carry both the vessel crew and the capture and tagging teams, as well as all necessary equipment for operational procedures. The vessel used for tagging should have a davit and a means of lifting and securing the tagging stretcher. Vessels used should comply with appropriate survey requirements for the area of operation.

2 Description of procedures, identification of risks and management of those risk

Juvenile white sharks are usually visually located by patrolling the vessel near to the surf zone. Once located a shark is approached and presented a baited line. Sharks are captured by hooking and tiring them 'by hand' on 12 mm rope using a single 12 to 14-0 hook attached to a short multi-strand steel trace. It is preferable to hook sharks on the left side of their jaw. Hooking sharks on their left side generally ensures that the sharks are more easily controlled to enter an in-water stretcher set on the starboard side of the tagging vessel (Figure 1). If the stretcher was set on the port side of the vessel, hooking the shark on the right side of the jaw would be preferable. Sharks are gradually tired to the point whereby they can be safely handled, yet are still able to independently swim when released. This process may take from 15 - 30 minutes and is dependent on the behaviour of the shark. When ready, sharks are restrained in a purpose built stretcher that is in the water beside the vessel (on the starboard side). Once secured in the tagging stretcher, tagging follows the following sequence:

- surgery to insert acoustic tag into peritoneal cavity
- satellite tag attached to first dorsal fin
- external tags (conventional or additional electronic tags) attached as appropriate
- length measurement
- removal of hook
- release.

Figure 1: Single capture-tagging vessel with in-water stretcher secured to starboard side.

2.1 Assigned tasks – Team members

2.1.1 SCIENTIFIC

Field leader – (can be any member of the overall team) - coordinates overall capture, tagging and release procedures, conducts briefings, liaison with vessel skipper.

Catching team - two staff - responsible for hooking and controlling the shark, identifying when shark is ready for tagging. One person (*Capture Leader*) assigned to lead the capture procedure including presenting baits, controlling the hooking and rope handling procedure as well deciding when the shark is ready for loading into the stretcher. The second team member (*Rope Handler*) ensures that the capture rope is managed as it is fed out or brought in by laying it into a container (usually a fish bin) on deck.

Tagging team – minimum two staff - responsible for attaching the tags to the fin and body of the shark, surgical procedures, husbandry protocols (e.g. administering oxygen therapy) and removal of the hook. One person (*Tag Leader*) is the nominated tagger, the other (*Tag Assistant*) passes and retrieves tagging hardware to and from the tagger during the process. One or more of the catching team may double as a member of the tagging team. The tagging team may seek assistance from the vessel crew provided it is operationally safe for the crew to provide such assistance (at the discretion of the vessel skipper). The Tag Leader is required to be trained under CSIRO procedures for fish tagging and surgery (the latter if surgical procedures are used). A document summarising training protocols is available from CSIRO (Bradford *et al*. 2009).

2.1.2 VESSEL

Skipper - responsible for the overall safety of staff and the vessel. Manoeuvres the vessel during search, capture and tagging procedures to assist the team in locating, capturing, tagging and releasing sharks. Ensures the vessel and all associated vessel equipment (including all safety equipment) is in working condition and meets survey requirements. Liaises with *Field Leader* on operational decisions.

Crew – if required on the vessel. The crew will follow the directions of the skipper and be available to assist the Capture and Tagging teams if required.

2.2 Risk management

Vessel staff and scientific staff will hold a current first aid certificate. A suitable First Aid kit is available onboard.

2.2.1 HANDLING AND ORGANISING GEAR – WORK SPACE ON DECK

Catching and tagging of sharks requires a considerable amount of gear to be organised in restricted space onboard a vessel (e.g. see Figure 2). Gear includes capture rope, bait ropes, floats, hooks and traces, bait, tools, compressed air hoses, oxygen delivery equipment, surgical gear, logbooks, tags, knives and safety equipment. It is imperative that the deck/work-space of the vessel is cleared of all unnecessary equipment prior to attempting capture. All required gear should be stowed in vessel storage spaces or organised in specific water resistant containers/boxes, allowing for sufficient deck space for the catching team to operate safely.

Figure 2: Capture and tagging of sharks requires organising a considerable amount of gear into a restricted vessel space.

2.2.2 SEARCH PROCEDURE AND CONDITIONS

The vessel skipper and Field Leader will make an assessment of sea conditions at the start of each fieldwork day and work will only proceed if sea conditions are considered suitable. Typically, wind-speed should be less than 20kts and swell below 2 m. However, conditions vary locally and field conditions will be continually assessed throughout the operational day by the vessel skipper and field leader. Either the vessel skipper or field leader may direct field operations to cease should conditions be considered unsafe and each must take into account safety concerns expressed by any staff onboard.

All staff on-board a vessel undertaking procedures for the capture of sharks in near-shore waters are required to wear a suitable PFD. Inflatable PFDs are recommended. The capture vessel is manoeuvred near to the surf zone/shore with due regard to the environmental conditions (swell and wind). The vessel skipper manoeuvres with priority regard to the safety of on-board staff and the vessel. All staff (vessel and field team) will maintain a constant lookout in all directions for approaching waves and for sharks (Figure 3).

All staff must wear suitable leather gloves at all times when handling either the capture line, transfer line or trace to minimise the risk of rope-burns. In general, the capture line consists of a minimum 100 m of 12 mm floating rope to which an approximate 1.5 m braided stainless steel trace fitted with a swivel is attached. The galvanised 12 to 14-0 hook has its barb partially removed (to facilitate removal of the hook prior to release of the shark) and is attached to the trace by a stainless steel shackle which can be undone and the trace removed in the event that the hook cannot be removed.

Figure 3: Vigilance in monitoring wave conditions from all directions, as well as for spotting sharks, is essential in near-shore waters.

Once a shark is located, the vessel approaches as close as practical to enable the Capture Leader to present the baited line to the shark (Figure 4). Where possible the baited line should be presented on the left side of the shark to facilitate hooking the shark on the left side of the jaw (Figure 5). Sharks, when brought near to the vessel, tend to pull away from the side they are hooked on. Hooking a shark on the left side of the jaw helps to control a shark's entry into the in-water stretcher which is always positioned on the starboard side of the vessel.

Figure 4: Vessel approach to a juvenile white shark.

Figure 5: Presenting a baited line to the left side of a juvenile white shark.

2.2.3 CAPTURE PROCEDURE

After the bait is presented to the shark, the vessel skipper will generally turn the vessel to face away from the beach in preparation to steam ahead once the shark is hooked and lead the shark away from the near-shore zone. The Capture Leader will provide directions to the skipper so as to control the speed of the vessel after hook-up to ensure that the capture rope remains under sufficient tension and that the shark remains close enough to the vessel to maintain control.

Hook-up usually includes a rapid run by the shark, a possible partial or full breach and may initially include a directed run by the shark towards the vessel (Figure 6). It is imperative that some tension be maintained on the capture rope at all times with rope fed from the vessel when the shark is running away or rope being retrieved to the vessel when the shark is approaching.

Figure 6: Full and partial breaches by juvenile white sharks on hook-up.

Staff entanglement in the capture rope is a risk. It is imperative that the rope-handler ensures that all rope is contained in the rope bin and no loose rope is on the deck at any time during the capture procedure (Figure 7). A safety knife capable of quickly severing the capture rope if required will be mounted in close proximity to the capture operations at all times.

The shark is gradually led away from the near-shore zone and tired by additional polystyrene floats (using quick release shark-clips) to the line - this ensures that the shark is 'worked' by the floats and eases the workload on the capture team (Figure 8). These floats are gradually worked down towards the trace as the capture rope is retrieved.

The vessel is manoeuvred to assist the capture team by limiting the distance between the shark and the vessel and to approach the shark in a controlled manner when hauling the capture rope. Directions are provided to the vessel skipper by the Capture Leader. The capture vessel maintains headway at all times, although the speed will vary depending on requirements.

Figure 7: The rope-handler's task is to ensure the capture rope feeds into and out of the rope bin (the blue fish box seen here).

Figure 8: Polystyrene floats attached to the capture line.

2.2.4 SHARK CONTROL AND HANDLING

A shark is ready for handling when it is swimming slowly at the surface; it is not making directed runs away from the vessel and will follow the vessel during manoeuvres (Figure 9). The Capture Leader is vested with making this call. The time taken to reach this point is independent of the size of the shark and can range

from approximately 15 to 30 minutes. This ensures that the shark will be in a calm and controlled state when secured in the stretcher and will present minimal risk to its own safety and that of staff in close proximity.

Figure 9: A juvenile white shark showing all signs of being ready to be loaded into the tagging stretcher.

Loading of a shark into the tagging stretcher may occur at the capture vessel, or using a separate vessel to the capture vessel. The procedures to load a shark into the capture stretcher are the same in both cases. However, the use of a second vessel requires that the shark be transferred from the initial capture line on the capture vessel to a transfer line resident on the tagging vessel.

2.2.5 TRANSFERRING A SHARK FROM THE CAPTURE VESSEL TO THE TAGGING VESSEL

Transferring a hooked shark from a capture vessel to a tagging vessel requires specific adaptations to the capture rope system (Figure 10). The main capture rope on the capture vessel is terminated in a spliced loop on which is mounted a quick-release snap clip. A small float is attached to the capture rope immediately prior to the snap clip to compensate for its weight and maintain the buoyancy of the capture rope system. An identical transfer rope is resident on the tagging vessel. The main capture rope is clipped to a secondary five metre length of capture rope with a spliced end loop. The trace and hook are attached to the distal end of this secondary rope. The main and secondary capture ropes are attached (1) when the shark is initially hooked. Once the shark is tired sufficiently to load it into the tagging stretcher, the transfer rope is passed from the tagging vessel to the capture vessel and clipped to the secondary capture rope (2). Once the transfer rope is attached, only then is the main capture rope unclipped leaving the shark attached to the transfer rope. The tagging vessel then has full control of the shark.

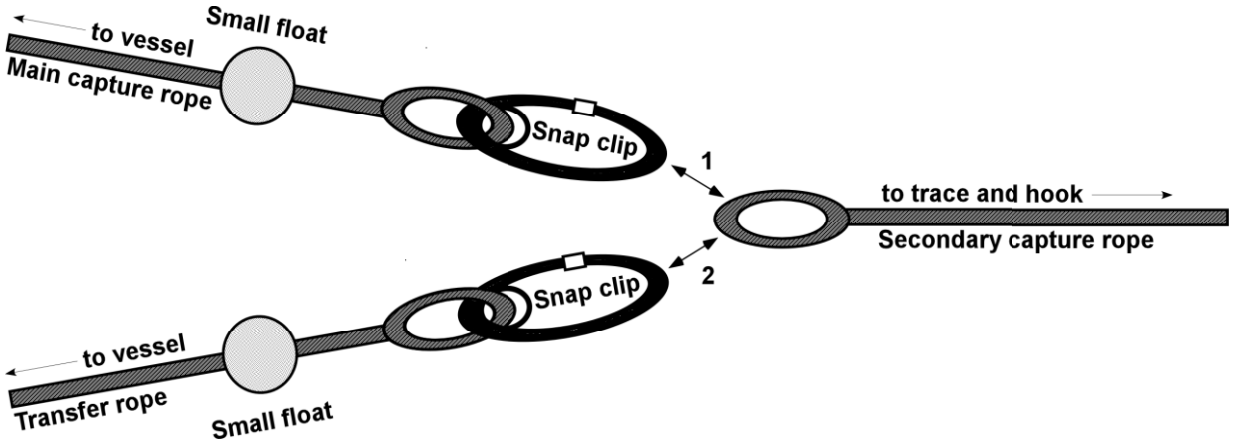

Figure 10: Configuration of main capture rope, secondary capture rope and transfer rope. Numerals 1 and 2 refer to actions described in the text.

Once the shark is deemed ready to be transferred by the capture team and the capture vessel is able to maintain a steady forward speed, the tagging vessel is informed and takes up position in front of the tagging vessel. The capture vessel will be underway. The tagging vessel must not impede or slow the progress of the capture vessel as this will cause the capture rope to lose tension and result in a loss of control of the shark. The tagging vessel needs to come within sufficient distance to pass the transfer rope to one of the capture team who will be positioned on the bow of the capture vessel. The transfer rope is then taken along the side of the vessel on which the shark is swimming and clipped to the secondary capture rope. Once attached, the main capture rope is unclipped, the tagging vessel is informed to take up any slack in the transfer rope and take control of the shark. The capture vessel immediately places all motors in neutral and allows the shark to pass, attached to the transfer rope. Two staff on the tagging vessel assume the role of Capture Leader and rope handler to ensure the control of the shark and safe rope-handling practices.

Once the tagging vessel has taken control of the shark, the capture vessel may return to the near-shore environment to continue searching for sharks unless otherwise directed by the tagging vessel. The tagging vessel may request one of the capture team to assist with loading the shark into the tagging stretcher. If this request is made, the capture vessel will come along side and transfer the nominated team member.

2.2.6 RESTRAINING THE SHARK IN THE IN-WATER STRETCHER

Sharks are readied for tagging by first loading them into the tagging stretcher. This can be the most challenging part of the capture-tagging process for all staff and concentration is vital. The vessel should be turned down-wind to maintain some forward momentum for when the motors are placed in neutral. The tagging vessel will maintain forward momentum at the direction of the Capture Leader. The tagging team, with the assistance of vessel crew if available, will ready the stretcher and lower it into position in the water as the vessel continues forward momentum. The front ends of the stretcher are pulled together to form a 'V' to prevent the shark from moving all of the way through. The Capture Leader will bring the shark towards the rear of stretcher and, once in position, will call for motors to be placed in neutral by the skipper. The Capture Leader, assisted by the tagging team, leads the shark into the stretcher (Figure 11).

On occasions, the shark will not stream directly into the capture stretcher and will stall its forward progress at the entry to the stretcher or will move slightly past the mouth of the stretcher on the outer side (Figure 12).

Figure 11: Leading a juvenile white shark into the tagging stretcher. Notice the stretcher forms a 'V' to contain the shark.

Figure 12: A shark positioned on the outer side of the stretcher during entry.

In these cases, it is important for the Capture Leader to maintain tension on the trace in order to keep the shark's head at the surface and, if possible, slightly out of the water. This position will maintain control of the shark. A shark in this position may attempt to roll, but this can also be controlled by keeping tension on the trace. With the head of the shark controlled, the vessel may be placed momentarily in gear to assist in streaming the shark's body towards the surface thus assisting its entry into the stretcher.

Sometimes it is easiest to lower the outer side of the stretcher and allow the shark to come in over the lowered side. If necessary a tail rope will sometimes assist in securing the shark at this point.

Once in the stretcher, the outer-side of the stretcher is raised using the davit. The stretcher should be raised to a level where there is sufficient access to the shark for the purpose of tagging, with its dorsal musculature or flank just out of the water (or ventral surface if the shark is inverted), but where the shark's head is still underwater (Figure 13). Sharks generally settle very quickly in the stretcher and will usually remain montionless. The Capture Leader (or team designate) will take control of the trace, moving to the head of the shark. The trace should be kept under some tension while the shark remains in the stretcher. However, care should be taken that the trace does not rub over the shark's eyes. The tagging team remove the floats clipped on to the capture rope and stow.

Figure 13: The stretcher is raised to the level where the shark is secure, the dorsal surface or flank is accessible and just clear of the water, but the head remains submerged.

The oxygen delivery system is lowered into the water in front of the shark's head (Figure 14). The delivery system is a 12 volt submersible bilge pump housed in an open ended PVC pipe and attached to a pole. A tube delivers medical grade oxygen from a cylinder located onboard (set at approximately 6 litres per minute) into the PVC pipe ahead of the bilge pump. The bilge pump is powered by the 12 volt system onboard the vessel. The flow of water from the oxgen delivery system is directed into the mouth of the shark during the tagging procedure. This has two purposes - it maintains the health of the shark while it is restrained (white sharks are normally required to swim in order to maintain sufficient oxygen flow over their gills to respire) and it has a slight sedative effect, which keeps the shark calm.

Smoking is not permitted at any time onboard due to the use of oxygen.

Figure 14: Oxygen delivery system in place in front of the shark's head.

Although every effort should be made to minimise the time in the in-water stretcher, sharks provided oxygen using the system above will remain in a vigorous state for at least 20 minutes. We have observed no demonstrable ill-effects of such extended periods in the stretcher. Sharks will generally remain motionless during the tagging procedure with the exception of two predictable periods described below. However, care should always be taken if working near the head of the shark. In all cases only the Capture Leader, or a team designate assigned to hold the trace, should be present near to the head of the shark and should remain vigilant regarding any movement of the shark.

2.2.7 TAGGING

Intra-peritoneal tags (if used) are applied first. The surgical procedure requires the shark to be ventral side up. In most cases this requires the shark to be rolled into this position. Physically handling a live shark should always be done so with caution. The shark will usually be rolled away from the vessel to expose the ventral surface. Tension on the trace will need to be relaxed during this process and in some cases the stretcher may also need to be lowered slightly to allow the shark to roll more easily. Various species of sharks, including white sharks, demonstrate tonic immobility where individuals will remain in a relaxed and immobile state when inverted (Henningsen 1994).

Suitable surgical gloves should be worn by the Tag Leader. Once inverted and stable, the Tag Leader applies Betadine™ to the incision area prior to the surgical procedure. They then make a 25-30 mm incision, using a surgical knife, beside the ventral midline within the zone approximately one third to two thirds the distance between the anus and the pectoral fin insertion where the combined skin, musculature and peritoneal wall is thinnest (Figure 15). A surgical knife is used in preference to a scalpel due to its greater robustness. Scalpels can easily break and present a hazard under these field conditions. Care is taken when making the incision not to cut into the liver when piercing the peritoneal wall. Incisions are closed using PDS II synthetic absorbable sutures (Ethicon Inc.) All surgical instruments and the acoustic tag are sterilised in Betadine™ prior to use. The Tag Assistant stands by near to the Tag Leader and passes tools and tagging gear as requested.

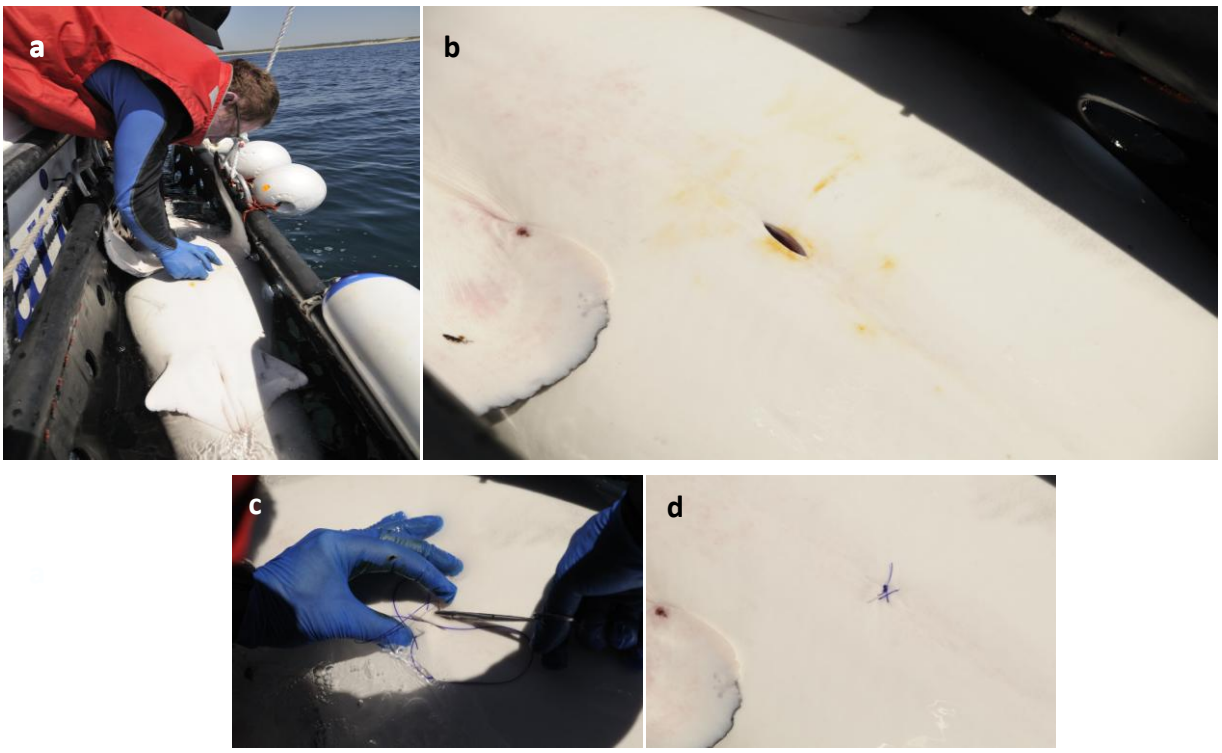

Figure 15: Surgical procedure. (a) Making the incision on the ventral surface of the shark; (b) the incision; (c) suturing the incision; (d) the sutured incision.

Once the incision is closed, the shark is again rolled in the stretcher to an upright position as to allow access to the dorsal surface. Once righted, sharks will usually twist and move in the stretcher, possibly in response to the disruption of tonic immobility. Care should be taken at this point to keep tension on the trace and to stay clear of the head. Sharks will then usually rapidly re-settle and tags can then be applied to the dorsal fin and musculature.

Dorsal fin mounted satellite tags are attached by piercing the dorsal fin using a compressed air-powered drill and purpose designed stainless steel tissue-sampler. A template is used to position the tissue sampler during the process. A Teflon board is placed behind the dorsal fin to hold the fin steady and protect the Tag Leader's hand from the sampler during the process (Figure 16). The tissue sampler makes an approximate 5 mm diameter hole through the dorsal fin and retains the tissue plug for genetic analyses. All compressed air powered tools must be tested prior to each field-trip and appropriately cleaned and serviced after each trip. Compressed air for the tools used is sourced from an onboard SCUBA tank fitted with an approved low pressure regulator.

After the satellite tag is attached other tags (e.g. a conventional spaghetti tag and a PSAT tag if used) are inserted into the dorsal musculature near to the base of the dorsal fin. A small incision is made in the musculature using a surgical knife. Tags are applied using a hand-held tag applicator through the small incision. Sharks will sometimes twist and move at this point thus it is important for the Tag Leader to inform all team members near to the shark prior to inserting such tags.

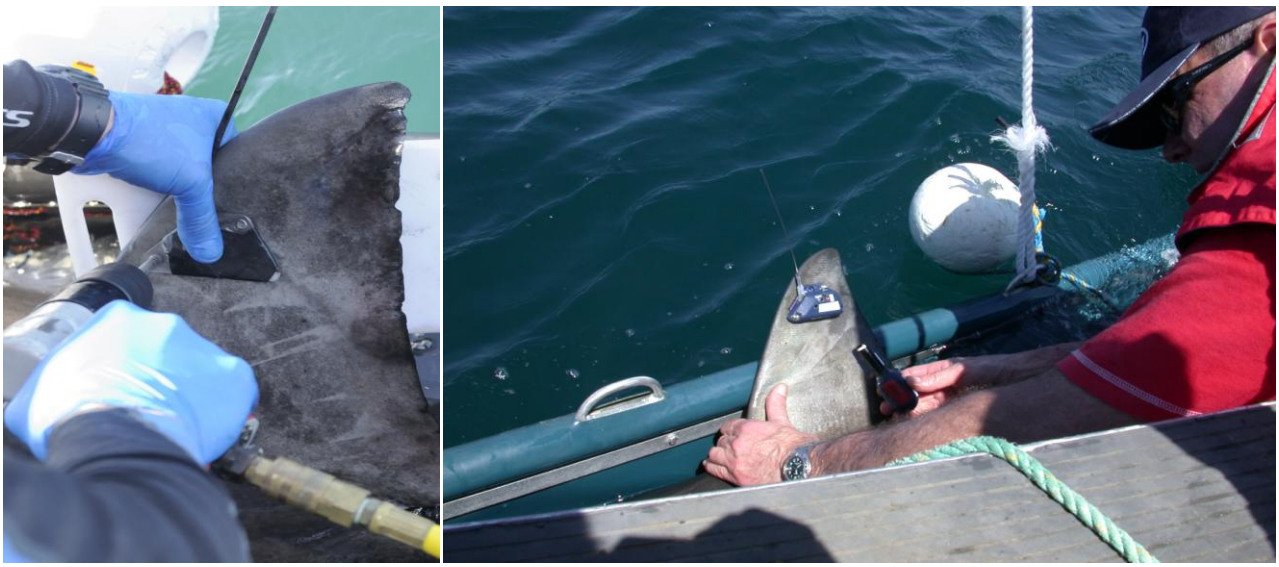

Figure 16: Using the dorsal fin tissue sampler and the attached satellite tag.

2.2.8 POST TAGGING PROCEDURES

All sharks are measured to the nearest centimetre prior to release using a standard steel tape measure. Total length is measured with the tail in a normal swim position (Figure 17).

Figure 17: Measuring a shark prior to release.

All reasonable steps should be taken to remove the hook from the mouth of the shark using a suitable de-hooking tool.

Extreme care must be taken when working near to the mouth of the shark.

If the hook cannot be accessed or easily removed, the trace can be removed by undoing the connecting shackle using the de-shackling tool.

If this is not possible, the trace should be cut with suitable wire cutters as close to the hook as possible.

Figure 18: Removing the hook prior to release.

After all procedures have been completed and the hook/trace removed, the front ends of the stretcher can be opened, the stretcher lowered slightly and the shark moved forward to a release position, allowing the shark to swim out of the stretcher (Figure 19). Care should be taken by team members of the tail of the shark at this point as the shark may power out of the stretcher, moving its tail rapidly in the process.

Figure 19: Releasing tagged sharks.

2.2.9 ADDITIONAL PRECAUTIONS

It is common for multiple sharks to be present in areas where juvenile white shark tagging operations occur. In some circumstances it is possible that larger sub-adult or adult sharks may also be present. This presents a risk that the capture and restraining of a juvenile shark may attract attention from a larger

conspecific. All staff not directly involved in the capture or tagging process should regularly scan waters around the vessel to ensure that no other sharks are present in the work environment.

Vessel staff should remain particularly vigilant when a shark is in the stretcher and the tagging team is focussed on operational tasks. Should another shark be sighted in the work environment when tagging is in progress, all tagging activities should cease and the behaviour of the free-swimming shark monitored. Tagging will be terminated should the free-swimming shark approach or interfere with the stretcher. The captured shark should be released at the earliest and safest opportunity (regardless of the stage of the tagging process) and tagging terminated for that day.

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