

5. Regulatory measures

5.1 SIZE LIMITS

Definition

A minimum individual length or weight of sea cucumbers that can be legally fished or traded.

Size limits are species-specific and can pertain to fresh, live animals, or to animals in various stages of processing, e.g. minimum size limits for beche-de-mer.

Use

A principal use of size limits in sea cucumber fisheries is to protect juveniles and recently matured adults to allow individuals one or more seasons to spawn before they can be fished (Purcell, Gossuin and Agudo, 2009a). Minimum size limits must therefore have some biological basis corresponding to size at which individuals first become mature plus some additional buffer so they have time to contribute to spawning.

Fisheries managers may also want to set minimum size limits on (dried) beche-de-mer of different species, so that fishers and processors can maximise the export income for each individual removed from the stock. Large sea cucumbers are generally placed in a higher grade for export and fetch higher prices (Section 2.2).

Minimum legal size limits can be based on growth of animals in some fisheries but, in sea cucumber fisheries, are commonly based on the size at which individuals of a species first attain sexual maturity (i.e. have recognizable oocytes or spermatozoa in their gonads). Size limit varies with species because size-at-first-maturity differs from one species to another. Size limits can also vary from one country to another (Table 8 – Kinch *et al.*, 2008a) or vary between regions within a country, such as in Cuba (Toral-Granda, 2008a). Minimum legal sizes may differ because fisheries agencies have different management goals or because the size-at-first-maturity is higher at one country, or region, than another for the same species. Minimum legal size limits are imposed in about half of the fisheries of the Western Central Pacific (Kinch *et al.*, 2008a).

Limitations

It should be no surprise to those experienced with sea cucumber fisheries that determining and applying appropriate size limits is not as easy as it seems. One initial limitation is that they should reflect a size that the animals would be some years after animals first reach sexual maturity. Unfortunately, that information is available for only a relatively small number of species and such life-history traits vary from one region or country to another. Determining the size at reproductive maturity requires a significant amount of data (Bruckner, 2006b). Conand's (1989) seminal thesis¹ (recapitulated in English in Conand, 1990) provides these data for ten tropical species: *A. echinites*, *A. mauritiana*, *H. atra*, *H. fuscogilva*, *H. fuscopunctata*, *H. scabra*, *H. lessoni* (then *Holothuria scabra* var. *versicolor*), *H. whitmaei* (then *H. nobilis*), *S. herrmanni* (then *S. variegatus*) and *T. ananas*. Some other studies have provided size-at-first-maturity data for a handful of other species (Kohler, Gaudron and Conand, 2009). For other species and locations, determining size limits rests as educated guesswork but should

¹ Parts of the full thesis were also translated into English by the Secretariat of the Pacific Community (SPC) and are available by e-mailing: reefishobs@spc.int



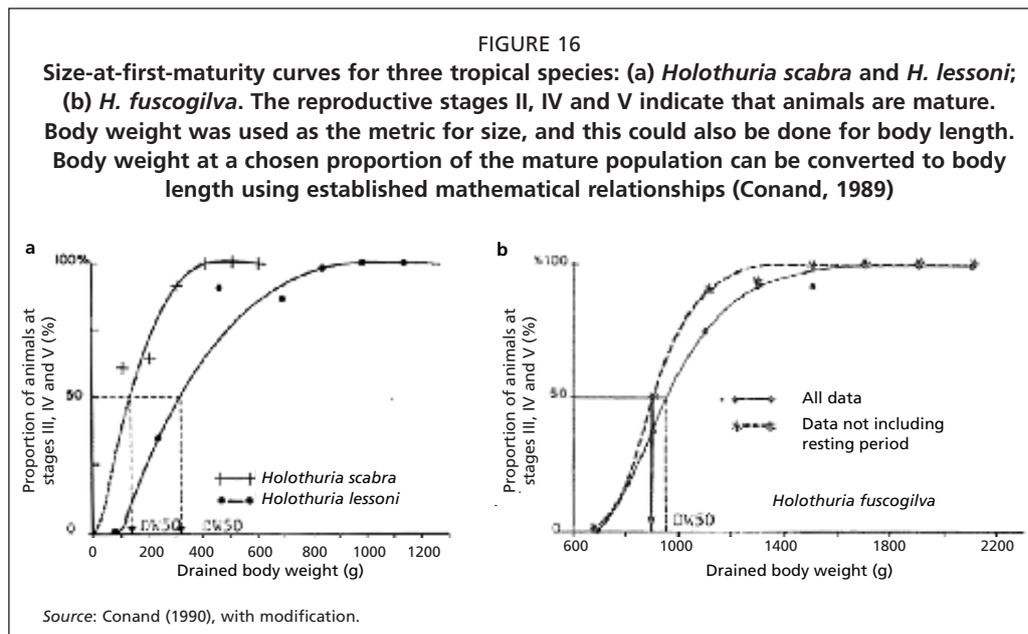
be based on closely related species and local knowledge of the biology of the species. More often, limited data are employed in other countries without local validation.

A second important limitation is that most commercial sea cucumbers contract when handled, so body length can differ greatly from the live size of undisturbed animals (Figure 15). This is an immediate concern of fishers when discussing size limits. Some species contract and expand markedly, so size limits based on weight, rather than length, would be more appropriate. This is particularly true for most *Actinopyga* species, *H. fuscogilva* and *H. whitmaei* (Purcell, Gossuin and Agudo, 2009a). As they contract, sea cucumbers gain in width and/or body height while their body weight remains unchanged. But implementing weight limits may cause compliance problems in many situations, as few fishers in developing countries have access to balances to weigh animals. Some other species, like *H. scabra*, *H. lessoni* and *S. herrmanni*, undergo minor contractions of the body length compared to other species (Purcell, Gossuin and Agudo, 2009a) and are thus less problematic to manage using length-based size limits. Fishers may still argue that it is difficult to abide by size limits but they will quickly know how the size of live sea cucumbers compares with the body lengths of the same animals once dead.

Variation in the shape of sea cucumbers of similar weight appears far less of a problem once the animals are boiled and dried into beche-de-mer, which tends to be uniform in dimensions and reflect the shape of dead animals. Although fishers will have to use sound judgement in collecting live sea cucumbers that are not under the legal minimum length once dead, there should be little difficulty for processors to know when a dead, unprocessed, sea cucumber will be undersized once cooked and dried. Thus, processors have little grounds to object to minimum size limits for (dried) beche-de-mer.

How to implement

Minimum size limits for sea cucumbers have been typically based on the size at first sexual maturity (Bruckner, 2006b). Some studies report size-at-first-maturity as L_{50} (the length at which 50 percent of the population is estimated to be mature) (Figure 16). However, using this length as the minimum size limit would mean that half of the population at that size is immature and could be fished legally. It would



be more conservative to set size limits that allow animals to reach maturity *and* have one or two seasons to spawn with the rest of the population before being fished. This could be done by taking a larger size along the size-at-maturity curve, such as the L_{90} , and add some centimetres to this to allow for a season or two of spawning (Purcell, Gossuin and Agudo, 2009a). Although observations of dissected animals can show the size at which individuals first develop a gonad, i.e. the onset of sexual differentiation, such individuals are not necessarily mature. The oocytes of females may not be fully developed or they may not yet actively participate in spawning. This is a further reason to add some centimetres to the estimated size-at-first-maturity and to use a conservative metric of the length at first maturity (e.g. the L_{90}). More scientifically, true size at sexual maturity can be determined from the first occurrence of mature (vitellogenic) oocytes and mature spermatozoa in the newly-developed gonad.

Where possible, managers should use biological parameters based on data collected in the fishery or region, or adopt examples from similar fisheries. However, in the absence of locally-representative studies, fishery managers should support at least some basic biological studies to compare with published findings from other regions and apply conservative size limits (FAO, 1996; Section 3.2). Ideally, the studies should assess size at sexual maturity in males and females and establish size-at-maturity relationships for commercial species.

Meet with fishers and processors and educate them on the biological reasons for size limits (Figure 17). Find out from fishers and processors what sort of measuring tools they could use to aid in verifying sizes of animals in the field and once processed. These could be as simple as rulers, sliding callipers, or stickers with graduated marks to place on boats. Fishery managers should be pro-active in developing and commissioning such measuring tools.

The process of deciding appropriate size limits in sea cucumber fisheries should involve fishers, processors, biologists and enforcement personnel. Fishery managers can expect to reduce their inspection costs and have a better compliance of minimum legal size limits by inspecting sea cucumbers (either dead or fully processed) of processors and traders more so than fishers. They will be often less numerous than fishers and at known locations, thus making the inspections easier to conduct. Improved compliance will arise when all processors and traders begin to refuse to buy undersized sea cucumbers from fishers. In this case, many fishers are forced by the buyers to comply with the minimum legal size limits rather than by the fisheries authority.



EXAMPLES AND LESSONS LEARNED

Galápagos Islands, Ecuador

Since its re-opening in 1999, the fishery for *Isoctichopus fuscus* in the Galápagos has been regulated by a minimum size limit for both fresh and processed sea cucumbers (among other regulatory measures). The size limits are not regarded as a useful tool by the fishers because they believe that sea cucumbers change length too easily to be effectively measured. Nonetheless, local fishers mostly agree, in principal, to have minimum legal size limits rather than none at all. Both management authorities and scientific bodies concur that this regulation is not as effective as others.

Source: V. Toral-Granda.

New Caledonia, France

At present, only the Northern Province has established minimum legal size limits for fishing sea cucumbers; there are no size limits in the other two provinces. A minimum legal length (in cm) is given for the fresh (live or unprocessed) animals and a corresponding one for the dried form. However, these were provided only for about half of the 15, or so, tropical species that are commonly collected by fishers. The size limits were based on analyses of the size-at-first-maturity of these species (or closely related species) plus a small percentage, and corresponding conversion factors of the change in length during processing, presented by Conand (1989) for these sea cucumbers in New Caledonia. While fishers did say that it is difficult to enforce legal size limits on fresh animals, because most species can contract and expand their body lengths considerably, fishers were in general agreement that the size limits should also pertain to the fresh animals (Purcell, Gossuin and Agudo, 2009a). At a national participatory forum in 2007, some processors objected that the corresponding minimum legal lengths of dried animals were inappropriate, leading to adaptive modifications to the legal size limits via a further participatory meeting. The process of consultation and discussion about the size limits seems to have improved the acceptance by fishers and processors.

Source: S.W. Purcell.

Yap, Federal States of Micronesia

Yap has recently developed a fisheries management plan based on regulating weight rather than size. Commercial species groups included in the management plan are described as either “premium” or “standard”. The plan establishes that a quota should be set for “standard” species groups individually, while more comprehensive quality control should be implemented for “premium” species groups. For export controls of “premium” species groups, shipments will be made and checked in 10 kilogram packages of beche-de-mer. Each package must only include beche-de-mer from a single “species group” and be labelled so as to be easily identified for inspections by the checking authority (for weight and counts). All “premium” species 10 kilogram packages need to include a maximum rate of dry sea cucumbers set out in the management plan; for instance:

<i>Species group</i>	<i>Wet (live) weight (g)</i>	<i>Dry weight of beche-de-mer (g)</i>	<i>Max. number per 10 kg package</i>
<i>Black teatfish</i>	2 400	168.0	60
<i>Sandfish</i>	750	37.5	280
<i>Golden sandfish</i>	1 400	70.0	150

The 10 kilogram packages allow agents to include product with a small weight variation around the specifications for individual dried sea cucumbers, as long as the 10 kilogram package as a whole complies with the maximum number of sea cucumbers allowed. The 10 kilogram packaging system is well aligned to market conditions and industry standards and also allows the authorities some ease of checking, being well suited to a small country with limited enforcement capacity.

Source: Friedman, Ropeti and Tafleichig (2008).

On setting minimum legal size limits

Setting minimum legal size limits should best be based on size at first sexual maturity of sea cucumbers, rather than opinions by fishers and processors about what are “good sized animals” (Purcell, Gossuin and Agudo, 2009a). The onset of sexual maturity is often reported as the L_{50} length, which is the estimated length at which 50 percent of animals in the population are mature. Whereas the size at onset of sexual maturity has been suggested elsewhere for setting minimum size limits of sea cucumbers (Bruckner, 2006a), Purcell, Gossuin and Agudo (2009a) argued that minimum legal size limits should be large enough such that animals can have at least one year to spawn after reaching maturity. They recommended a conservative approach of adding some centimeters to the L_{90} (estimated body length at which 90 percent of the population is mature) from the size-at-maturity analysis curves (e.g. provided in Conand, 1990, 1993; Kohler, Gaudron and Conand, 2009) to set the minimum legal size limits for each species. The equivalent size of dried animals can be calculated using conversion equations in Skewes *et al.* (2004) and the conversion factors determined by Conand (1989, 1990) and Purcell, Gossuin and Agudo (2009b). Fishery managers can prepare simple plastic rulers, with graduations corresponding to size limits of species, to give to fishers to verify sizes of animals in the water. It may be more practical to group species that have similar estimated size limits, rather than having many different sizes for fishers and processors to remember; e.g. the 15 or so species commonly fished in New Caledonia could be allocated into 6 to 8 size-limit groups.

Source: S.W. Purcell.

5.2 GEAR LIMITATION AND DEVELOPMENT

Definition

A prohibition or limit on the use of certain types, sizes or number of equipment for collecting sea cucumbers.

Gear limitations could entail a general prohibition on gears, e.g. no hookah gear allowed, or a specific limitation on the size of specifications of gears, e.g. net mesh size for trawl fisheries or the number of hookah hoses permitted per boat in dive fisheries.

Use

A principal use of gear restrictions is to reduce the number and places where sea cucumbers can be harvested by prohibiting the use of efficient, or industrialized, fishing systems. Examples of gears are nets, self contained underwater breathing apparatus (SCUBA) or hookah equipment, “bombs” (lead weights with small sharpened points imbedded; Figure 18) or spears, trawls and torches or surface lights (for night fishing).

Gear controls, like prohibition of compressed-air diving or use of equipment to collect sea cucumbers in deep water, give some respite to the resource to either being fished too rapidly, or being fished in areas not accessible to free-divers. For example, in the Seychelles, deep habitats have protected deeper, high-value, species from severe depletion (Aumeeruddy *et al.*, 2005).

Gear restrictions are imposed in half of the sea cucumber fisheries in the Western Central Pacific (Kinch *et al.*, 2008a) and most temperate fisheries (Hamel and Mercier, 2008a) (Section 2.4). While the prohibition of compressed-air diving, i.e. using SCUBA and hookah gear, is the most common gear restriction of sea cucumber fisheries, this regulation does not protect species with shallow distribution (Bruckner, 2006b).

Gear limitations can also be set to avoid risks to the environment or the fishers themselves. The FAO Code of Conduct for Responsible Fisheries (1995) advises

FIGURE 18

Left: a weighted “bomb” used for collecting sea cucumbers in deep water by skindivers. Right: the bomb is weighted and has a barbed metal harpoon at the end, which is lowered by a rope or fishing line to harpoon sea cucumbers on the sea floor that are too deep to reach by free diving



FIGURE 19

Dragnets are used in Japan to collect *Apostichopus japonicus* from the sea floor in the province Hokkaido. Left: the large drag frame lifts the sea cucumbers from the sea floor and has tassles (yellow) that prevent the net from being caught on rocks. Right: the net of the drag follows behind the frame to collect the harvested animals



PHOTOS: J. AKAMINE

managing agencies to ensure that fishers use selective and environmentally safe fishing gear and practices (see Sections 3.1 and 3.3). Certain regulations, such as prohibition of “drags”, dredges or trawls, safeguard against unnecessary damage to benthic habitats. “Drags”, dredges (see Figures 7 and 19; *Examples and lessons learned* below) and trawls can damage seagrass beds and other benthic organisms like sponges and sea pens. The fishery might allow such gears, with a regulation on the equipment design that minimises damage to the sea bed or damage to the sea cucumbers being harvested. In Maine, *Cucumaria frondosa* are collected using “urchin drags” that cannot be wider than 1.67 m (Hamel and Mercier, 2008a).

Limitations are sometimes placed on the use of SCUBA or hookah to minimise diving accidents in the fishery. This is mostly relevant for developing and low-income countries where diver training is less rigorous or difficult to obtain, and often lack the medical capability and facilities to deal with diver ailments such as the “bends”.

In certain circumstances, gear restrictions could help to enforce, or aid the implementation of, size limits. For example, trawl nets could be allowed but the mesh size could be restricted to greater than 50 mm for collecting sea cucumbers.

Limitations

Surveillance of the use of some fishing gears will be difficult, and enforcement on the water will be needed to see what gears are being used. Such enforcement brings added cost to management agencies. For example, torches and surface lights are prohibited in Papua New Guinea but fishers in all provinces regularly use them for harvesting sea cucumbers because enforcement officers are few and rarely conduct inspections at night (Kinch *et al.*, 2008b).

In some cases, the onus may be on the management authority to assess the effectiveness and optimisation of new gears. For example, to conduct experiments to find an optimal mesh size of trawls that minimises destruction to the benthos

and bycatch while selecting animals that correspond to a minimum size limit. Gear development of this nature is usually costly.

How to implement

A survey of fishers should be conducted to know which gears are currently used. A literature review of other project reports and studies may be necessary to understand the advantages/disadvantages of other gear. For example, managers should have some information on how new gears would be likely to change catch rates and affect the environment. Also determine what gear restrictions could provide a refuge for some sea cucumbers.

The manager should then assess what human and financial resources are available to enforce gear restrictions. Also, how compatible will the restrictions be with other management measures in place, or what other companion management measures are needed (see Section 8.3)? Fishers should also be consulted to make sure they understand the reasons for gear restrictions and are prepared to respect them.

EXAMPLES AND LESSONS LEARNED

United States of America and Canada

Beginning around 1988, the “drag” or bottom trawl fishery for *Cucumaria frondosa* in Maine, United States of America, raised concerns about bycatch that led to conflicts with other local fishers over the gear employed in the fishery. Henceforth, a dragnet for sea urchins was modified for collecting *C. frondosa* and resulted in an acceptable reduction in bycatch.



PHOTO: L. BARRETT

Above: a “sea cucumber drag” used for fishing *Cucumaria frondosa* in Canada. It is towed behind a fishing or research vessel to collect the sea cucumbers in Newfoundland and Labrador, Canada. The sea cucumbers are too deep for collecting by divers.

In Newfoundland and Labrador, Canada, the exploratory sea cucumber fishery was initiated in 2001. Permission was granted by Fisheries and Oceans Canada (DFO) to use the drag gear developed for scallop (known as the Labrador scallop bucket) as the fishing method. In the following year, the gear used in Maine was modified and approved by DFO, who later gave permission to test the gear. Catch rates and bycatch were compared with two other vessels fishing commercially, one using Labrador scallop buckets and the other

using Digby scallop buckets. Results of the study were positive and DFO approved the new “Newfoundland sea cucumber drag” design. Underwater video observations confirmed the efficiency of the gear, which is now used as both a commercial fishing gear and a scientific survey instrument for the estimation of population abundance and distribution. This example shows that fishing gears can be developed and regulated in cooperation with the fishery management agency and used in population studies.

Source: A. Mercier and J.-F. Hamel.

New Caledonia, France

There are three sea cucumber fisheries in New Caledonia, managed by the fisheries services of the country’s three provincial governments. In the Northern and Southern Provinces, the use of compressed-air devices (SCUBA or hookah) is prohibited, so fishers only collect the animals by free diving or wading in the intertidal waters. Torches and night fishing is also prohibited to allow some respite for sea cucumbers that feed more actively at night and would be exposed to divers more during that time. Despite this regulation, some direct accounts from fishers shows that some night fishing using torches does occur. It is difficult for authorities to enforce this regulation without conducting inspections at sea during night-time. There are no prohibitions yet on other gear, such as drags, dredges or trawl nets, although these are not yet in use. A recent study recommended the prohibition of gears like trawls, which could otherwise be developed and used in the fisheries (Purcell, Gossuin and Agudo, 2009a). A lesson is that some gear restrictions, like the use of torches at night, are difficult to enforce but some inspections by compliance officers at inconvenient times or locations are needed to ensure that fishers comply with regulations on fishing gear.

Source: S.W. Purcell.

Western Indian Ocean

Two contrasting examples of sea cucumber fisheries occur in the Western Indian Ocean. In the Seychelles the harvesting of sea cucumber is an industrial activity involving SCUBA divers. In Madagascar it is mostly a small-scale activity by villagers (Conand and Muthiga, 2007; Conand, 2008; Aumeeruddy and Conand, 2008). The use of SCUBA was prohibited in Kenya in 2003, but the lack of enforcement and communication with fishers has led to poor compliance of the ban (Muthiga, Ochiewo and Kawaka, 2007). While in the Seychelles there are specific regulations on the use of SCUBA, e.g. fishers need to be trained in SCUBA diving, in Madagascar the use of SCUBA is now legally prohibited, but still used and causing diving accidents. Enforcement, communication and, in some cases, training, are needed to ensure that fishery comply with gear restrictions, like the use of SCUBA.

Source: C. Conand.

5.3 EFFORT AND CAPACITY CONTROL

Definition

Capacity controls seek to restrict the total size of the fleet, while *effort controls* seek to restrict the fishing activity (FAO, 2003).

Both types of input controls are discussed here, and both types will group more specific regulatory measures. For example, capacity controls could pertain to the maximum allowable size of boats or the maximum number of them permitted in the fishery.

Use

These management measures aim to regulate the effort and/or capacity to levels that are biologically and economically sustainable for the demographics of the resource.