Chapter 20
Shells as Collector's Items

Peter F. Duncan and Arne Ghys

Abstract Shell collecting, and the more scientific discipline of conchology, have a long history, and the general activity has made significant contributions to art, commerce and science since at least the seventeenth century. Modern shell collecting encompasses a wide range of molluscan families and species, including numerous bivalve taxa, and collections may be developed via a range of methods including self-collection, purchase from specialised dealers, exchange or from older collections. The fundamentals of building and maintaining a scientifically-valid specimen shell collection are discussed, including the role of conchological organisations in promoting shell collecting and increasing awareness of the activity.

The International shell trade can be locally significant, and some trends in shell collecting are presented, with a particular focus on the most popular bivalve families and online specimen-shell sales. The issues of sustainable harvesting, regulation and enforcement are discussed. However, the importance of shell collections and collectors in relation to molluscan taxonomy is also presented, as is their relevance to environmental awareness and potential role in enabling people to better interact with and understand the marine environment.

A number of important and highly collectable bivalve species are presented as examples.

Abstract in Chinese 贝壳收藏有着悠久的历史, 从17世纪开始, 已经作为一项非常普遍的活动在艺术, 商业和科学的发展方面作出了重要贡献, 基于贝壳收藏形成了更科学系统化的贝壳学。 现代贝壳收集包括多样的软体动物家族和物种, 双壳贝类包含其中。通过个人收集, 专业经销商交易, 交换或旧品淘取等一系列方法, 贝壳的收集和交易得以发展。我们对贝壳标本收藏系统的科学构建和有效维持的基本原则进行了讨论, 包括了贝类学相关机构在促进贝壳收藏和提高相关活动影响力方面所能起到的作用。

国际贝壳贸易具有重要的意义, 我们将展示较受欢迎的双壳贝类家族和贝壳样品的销售收藏趋势。同时就如何实现交易的可持续性, 交易管理和执法

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问题进行了讨论。 此外, 本文介绍了贝壳收藏活动和贝壳藏品在软体动物分类学方面的重要性, 旨在提高人们的环境保护意识, 使人们能够更好地了解和爱护海洋。

本节, 我们将以一些极具收藏价值双壳贝类物种进行举例说明。

Keywords Conchology · Bivalves · Shell collecting · History · Collections · Taxonomy · Trade · Scientific value

关键词 贝类学 • 双壳贝类 • 贝壳收藏 • 历史 • 收集 • 分类学 • 交易 • 科学价值

20.1 A Short Introduction to Conchology

Humans may have been collecting shells throughout their history as a modern species, and there is evidence to indicate that ancestral humans /con-specifics also collected shells for various purposes (d'Errico et al. 2005, 2009; Zilhão et al. 2010; Joordens et al. 2015). As by-products of food foraging, it is easy to see the practical use of some shell collecting, but at some point shells must also have been collected for aesthetic and ornamental purposes. Evidence from archaeological excavations in Africa suggests that modern humans were using sea shells as ornamental jewellery during the middle stone age (middle Paleolithic) in southern Africa and in the Maghreb (north-west Africa) (d'Errico et al. 2005, 2009) between 70,000 and 120,000 years ago. However, at that time, modern humans are not thought to have existed in Europe, with Neanderthals being the dominant hominid group there.

Zilhão et al. (2010) reported pierced and pigmented shells, considered to be ornamental jewellery, from caves in south-eastern Spain dating to 50,000 years, around 10,000 years before modern humans are believed to have inhabited the area. Therefore, the discovery that Neanderthal hominids also used a range of bivalve families for ornamental purposes, including species of Cardidae, Glycymeridae, Spondylidae and Pectinidae, indicates that the collection and abstract use of molluscan shells is not a modern pursuit, but one practised by both our distant ancestors and closely-related hominids.

Baldwin Brown (1932) (in Dance 1986) discussed the non-practical use of shells as jewellery or aesthetic pieces recovered from the Grimaldi caves in north-west Italy, which were dated to the upper Paleolithic of around 30,000 years ago. Various molluscan species have been recorded from excavations of this cave system, some of which must have been traded over long distances, since several came from the Atlantic Ocean and wider Mediterranean Sea.

However, rather than considering all aspects of shell use, this chapter will focus on the collection of shells in their natural state as the aesthetic and scientific pursuit known as conchology. Conchology may be defined as the study of terrestrial and

aquatic molluscan shells, and their associated hard parts, including the operculum and radula. The primary distinction between conchology and the wider discipline of malacology lies in its focus on shells, rather than the mollusc as a whole animal (Dance 1986).

There is also some debate about the definitions of conchology versus shell-collecting. Conchology, as a scientific discipline, has a specific focus on the shell as a means to better understanding molluscs as organisms, whereas shell collecting, in its typical form, can be considered to be the acquisition and collection of shells for primarily aesthetic purposes, with limited relationship to a scientific discipline. However, a properly curated collection of shells, accompanied by its collection data, may have very significant scientific value and will be discussed further in this chapter.

To paraphrase an adage, 'not all conchologists are shell collectors, and not all shell collectors are conchologists'. However, as with most disciplines, divisions are somewhat subjective, although the generalities, as outlined above, are perhaps worth defining from the beginning.

It is also important to recognize that while this volume is primarily on the subject of marine bivalves, it is almost impossible to consider conchology, or shell collecting, without reference to the collection of the other major molluscan classes, in particular the Gastropoda. Conchologists and shell collectors are primarily interested in four of the seven classes of mollusc, namely Polyplacophora (chitons), Scaphopoda (tusk shells), Bivalvia (clams etc.) and Gastropoda (snails etc.), due to the presence of shells in these taxa and their general availability.

The total number of extant mollusc species has been estimated to be as high as 200,000, with between 50,000 and 120,000 having been formally described, although there is no common agreement. For example, Bouchet et al. (2016) noted that WoRMS (World Register of Marine Species) listed around 46,000 valid species of marine mollusc. With the addition of terrestrial and freshwater species (see Rosenberg 2014) the total is around 75,000. Bouchet et al. (2016) also reported 82,000 valid molluscan names, which is a little less than Chapman's (2009) estimate of 87,000 described species. We can probably say that the number of described mollusc species is between 75,000 and 87,000, with a likely tendency towards the lower part of the range. Moreover, Mora et al. (2011) and Bouchet et al. (2016) estimate that un-described species may still constitute between 75% and 91% of the true total. Regarding the diversity in the main molluscan classes, Gastropoda are considered to constitute around 80% of all described species (Ponder and Lindberg 2008), and bivalves around 11–14% (Nicol 1969).

In terms of popularity with collectors, these proportions are also broadly indicative, although for bivalves the number of commonly collected species is probably even less than this. Therefore, while bivalves are the central subjects of this chapter, some important gastropods are included where relevant, in part to provide a more complete context for conchology and shell-collecting in general.

20.2 Historical Aspects and the Development of Conchology

A history of recent shell collecting has been well described by Dance (1986), and some useful examples from this work are included here.

One of the earliest 'modern' records of shell collecting and collections dates back to AD 79 where apparent collections of bivalves and gastropod shells, both marine and freshwater, have been found in the excavations of Pompeii (Tiberi 1879). The purpose of this multi-species collection, whether for aesthetic display, decoration or more serious study, remains unknown, but it did include a specimen of the bivalve *Pinctada magaritifera* (the black-lip pearl oyster), which is a striking, nacreous shell found in the Indian and Pacific Oceans, including the Red Sea. Presumably this indicates that attractive shells were valuable enough to warrant transportation and perhaps trading.

Pliny the Elder, who died in the same volcanic eruption of AD 79, wrote extensively on molluscs, and was particularly comprehensive on the commercially-important species and their products, such as pearls and murex dyes. However, the actual collection of shells for aesthetic or scientific purposes has little definitive history until much later, and was primarily associated with the so-called 'golden age' of exploration, colonialism and trading during the seventeenth century. Unsurprisingly, the popularity of shell collecting was greatest in those countries with the strongest interests in overseas expansion, particularly in areas with significant molluscan biodiversity, such as the tropics and the Indo-Western Pacific biogeographic region. As such, the port and capital cities of the Netherlands, Belgium, France and Great Britain developed as the major shell-collecting centres and, with the wealth from colonial commerce, helped established the inherent value and trading of shells that persists today (Fig. 20.1). See Dance (1986) for a more comprehensive account.

The characteristics of shells that appealed to early collectors and artists; aesthetics, exoticism, rarity, commercial value and durable structure have ensured a certain longevity to shells over time, such that specimens have circulated around collections and persisted over time. Indeed, the value of many exotic shells ensured that only the wealthy were able to accumulate important specimens and collections, that same value ensuring their longevity and provenance. Notably, the royal collections of several European countries have proven particularly enduring and important. For example, the collection of Queen Ursula of Sweden provided Linnaeus with several hundred species for the most important editions of the *Systemae Naturae* (1758–1768, 10th and 12th editions). The advent of a more systematic approach to science and collecting, along with useful and value-enhancing collection information, then provided a basis for the development of more scientific endeavours.

Ultimately, wealth, royal patronage and bequests enabled significant scientific institutions, museums and their shell collections to developed in western Europe from this time, providing the basis for the 'gentlemen scientists' of the 18th and 19th centuries who contributed much to the associated disciplines of conchology and malacology.

Fig. 20.1 'Peace and the Arts' by Dutch artist Cornelis van Haarlem (also known as Cornelis Cornelisz). Painted in 1607, it illustrates the early use of tropical and sub-tropical marine shells in art as a direct consequence of wider international trading and exploration by Europeans. Shell specimens include: *Strombus pugilis* (tropical and sub-tropical west Atlantic and Caribbean), *Trochus niloticus* (tropical Indo-west Pacific), *Cymbiola vespertilio* (tropical western Pacific), *Harpa doris* (tropical and sub-tropical eastern Atlantic), *Conus* sp. and *Hippopus hippopus* (Indo-west Pacific). (Identification from Dance 1986) (Image: National Trust)

20.3 Major Bivalve Families for Collectors

People who collect shells probably fall into two general categories, although in practice it may be a continuum, namely; aesthetic shell collectors, and those with a more specialized focus, approaching a true conchologist as the specialization increases. Aesthetic collectors will probably not collect a single family, but rather a range of more attractive species from all over the world, focusing mainly on the most impressive specimens across a wide range of taxa. By contrast, conchologists, or specialists, typically focus on one, or a very few families, as the major subject for collection. More simply, a specialist will typically identify as a collector of, for example, Pectinidae (scallops), and have reasonable representation of shells across a number of genera within that family. This makes logical sense for several reasons; the form and shape within a family are relatively consistent, lending a degree of aesthetic continuity to a collection. In addition, families comprise a number of sub-taxa that make for a challenging, but potentially attainable completion of a series, as well as a number of individual specimens that make for a good display. Finally, the family level also appears to provide an attainable level of intellectual specialization within the group, enabling an individual to become somewhat expert over the life-time of a collection.

While conchologists generally specialize in particular families, some may also focus on biogeographic regions, thereby collecting a wider range of taxa from a particular locality, for example Australian, island or deep-water shells.

Individuals may further specialize in rare or low-diversity taxa, providing opportunities for achieving complete collections, and probably over time, a very specific expertise in the group. In addition, some opportunistic collectors may acquire specimens of limited interest to themselves, but with a view to subsequent sale or exchange for more relevant shells.

Therefore, while we can generalize about popular families, shell collector's interests and collections may be as diverse as the molluscs themselves.

As noted previously, bivalves are not as widely collected as gastropods amongst conchologists and collectors for several reasons. The lower diversity of taxa, and perhaps shell forms, probably limits their popularity compared with gastropods and, in general, bivalves are less visually spectacular, usually lacking the intensity and range of colours, patterns and architectural forms of gastropods. In addition, the requirement to retain two valves, and fix them appropriately for display or storage, adds to the problems of space and curation effort by comparison to uni-valved species.

Analysis of the catalogues of online shell retailers, i.e. shells available for sale via the internet, can provide some insight into the relative availability, and assumed desirability of the various molluscan classes and families. For example, using probably the two largest online specimen shell suppliers (Conchology Inc.[1] and Femorale[2]) indicates that for the Gastropoda there were 127 families and 98,335 specimens for sale, compared with 21 families and 684 specimens for Bivalvia (based on early 2017 data).

We should be a little cautious about simple comparisons between gastropods and bivalves using actual numbers offered, since there may be many more species (biodiversity) or specimens of some families compared to others, and it seems reasonable to assume that commercial dealers will be offering shells for sale that are the more desirable species and specimens. However, additional data from the largest internet dealer, indicated that about 14% of handled shells are bivalves (12.9% marine, 0.7% freshwater) (G. Poppe, Pers. Comm.), with gastropods making up the vast majority of the remainder.

Nevertheless, in bivalve taxa where the visual and physical disadvantages are naturally overcome, then these are typically the most popular for collecting, often generating equivalent levels of enthusiasm, passion, availability and sometimes the commercial value found in the most popular gastropod families.

The following analysis (Fig. 20.2) again uses two of the largest online specimen shell retailers and provides a breakdown of availability of bivalves by family, noting that multiple specimens may be offered for sale; therefore the numbers presented for each family are total individual specimens. However, we consider that this is probably reflective of demand and therefore an index of both desirability and collectability.

[1] http://www.conchology.be

[2] http://www.femorale.com

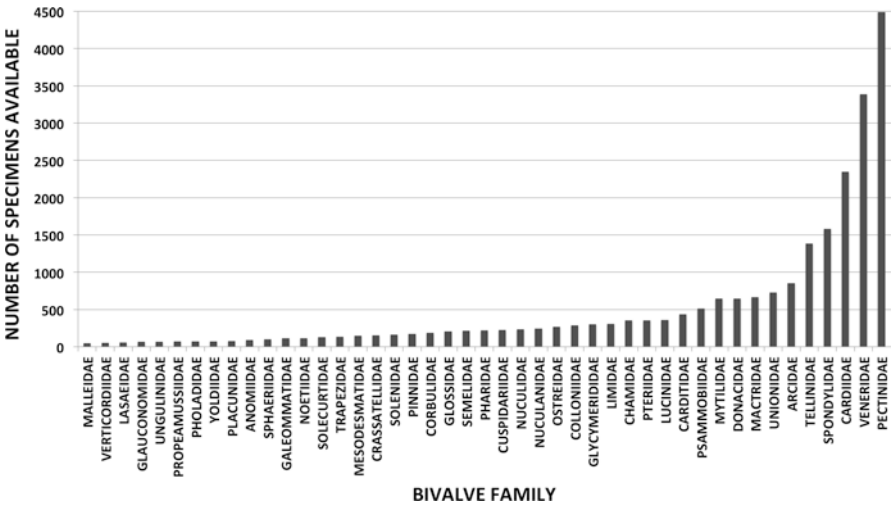

Fig. 20.2 Total number of individual specimen shells by major family (bivalves only) available for sale online (March 2017), from the two largest specimen shell retailers. Only families with 50 or more specimens available are included

This relatively basic analysis indicates that specimens of the following bivalve families are the most available and, by inference, the most popular with collectors. In decreasing order (by number of specimens available), the ten most popular families are; scallops (Pectinidae) (4491 specimens), venerid clams (Veneridae) (3388 specimens), cockles (Cardiidae) (2346 specimens), thorny oyster (Spondylidae) (1579 specimens), tellins (Tellinidae)(1386 specimens), arc shells (Arcidae) (855 specimens), freshwater mussels (Unionidae) (729 specimens), mactrid clams (Mactridae) (667 specimens), donax or wedge clams (Donacidae) (646 specimens), marine mussels (Mytilidae) (645 specimens). All are marine families except for the Unionidae. By comparison, on the same internet sites, the two most popular gastropod families of Conidae and Cypraeaidae constitute more than 15,000 and 12,200 specimens respectively.

In terms of actual sales of specimen shells, anecdotally, it is confirmed that Pectinidae are the biggest sellers, followed by Spondylidae (G. Poppe, Pers. Comm.), which are probably the two most colourful and spectacular bivalve families.

To provide a little more detail on the most collectable bivalve families, Table 20.1 shows a partial taxonomic classification, ordered in terms of their general collectability, and including some key genera and their wider uses and relevance beyond specimen shells. Popularity amongst collectors undoubtedly relates to aesthetic features such as shape and colour, but familiarity, availability and cultural significance may also be important.

Table 20.1 Bivalve taxa of importance to conchological collectors and other goods and services

Superfamily	Family	Genera	Product (goods and services)
Pectinoidea	Pectinidae	Numerous, including *Pecten*, *Aequipecten*, *Placopecten, Argopecten, Mizuhopecten, Chlamys* etc.	Food, specimen shells.
	Propeamussidae	Glass scallops, 22 genera including *Cyclopecten, Parvamussium, Similipecten*. Deep water.	Specimen shells.
	Spondylidae	*Spondylus*	Specimen shells, jewellery.
Veneroidea	Veneridae	Numerous, including *Venus*, *Ruditapes*, *Mercenaria*, *Venerupis*	Food, specimen shells.
Cardioidea	Cardiidae	Numerous, including *Acanthocardium, Cerastoderma, Cardium, Fragum*	Food, specimen shells.
	Tridacnidae	*Tridacna*	Food, specimen shells (CITES[a] listed), aquarium.
	Tellinidae	Numerous, including *Tellina, Macoma*	Food, specimen shells.
	Arcidae	Numerous, including *Arca, Anadara*	Food, specimen shells.
	Mactridae	Numerous, including *Mactra, Lutraria, Spisula*	Food, specimen shells.
Pterioidea	Pteriidae	Numerous, including *Pinctada*, *Pteria, Isognomon*	Pearls, nacre (mother of pearl) products, specimen shells.
	Malleidae	Several including *Malleus*	Specimen shells
Pinnoidea	Pinnidae	Several, including *Pinna, Atrina*	Food, byssus thread (sea silk) fabric etc., pearls, specimen shells.
Ostreoidea	Ostreidae	Several, including *Ostrea, Crassostrea, Saccostrea*	Food, specimen shells.
Anomioidea	Placunidae	Primarily *Placuna placenta*	Shell products and crafts (Philippines), specimen shells.
Unionoidea	Unionidae Margaritiferidae	Numerous, including *Anodonta*, *Unio*, *Margaritifera*, *Hyriopsis*	Jewellery (pearls), nuclei for marine pearl production, specimen shells.

The taxonomy is based on various sources, and may differ between authorities.
[a]CITES: Convention on International Trade in Endangered Species

20.3.1 Some Rare or Highly-Collectible Bivalves

While bivalves are generally not amongst the most desirable or valuable specimen shells, there are a few species that have obtained a high status in both these characteristics over time. As such, when available, they continue to command relatively high prices and interest. Some of these species are included in the work 'Rare Shells' (Dance 1969), which provides details on 50 highly-collectible shells. Here are four bivalve examples;

Fimbria soverbii (Reeve 1842) (Fig. 20.3)
Common name: Common basket lucina
Family: Lucinidae
Locality: Western Pacific from Japan and China to Australia.

Dance (1969) states that "in the second half of the nineteenth century this was one of the few coveted bivalves" with "fine specimens seldom seen in collections." This is probably still true today. At auction in 1865 only *Pholadomya candida* (see below) attracted a higher price. The species is not exceptionally rare, but seems to appear irregularly for sale and still commands a relatively high price of around €70–80, depending on condition, size, appearance and locality.

Fig. 20.3 *Fimbria soverbii* from Australia. (Images courtesy of Marcus Coltro (Femorale))

Pholadomya candida (Sowerby 1823) (Fig. 20.4)
Common name: Caribbean piddock
Family: Pholadomyidae
Locality: South-eastern Caribbean

This is a rather legendary shell, partly due to its general rarity, but mainly because it is considered to be a 'living fossil" (Runnegar 1972). Its closest relatives are from the Miocene period (between 23 and 5 million years ago), and until recently this species was thought to be extinct. However, Diaz and Borrero (1995) reported fresh-dead specimens from Colombia and Venezuela, which were apparently the first traces obtained since the late nineteenth century. More recently, living animals were located in shallow water (3 m) off the Colombian coast and a specimen was obtained, providing opportunities for further study, including DNA analysis for phylogenetic purposes (Dìaz et al. 2009). This re-discovery has provided significant interest for evolutionary biologists and malacologists (Ausubel et al. 2010), since only once before have the soft body parts been studied (Runnegar 1972). The shell itself does, very occasionally, appear for sale, but these have inevitably been recycled from old collections, and the price is high, ranging from €1800 to €2500, making this a very limited market for a specialist type of wealthy collector.

Spondylus regius (Linnaeus 1758) (Fig. 20.5)
Common name: Regal thorny oyster
Family: Spondylidae
Locality: Western Pacific from Japan and China to northern Australia

Spondylus regius is a spectacular shell with a long history of popularity and value. The species was probably known to collectors even before it was described by Linnaeus in 1758, and Dance (1969, 1986) provides a number of anecdotes regarding specimens of this species. Such was the fame and value of some individual shells that their transactions, owners and even prices paid are a matter of historical record. As such, many of these famous shells are still to be found in national museums, providing a physical testament to the provenance. For example, the

Fig. 20.4 *Pholadomya candida,* Colombia. (Image courtesy of Juan M. Dìaz)

Fig. 20.5 *Spondylus regius*. (Image: courtesy of Marcus Coltro (Femorale))

famous conchologist G. B. Sowerby 1st, purchased the famous Tankerville collection in 1824, including a fine specimen of *Spondylus regius*, which was sold the following year for £25 (€30). This is around the same price that a good specimen would cost today, although in 1825 the relative value was the equivalent of over £2500 (€3000). As with many shells, the individual colour, locality and condition, particularly of the prominent spines in this species, determine the value, although recent prices range from as little as €5 up to €50.

Nodipecten magnificus (G.B. Sowerby 1st 1835) (Fig. 20.6)
Common name: Magnificent scallop
Family: Pectinidae
Locality: Ecuador (Galapagos Islands), and possibly Colombia

One of the largest and most striking scallops, this species is considered to be endemic to the Galapagos Islands of Ecuador, although it has supposedly been reported from the Ecuadorian mainland and south-west Colombia (Raines and Poppe 2006). However, its generally accepted centre of distribution as the Galapagos is ecologically relevant. The species can reach 200 mm in height, and its desirability and commercial value, more than €1000 for a large, high-quality specimen, combined with a very limited range makes the species potentially vulnerable to overexploitation and population decline. As such, this species is included on the IUCN (International Union for Conservation of Nature) red list of threatened species as data deficient,[3] acknowledging its vulnerability, but also limited ecological knowledge. This highlights a relatively uncommon, but important aspect of conchological responsibility, that of conservation.

[3] http://www.iucnredlist.org/details/14831/0

Fig. 20.6 *Nodipecten magnificus*. (Image: Arne Ghys, www.pectensite.com)

20.4 Shell Collections

20.4.1 Obtaining Specimens

20.4.1.1 Direct Collection

'Dead' Collecting

This refers to the collection of 'dead' material, i.e. a shell without the presence of the original live animal, although occasionally a shell may be inhabited by another animal, such as a hermit crab. In such cases the shell may be described in accompanying collection data as 'dead-collected' or 'crabbed', although the latter is much more likely for gastropod shells.

Dead material may be of varying quality. For example, a shell collected with original animal remains, perhaps as a result of natural predation, may well be of equivalent quality to live collected. In such cases, where quality is high, they may be referred to as 'fresh dead specimens' in accompanying collection data. However, in most cases some degree of deterioration of the shell will have occurred, ranging from physical damage caused by wave action or predators, natural chemical deterioration due to aerial exposure, or settlement of encrusting organisms, such as barnacles, tube worms or corals. Attempted removal of such organisms may further damage the shell, or leave unsightly residues that diminish the overall appearance and quality of the specimen.

The collection of dead-collected shells, or their inclusion in a collection, may be for several reasons including; the general rarity or difficulty in obtaining a particular

species, the inclusion of a 'dead' specimen until a better condition shell can be obtained, or due to an ethical objection to live collecting.

Live Collecting

Although these methods are primarily for the collection of live specimens, 'dead' shells may also occasionally be obtained in the same way.

To make a general point on live-collected shells; since specimens are ultimately intended for a collection, then the best quality examples are those that are specifically collected, either by the collectors themselves, or by professionals for subsequent sale. In either case the desirability and value are significantly affected by condition (see section 20.5). A general rule, often written into shell collecting codes of conduct, is that damaged or unsightly shells, e.g. chipped margins or spines, or with severe growth lines, and also mating, brooding or egg-carrying individuals should not be taken, but instead returned to the environment for breeding.

- Intertidal Collection
  The natural distribution of bivalves ranges from the intertidal zone to the deepest parts of the oceans. The intertidal (or littoral) province represents a highly biodiverse ecological zone containing a very large number of species. It also acts as a receiving environment for offshore areas with specimens being delivered by wave action and storms, and as such it is a profitable area in which to collect shells. Bivalves live in a wide variety of habitats in the intertidal zone, including under rocks, dead coral, and within a range of sediment types from muds to sand and gravels.

  The intertidal zone is also relatively accessible to people, both for food collection and for shells, and care must be taken to limit collection activities and minimize habitat damage. For this reason, national and local rules often apply to intertidal collection. Similarly, many shell clubs have developed codes of conduct/ethics for live shell collecting, which may include bag limits, not taking damaged or breeding individuals, and the replacement of turned boulders, dead coral slabs and other substrate materials.[4]

- Diving (free and scuba)
  Scuba diving and snorkeling offer additional opportunities for shell collecting, particularly for species below the intertidal zone. Scuba in particular provides for relatively extended periods of underwater collection, although shell collecting is also undertaken using surface supplied air (hookah diving). This may be a relatively cheaper, or more convenient option compared with compressed air cylinders, which require refilling, and is often the preferred method in many countries, e.g. the Philippines. However, local regulations may prohibit the use of particular equipment for collecting. In general, diving for shells is not a common activity outside the tropics, and typically requires a lot of experience to develop the skills necessary for finding molluscs underwater.

[4] http://www.conchologistsofamerica.org/conservation/ethics.asp; http://www.sydneyshellclub.net/ethics.html; http://www.malsocaus.org/?page_id=14

- Fishing operations
  Targeted collection of shells by directed fishing, or as secondary bycatch from commercial fishing operations, may also produce commercially valuable shells, and are important sources of specimens, particularly from deeper waters.

  Many different types of fishing can yield shells, and most types of benthic fishing gear, used on the seabed, can provide a variety of species, including infaunal, burrowing species.

  – Benthic trawls and dredges: otter and beam trawls are primarily used for demersal fish, but will also catch infaunal, benthic or swimming bivalves. Toothed and un-toothed dredges are often used for commercial scallop fishing, and also catch other bivalves living in the same habitats.
  – Benthic traps: perhaps surprisingly, baited traps for species such as crabs and lobster can also catch molluscs, although usually they are carnivorous gastropods attracted by baits. However, bivalves, especially swimming species such as scallops may occasionally appear in traps.
  – Nets; tangle or '*lumun-lumun*' nets: directed fishing for specimen shells using specialized nets is most common in the Philippines (Floren, 2003). Such nets, with relatively small mesh sizes, are set overnight in waters down to 100 m and primarily collect gastropods, but also swimming or spiny bivalves. However, this is a labour-intensive method of shell collection with low profit margins, and appears to have become less common in recent years.
  – Remotely-Operated Vehicles (ROVs): in recent years the use of remotely operated vehicles, or ROVs has increased, particularly for high-value species such as Australian *Zoila* cowries.
  – *Ex-pisce*: fishing operations may provide unusual sources of specimen shells. One example, more common for gastropods, but also occasionally for bivalves, is from fish stomachs, or *ex-pisce* as listed on collection data. This source has been particularly important for some rare, deep-water species, such as southern African cowries (Cypraeidae) (Boswell 1964).

20.4.1.2 Indirect Collection

Typically it is not possible to complete a shell collection, or obtain some specimens personally, so shell collectors often use third parties or 'indirect' collection methods.

Most collectors at some point either purchase or exchange specimens with fellow collectors or dealers. Such opportunities arise via shell-collecting clubs, dedicated shell shows (such as Antwerp, Paris, Australian or Conchologists of America), specimen shell shops and, more recently, via dedicated or general online auction sites.

Shell specimens are also sometimes obtainable by the purchase of existing collections, either via disposal through choice, or the death of the owner. Collections may also be acquired by dealers and sold off individually, a practice that has been going on since the seventeenth century and the advent of modern shell collecting (Dance 1986).

20.4.2 The Shell Collection

The purpose of a shell collection may be as variable as the collectors or the specimens they contain. It may represent a specific focus and expertise with a narrow range of species, which arguably tends towards a more conchological, or scientific purpose. Other, more eclectic collections may also serve a similar purpose, although diversity, aesthetics or commerce may also be the primary purpose.

Regardless of purpose the utility and value of any shell collection lies in both the specimens themselves, and in the accompanying collection data. Although there is no definitive list of data requirements, the general rule is that more information is better. Conchological publications and organisations often provide advice, but whether for scientific or commercial purposes, specimen shells are significantly more valuable with good data that records some or all of the following;

- Species name and taxonomy: although this may not be the most important information as identification can occur post-collection.
- Location: arguably the most important piece of data, and therefore as much detail as possible.
- Habitat, or ecological data, associated with the specimen; including depth, substrate etc.
- Collection date (and perhaps time of day).
- Specimen dimensions and condition.
- Original collector's name.
- Price paid (if purchased).

Ideally, data should be retained with the specimen itself, to avoid separation. This may be in the form of a paper label retained inside the valve(s), or within an individual compartment in a cabinet. Historically, shell specimens have been marked directly with Indian ink, providing a numerical reference on the shell associated with an accompanying catalogue. More recently computer-based systems have been used for data management and dedicated software is available for shell collectors,[5] along with less specialised database software.

20.4.2.1 Specimen Cleaning, Maintenance and Conservation

Mollusc shells have an organic component to their structure and may also have remains of organic tissue due to incomplete cleaning, especially from live-collected specimens. This presents the risk of specimen deterioration, odours or infestations, and therefore cleaning is important. Initial preparation of bivalves must also consider the hinge and ligament if the specimen is to be preserved with these features intact. Bivalves may be set (air dried) closed, or with the valves separated by breaking the hinge, dependent on eventual specimen purpose. For example, access to the

[5] Examples include: http://shellcollections.com/; http://home.global.co.za/~peabrain/software.htm

interior of the shell valves may be important to show features used in classification or ageing, e.g. pallial sinus shape, muscle scars and ligament rings, although separated valves present a greater risk of specimen separation. In this regard, water-soluble glue can provide a useful solution.

Secondary cleaning may also be undertaken, depending on specimen purpose or condition. This may be to remove encrusting organisms, such as tube worms or sponges, and can be achieved via simple brushing, treatment with diluted (e.g. 5–10%) bleach (sodium hypochlorite) or even small rotary power tools, depending on the severity or nature of the fouling. However, as before, it may be important to preserve some delicate components of the shell valves intact, such as the periostracum or shell micro-structure, which can be easily lost by bleach treatment or abrasion. Therefore, cleaning method and extent depends on the specimen, its purpose and the technical experience of the collector.

Emersion and cleaning processes tend to dehydrate shells, resulting in dulling of the surfaces and colour fading, although colour fading generally occurs over time regardless of remedial action. Before depositing in the collection specimens can often benefit aesthetically from a light application of mineral oil, which also helps to reduce desiccation and cracking of the periostracum and other organic components of the shell. Generally, vegetable, or other organic oils, should be avoided as these may provide a substrate for fungal or insect pests.

20.4.2.2 Collection Organization

There is no formal, accepted standard for organisation of a collection, since it depends on many factors such as specimen number, size and collection purpose. In addition to the specimens themselves, space may be a significant factor, since storage containers or cabinets, and the inevitable library of reference material, add additional components to collection management.

However, some fundamental characteristics of shells themselves require basic consideration to maintain their long-term condition.

Firstly, shells are relatively fragile, particularly specimens with delicate marginal lips, spines, projections or naturally thin shell valves, such as deep-water species. As such, they require separation from each other, either in individual, partially air-filled clip-seal polyethylene bags, or in compartmentalized drawers, boxes or inserts.

A variety of materials have been used for specimen shell storage, but exposure to light (which fades colours), air, dust, fungi, insects and potentially corrosive chemicals must be considered. Some of these factors can be controlled by storage in specifically designed cabinets, although the construction material may be important.

Historically shell cabinets were made of wood, particularly tropical hardwoods, which were generally more suitable than woods such as oak. Over time, and particularly in humid, poorly ventilated environments, acidic gases from storage material can significantly and irreversibly damage carbonate structures such as shells. This chemical reaction, one of several related processes, is called Byne's disease, or

Bynesian decay, and is the reaction of acidic vapours on the alkaline shell material, resulting in efflorescence of salts (Byne 1899). Significant literature exists on the subject, see Tennent and Baird (1985) and Cavallari et al. (2014).

For this reason many cabinets and drawers are now made of plastic, laminate or preferably metal.

20.4.2.3 Temporary Exhibition

A shell collection is primarily for the collector, but occasionally it, or components of it, may be exhibited for purposes such as competition or education.

Most shell shows are annual events, typically organized by shell clubs or organisations such as;

- Koninklijke Belgische Vereniging voor Conchyliologie (Royal Belgian Society for Conchology) (www.konbvc.be)
- Association Française de Conchyliologie (French Conchological Association) (www.xenophora.org)
- Conchologists of America (COA) (www.conchologistsofamerica.org)
- British Shell Collectors Club (www.britishshellclub.org)
- Conchological Society of Great Britain and Ireland (www.conchsoc.org)
- The Australian National Shell Show is organized by various state shell clubs on a rotational basis, often in addition to their own club or state shell show.

These shows are an opportunity to buy, exchange and exhibit shells (Fig. 20.7), and often have lectures on conchological subjects. Competitions covering a range of categories, e.g. specific molluscan families, regional or worldwide shells, colour forms, and 'shell of the show', are common and provide an opportunity to display particularly special collections or specimens to other conchologists and the public. Shows are typically open for general admission and well-organised annual shell shows provide advance publicity for the event, including media releases.

Educational displays are typically the preserve of museums, but short-term exhibits, loans or lectures often provide additional opportunities for conchologists to display or discuss their specimens.

Typically, for all such events, a collector will have, or be provided with a small display box which can hold up to 20 specimens and which usually includes a glass or transparent plastic lid to protect and secure shells while on view.

20.4.2.4 Disposal of Collections

A question that collectors have faced since conchology began, is the fate of a collection due to eventual disinterest, death or lack of money.

In simple terms there are probably three options; bequest, sale or donation. Bequest provides continuity for the collection and donation to an educational or conservatorial institution may ensure continued preservation of the collection intact,

Fig. 20.7 International shell shows. Clockwise from top left: dealer tables where specimens are sold, exchanged or displayed, table detail showing specimens and storage containers for sale, prize-winning competition displays showing collections of Spondylidae (thorny oysters) and Pectinidae (scallops). Note the use of standardized display box sizes and specimen collection data for competition entries

provided that the specimens are important enough to be accepted by a museum or equivalent.

Perhaps the most likely fate of a shell collection is purchase by another collector or dealer, in which case it is probable that only some specimens will be retained by the purchaser, with the majority being subsequently offered for individual sale.

20.5 The Value of Conchology

20.5.1 Commercial

Estimating the overall commercial value of collectable mollusc shells alone, as distinct from the rest of the animal as food, may be difficult, although there are some useful indicators. The Philippines is probably the country with the largest contribution to the shell trade and shell collecting, particularly from a specimen supply and trade perspective. The Philippines Bureau of Fisheries and Aquatic Resources collates data on many aquatic products, including shells and shell-byproducts, and have been consistently reported since 1998 (Fig. 20.8) (BFAR 2017). These products are mostly for export, and the vast majority are likely to be shell products, worked shells and display items, rather than specimen shells for collectors. However, some specimen shells are included in the total.

Floren (2003) reported that the peak of Philippines shell and shell-craft exports was in 1988 at 10,000 t, (valued around US$21.45 m) and a low of 1600 t in 2000, although still worth more than US$18 m. Thereafter, as indicated by Laureta (2008),

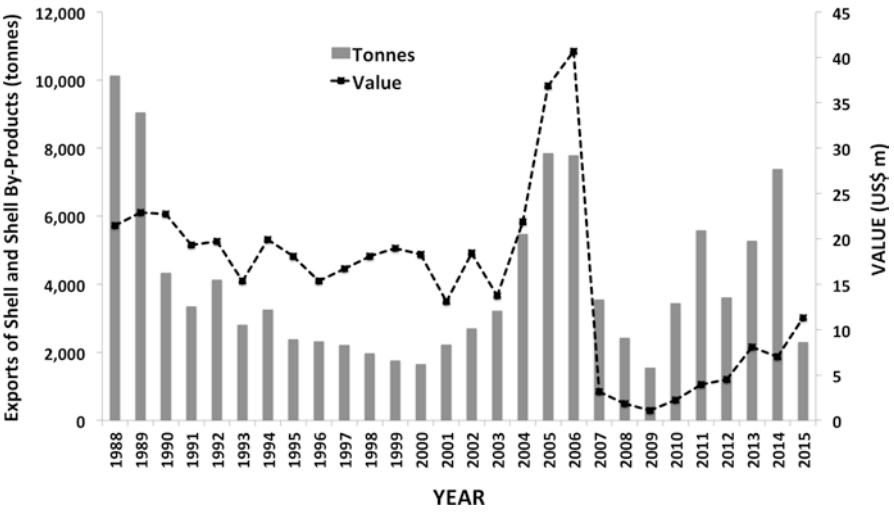

Fig. 20.8 Exports of shell and shell by-products from the Philippines, as reported by BFAR. Exports are in tonnes, values in million US$. (Data source: BFAR http://www.bfar.da.gov.ph/publication)

exports began increasing again to around 2233 t, worth US$13.1 m in 2001. While it seems probable that a relatively small proportion of these volumes are for edible consumption, given high domestic consumption and food regulation requirement in other countries (Duncan et al. 2009), Floren (2003) did note that 300 t of abalone (*H. asinina*) was exported in 1999, which may account for a significant proportion of the value around that time.

More recently BFAR reported that exports of 'shells and by-products' for the years 2005 and 2014 (Fig. 20.8) amounted to 7854 t (worth US$36.8 m), and 7388 t (worth US$7 m), respectively. Therefore, it appears that values and quantities have fluctuated considerably, with particularly low values around 2008–9 of only US$1.1 m. It is unclear whether this was due to global economic conditions, changes in product types, or that statistical data is not directly comparable. Floren (2003) noted discrepancies between national statistics and individual islands, with Cebu alone reporting 19,565 t of shell and shell craft sales in 1999, which was apparently not included in official figures. However, it may also be simply that high-value components, such as abalone, have declined.

The Philippines is also the largest producer of *kapis*, or window-pane shell, (*Placuna placenta*)(Placunidae). The shell itself is not particularly collectible, but it is used for shell craft in a wide variety of applications from lamp shades to windows. Gallardo et al. (1995) reported that exports between 1986 and 1991 were worth around US$36 m, although they also noted that significant depletion of beds was occurring due to overfishing (see also Adan 2000), suggesting an equivalent decline in its commercial value in recent years.

20.5.1.1 Individual Shells

The range of an individual shell's worth varies considerably and essentially depends on rarity and demand. Bivalves do not command the highest prices amongst shell collectors, which tend to be for the rare species of gastropod, but as might be expected, rarer, larger or more colourful specimens of the most collectable bivalve taxa, e.g. Pectinidae or Spondylidae, are not insignificant in terms of individual commercial value.

In shell collecting, specific consideration of rarity, would include the following;

- Numerical scarcity: the actual number known to exist, or the ecological rarity of the species. This can change over time; increasing, with additional specimens becoming available as their habitat becomes better known or explored, or decreasing, if a habitat is damaged or natural mortality increases (e.g. due to disease or pollution), or a species is exploited towards local extinction.
- Collection difficulty: some specimens are simply hard to collect, reflected in numerical availability. However, if a new collection method becomes available then supply may increase and value decrease. Similarly, if existing collecting methods disappear or change, then the opposite may be true.

- Specimen locality, e.g. geographic, depth, protected area etc.; the difficulty of collecting specimens from inhospitable or rare habitats may be reflected in value. Similarly, an area or habitat that becomes protected may increase the value of previously collected specimens, since many shells are 'recycled' from old collections, and a knowledgeable dealer/collector will price according to current conditions. There are also examples of rare shells that existed in low numbers because their actual habitat or location was erroneously reported or unknown. If it subsequently becomes known, then supply may increase and price fall, for example, the scallop *Annachlamys reevei* from the Philippines.
- Specimen size; both unusually large or small shells of a particular species, often command a premium and there are lists of record sizes for different species available with which to gauge such characteristics.
- Specimen condition; is typically very important, unless a poor quality example of a rare species is acceptable until a better replacement is found. Damage, chips, erosion or marine fouling/boring generally detract from value.
- Specimen aesthetics; this characteristic is subjective, but unusual or particularly strong colours or patterns, well-developed or preserved structures, such as spines, scales or ribs can all enhance value. There is also a small, niche market for abnormal specimens, which often command higher prices than typical specimens. Such abnormalities may include unusual shapes, growth patterns, absence or presence of shell characteristics such as ribs or spines, shell deformation due to damage to shell-secreting tissues, melanistic or iron-oxide (rusty) specimens, unusual colours or partial colourations, or even odd associations such as shells with barnacles or other marine growths.
- Provenance, including the quality of accompanying collection data; a designated taxonomic type (usually paratypes, rather than holotypes which are typically museum deposited), illustration in media or part of a famous collection may increase value. Given that provenance can influence value, there is a well-recognised potential for collection data, and even specimens to be forged, although this is common in many human pursuits where significant commercial value is involved.

However, rarity in itself does not make a specimen valuable if it is not from a collectible family. Therefore, as with most objects of value, rarity and desirability, their availability and demand combine in different ways to determine the commercial value of any individual shell.

In terms of the actual range of shell values, it is often said that a good example of any shell with collection locality data is worth at least a single major international currency unit, i.e. €1, £1, $1 etc.

For upper limits, high quality, rare bivalve specimens, from the families Pectinidae or Spondylidae, can be worth up to several hundred Euro/US dollars/Pounds each, but very few exceed €/US$1000 or more. For example, tridacnid clams (Tridacnidae), which are protected under CITES, an international treaty which regulates trade in endangered species, should restrict availability. As such supply is usually limited to older specimens, and particularly large shells may command very high prices, although few other bivalves are anywhere near as valuable.

By comparison, some geographically localized, deep water, rare or particularly spectacular Cypraeidae (Gastropoda) specimens are offered in the tens of thousands of €/US$/£ range. In fact, high prices for particularly rare shells are not new since, relatively speaking, even higher prices have been paid from the beginning of commercial shell trade in the seventeenth century (Dance 1986). However, these are unusual exceptions, and the vast majority of individual specimen shells, even within the most-highly collectible families, can be acquired for less than €/US$/£100.

20.5.2 Scientific

Bouchet et al. (2016) estimated that in recent years, around 443 new species of mollusc have been described annually. This output is based on relatively few individual taxonomic specialists, perhaps only 500 people, and half of all new mollusc species were described by only 34 individuals. Importantly, based on first authors, 57% of new species were actually described by amateur, or 'citizen' scientists, compared to academic scientists. Of the top seven first authors, in terms of new species described, five were 'citizen' scientists and two were academics. Bouchet et al.'s study highlights several important points. Firstly, that amateurs continue to make an important contribution to molluscan science, certainly in relation to taxonomy, as has been the case since the nineteenth century at least (Dance 1986). Secondly, the general paucity of research funding from government and universities for relatively non-applied, baseline subjects such as taxonomy, means that the work is increasingly carried out by self-funded individuals using their own time and resources to help increase the knowledge of molluscan biodiversity. Thirdly, and one specifically noted by Bouchet et al. (2016), '*the factor limiting the description of more new species of marine molluscs is the availability of taxonomists – not the availability of new species to be described – and the difficulties of sampling them*.' As such, it will be increasingly important to encourage and recruit existing and new shell collectors to become knowledgeable and interested in taxonomy to ensure that this biodiversity resource remains available and active. Amateur and academic conchologists must cooperate better to achieve this, rather than pursuing divisive practices of separating shell collectors and scientists. This will be particularly important if the estimated 150,000 un-described molluscan species, including bivalves, are to be named in less than the 300 years that Bouchet et al. (2016) have estimated, based on current description rates.

While species descriptions are certainly significant contributions that amateur conchologists can make, all collectors can improve the scientific value of their collection by maximizing the accuracy and scope of collection data. Over time, a collection focused on a particular taxonomic group or geographic distribution, may approach completeness, enhancing its scientific value. As such, any well-curated collection has a potential long-term scientific contribution.

Some amateur collections can include type material, i.e. those specimens used to first describe a species, particularly given the high representation of amateurs in new species designations. By convention the holotype of any new species should be deposited in a named public institution, which provides for general access to it. However, since many species are described using multiple specimens, there may be multiple paratypes, often quite different from the holotype, and these are often retained in personal collections. While paratypes, and other type specimens, are noted in the original description, including their location, it is important that such specimens are accurately recorded, available for study on request, and not lost to science when collections are eventually dispersed or disposed of.

Amateur conchologists may also rarely own specimens from famous historical collections. Dance (1986) provides an overview of these, generally nineteenth century, collections, and many have remained intact and been ultimately bequeathed to national museums. For example; the Melvill-Tomlin collection in the National Museum of Wales,[6] Linnaeus' collection in the The Linnean Society of London, Darwin and Sowerby's in the British Museum of Natural History, and the Kohn Collection (Conidae) in the Field Museum, Chicago.

While many important collections have remained intact, it is also the case that some have not, or that important specimens were separated over time. If such specimens can be identified, then they may have important scientific, as well as historical and commercial value, but their identification is an important first step, again highlighting the importance of good data, and the retention of original data records.

The active collection of shells by conchologists, either individually or part of an organisation requires the acquisition of knowledge regarding species' habitat preferences and behaviour, as well as general ecological field-work skills. Even biodiverse areas such as tropical reefs and intertidal habitats can appear devoid of molluscan life to inexperienced observers, but a knowledge of tidal state, species' activity patterns and ecological associations can enable much more efficient collection. The ability of experienced shell collectors to find their subjects is best appreciated at first hand, but a good example of such skills has been demonstrated in the case of conotoxin research, which began in the 1990s (Adams et al. 1999). Biochemists, interested in the pharmaceutical application of *Conus* venoms, made use of shell collectors, both amateur and professional, to source a wide range of species for bio-prospecting and research (e.g. Safavi-Hemami et al. 2011; Robinson et al. 2014, 2016). Such was the popularity of the research field, and the effectiveness of collectors, that concerns arose regarding the sustainability of wild harvesting, since researchers, drug companies and shell collectors were searching for a wide range of *Conus* spp. at the same time. At one point it was even suggested that the genus should be CITES listed (Chivian et al. 2003) to protect species from overcollection. While efforts have subsequently been made to harvest cone venoms less destructively or produce them artificially, and the initial research urgency has declined, two points are important. Firstly, experienced shell collector's skills in

[6] http://naturalhistory.museumwales.ac.uk/molluscatypes/Collection.php

finding and identifying molluscs are well-developed and effective, with useful applications in field biology and other research endeavours. For various reasons such local ecological field experience and knowledge is becoming rarer, particularly in developed countries, but its usefulness should be recognised before it is lost to future generations. Secondly, and as with all wild harvesting, care and consideration needs to be taken in relation to sustainable levels of collection.

20.5.3 Education

The collection of shells is not necessarily an individual occupation, and many organisations exist to provide opportunities for collecting trips, discussion, exchange, display and education. Annual shell shows in particular offer a regular and public-facing opportunity for awareness raising of both conchology and wider ecological and biodiversity topics.

Conchological organisations typically provide guidance to members and non-members regarding the ethical or sustainable collection of specimens from the wild, with most making this information available on host websites (see section 20.4 for examples), and many produce regular newsletters or magazines, some of which have been published for many decades (Table 20.2). Bouchet et al. (2016) provide a detailed list of conchological publications, noting that many are now available online, for example http://www.conchology.be/?t=405.

These endeavours by conchological organisations help to ensure responsible behaviour amongst members, provide a focal point for newcomers to begin responsible shell collecting, and provide continuity of essential molluscan knowledge and skills. The encouragement of sustainable practices, but also the promotion of fundamental interests in biodiversity, ecology and the natural world is an important role played by conchological organisations in society.

Table 20.2 Selected list of conchological/malacological organisations and publications

Organisation	Publication	Published Since
Royal Belgian Society for Conchology	*Gloriamaris*	1961
Belgian Society for Malacology	*Novapex*	2000
French Conchological Association	*Xenophora*	1981
Conchologists of America	*American Conchologist*	1972
Hawaiian Malacological Society	*Hawaiian Shell News*	1960 (New Series)–2011
British Shell Collectors Club	*Pallidula*	1970
Conchological Society of Great Britain and Ireland	*Journal of Conchology*	1879
Malacological Society of Australasia	*MSA Newsletter*	1953
	Molluscan Research	1957

20.6 Conchology: Environmental Threat or Conservation Benefit?

Conchology, at least the acquisition of specimens, is essentially a hunter/gatherer activity, and such behaviours are becoming relatively rare in modern agricultural societies, with probably commercial and subsistence fishing as the only remaining large-scale examples.

There are many reason for this behavioural change, but one of the more recent considerations has been the potential damage that wild harvesting can have on natural biological populations, particularly as the human population has grown so rapidly in recent decades. It may be increasingly unacceptable for people in developed countries to kill wild animals for sport, food or leisure when more efficient food production systems exist. Similarly, the sustainability arguments are obvious with the human population expected to reach 8.6 billion by 2030 (United Nations 2017).

Unregulated fishing effort and practices have resulted in many commercial fishery species becoming depleted to dangerous levels through overfishing (Pauly 2008; Jacquet 2009), and, although we are unaware of any specific examples of a mollusc species becoming extinct due to harvesting for conchology, instances of overharvesting of shellfish for food and shell byproducts have been widely reported. Examples of such depletions include several scallop species (Blake and Shumway 2006; Duncan et al. 2016), *Pholas orientalis* (pacific angel wing) (Laureta and Marasigan 2000; Ronquillo and McKinley 2006), *Lobatus gigas* (formerly *Strombus*) (queen conch) (NOAA 2015) and tridacnid clams (Van Wynsberge et al. 2013), to the extent that the latter two are CITES Schedule II listed, indicating a now-regulated international trade. In all cases the shell has been a byproduct of a food fishery, but habitat damage, overfishing and the effects of pollution have all contributed to the declines, making remaining populations more vulnerable to additional exploitation pressures, whatever their form.

Over-collection of *Conus* spp. due to demand from research and enhanced shell trade, has been discussed with earlier, but another bivalve mollusc, *Placuna placenta*, used primarily for shell craft rather than specimens, has also been subject to over-exploitation in the Pacific and Indian Oceans (Gallardo et al. 1995; Laxmilatha 2015). As a result, restrictions on harvesting this species have been introduced, been implemented, and around the world several management authorities have introduced bag limits or complete collection bans for some molluscs that are collected for food, angling bait, or for their shells.

Typically, such restrictions apply near high-density human populations, e.g. the Sydney area of Australia,[7] but also in various types of marine protected areas, e.g. zoned areas of the Great Barrier Reef Marine Park[8] (Day 2002). Importantly however, zoned management strategies can allow for protection of the most important areas, but also for the continuation of a wide range of managed activities in other

[7] Collecting around Sydney, Australia, http://bit.ly/2dK8JC7

[8] www.gbrmpa.gov.au/zoning-permits-and-plans/zoning/about-zoning

zones, including shell collection and scientific research. Elsewhere in Australia, which arguably has the most developed management for specimen shell collecting, several important initiatives have been introduced, including specimen-shell fishery assessments[9] (Australian Government 2004, 2005), management plans (Queensland Government 2008, 2009) and professional shell-collector licencing.[10] Additional information on regulatory measures and catch statistics (2002–2003) from the specimen-shell fishery in Queensland can be found online.[11]

Australia is certainly not the only jurisdiction to regulate and manage specimen-shell fisheries and collecting, with the Philippines[12] (Philippines Government 2001) and USA, particularly Florida, having a variety of harvest control measures. However, despite regulation and protection, there are ongoing issues with enforcement, highlighted by several authors, e.g. Dolorosa et al. 2013 and Nijman et al. 2015. Nijman et al. (2015) reported on the shell trade in twelve, supposedly protected mollusc species from Indonesia. Research based on market surveys and customs seizures indicated open and significant trade in the shells of seven clam (Tridacnidae) species (CITES listed), four gastropods and one cephalopod, and while the individual values were not particularly high, the volumes were significant, and the trade was only possible due to very limited enforcement.

Legislation is, however, an 'end point', and is only as effective as its enforcement; therefore many responsible conchological organisations and shell clubs have attempted to pre-empt such measures by developing and adopting codes of conduct for responsible collection, as well as awareness raising and education of environmental and sustainability issues via shell shows and publications.

While human activities can have very detrimental effects on wild animal populations through over-harvesting, and conchological collection is no exception, it may be important here to differentiate between specimen shells for collectors (conchologists) and display shells; those particularly large and impressive species, which are collected and sold as souvenir or decorative items, rather than as part of a curated collection. There is some evidence that for particular species, display collecting and trade can be locally detrimental. Trade in bivalve species such as tridacnid clams, and gastropods, such as *Charonia tritonis* (trumpet shell), *Cassis cornuta* (horned helmet shell) and nautilus shells may be locally, and even internationally significant, with 42,000 specimens confiscated by Indonesian authorities between 2005–2013. Similarly, Gössling et al. (2004), estimated annual numbers of these species for sale in Zanzibar between 700 and 1500 per annum. Giant clams (*Tridacna* and *Hippopus* spp.) appear to be particularly vulnerable to over-harvesting, due to slow growth rates and their exploitation for both food and ornaments, and demand has led to local population extinctions (Floren 2003), hence their listing on CITES schedule II.

[9] www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_2011-12_statewide.pdf

[10] www.daf.qld.gov.au/fisheries/commercial-fisheries/queenslands-commercial-fisheries/harvest-fisheries

[11] https://www.environment.gov.au/system/files/pages/7f4f21c5-7fe2-4bcf-b594-2f17319cc48e/files/exceptional-circumstance-submission.pdf

[12] A useful summary of Philippines shell regulation can be found at: www.conchology.be/?t=1000

However, it is important to differentiate between shell-trade sectors and maintain perspective. UN FAO statistics (FAO 2016) indicate that in 2014 around 740,000 t of scallops (Pectinidae) were harvested from the wild. If we convert that into numbers of shells (at 10 per kg), then this equates to around 7.4 billion shells per annum. By contrast, an annual estimate of pectinid specimen shells traded to collectors (based on comments from online dealers, shell show sales etc.) would amount to a maximum of 5000 shells, and bearing in mind that this is the most popular family of collectible bivalves, and that many shells are 'recycled' through collections.

Nevertheless, all wild capture activities, including shell collecting, require a fundamental appreciation of ecology and sustainability, while the moral issues associated with killing for specimen collections are an individual matter. However, as we have seen, shell collecting is not only about 'killing molluscs'; specimens can be obtained via various other means (see Sect. 20.4), and over time it becomes apparent to the majority of collectors that their interest requires the protection of the environments and habitats that support the animals.

The Audubon Medal recipient, Richard Louv, in his work on "nature-deficit disorder' said, "*We cannot protect something we do not love, we cannot love what we do not know, and we cannot know what we do not see. And touch. And hear*." (Louv 2005).

If society alienates people from an appreciation of biodiversity and the natural world in general, and collecting in particular, then there is potentially an even greater risk that we will cease to relate to natural environments and the animals and plants that live in them. Unregulated or careless shell collecting certainly has the potential to cause environmental and biodiversity damage, but appropriately managed, well-informed and responsible wild harvest, as part of a wider collecting and curation process, may actually be a greater contribution to environmental good than harm.

20.7 Future Prospects

The inherent value of shells as collector's items has ranged throughout human history from aesthetic pieces of jewellery, exotic curiosities from a new world, subjects of artistic expression and design, scientific specimens, and also as commercial items for sale by specialist dealers.

These different values of shells, and hence shell collections, indeed the existence and persistence of the physical collection itself, have been critical for the development of natural history, taxonomy, systematics and evolutionary biology. Since the curiosity cabinets of seventeenth century Europe, scientists have been inspired to investigate and publish work on shells, enabling the gradual progression and accumulation of ideas and information that is at the core of scientific investigation. So, perhaps more than any other biological collectible, the rich diversity of shells has provided the material and opportunity for both amateurs and professionals to provide insights into the wider natural world.

However, throughout the conchological community there is concern that the demographic is ageing and that relatively few younger people are continuing the long tradition of the discipline. While the value of responsible specimen collecting and accessible institutional natural history collections are in little doubt (Rocha et al. 2014; Bradley et al. 2014), the future development of natural sciences also requires a next generation of interested, passionate and educated individuals to pursue it. Therefore, it is perhaps important to ensure that future generations are given opportunities to develop the interest and practical skills that come with hobbies such as shell collecting. Several high-profile naturalists, such as Sir David Attenborough,[13] have raised concern about the danger of wholesale restrictions on natural history collecting, and the reduced opportunities for younger people to explore their natural environment and develop the fundamental interests that lead onto significant scientific contributions, whether as professionals or amateurs.

There is no question that if we continue to collect live mollusc shells from the wild then we must do so sustainably, and responsible conchological organisations have recognized this for many decades. However, enabling people to pursue their interest in natural history, and better understand the fundamental links between biodiversity and the supporting environment, can help to encourage the next generation of environmental conservationists. The world's seas, particularly near-shore areas, face numerous threats from anthropogenic pollution, habitat loss and fragmentation, and overfishing, which are arguably much greater threats to mollusc populations than shell collecting.

If people retain an interest in these habitats and species we can better understand and protect them, although the converse is equally true. This interest requires appropriately managed access to at least some collecting areas, for both amateurs and professional scientists. In this way, we, as communities, can maintain local familiarity, expertise and relevant data series, as well as recognizing emerging environmental threats and deterioration.

Robert Louis Stevenson (1911) famously wrote; '*It is perhaps a more fortunate destiny to have a taste for collecting shells than to be born a millionaire*'; which, while part of a discussion about finding an interest in life beyond the simple acquisition of wealth, uses an example which continues to generate significant passion, even obsession, amongst its devotees. As such, it seems an appropriate conclusion to this chapter.

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[13] http://www.telegraph.co.uk/news/earth/wildlife/9657545/David-Attenborough-I-would-never-have-been-a-naturalist-under-todays-fossil-laws.html

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