SHELLBANK

MARINE TURTLE TRACEABILITY TOOL

NOVEMBER 2022

A WWF-Coral Triangle Programme production.

SHELLBANK
Global Marine Turtle Genetic Database

Acknowledgements
This report was written by Michael Jensen (research contractor to WWF-Australia/Aalborg University) and Christine Madden Hof (WWF-Coral Triangle Programme), with contributions made by Greta Frankham (Australian Museum), Cecilia Fischer (contractor to WWF-Coral Triangle Program), Rizza Araceli Salinas (Department of Environment and Natural Resources), Astrid OCampo (WWF-Philippines) and review by Erin L. LaCasella (NOAA), Peter Dutton (NOAA), Nancy FitzSimmons (Griffith University), and the Indo-Pacific Hawksbill Working Group.

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WWF
WWF is one of the world's largest and most experienced independent conservation organisations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature by: conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

WWF coordinates Southeast Asia and Pacific (Asia-Pacific) efforts to address unsustainable use and illegal trade in marine turtles and turtle products. With a focus on hawksbill turtles, the program of work is multifaceted and involves collaboration between several organisations. One of the initiative's objectives is to develop and apply new, innovative approaches to effectively track marine turtles and turtle products along the trade chain from source to sale. To catalyse enforcement and aid conservation, the traceability of hawksbill turtle stocks targeted in trade will rely on WWF's collaborative trans-Pacific forensic study characterising hawksbill turtle genetics origins and relationships between nesting and foraging populations.

Royal Caribbean Group
This project would not have been possible without the generous support of Royal Caribbean Group. From 2018-2022, Royal Caribbean Group and WWF-Australia worked together to better protect the hawksbill turtle from the illegal turtle trade.

About Royal Caribbean Group:
At Royal Caribbean Group, respect for the oceans and the environment is not a choice; it's a way of life. Oceans make up to 71% of the planet and are 100% critical to our business and our right to operate. That's why we are intensely focused on using the best technology to advance our efforts to ensure a sustainable future for all of us.

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KEY MESSAGES

THE ILLEGAL TURTLE TRADE IS ALIVE AND THRIVING IN MANY COUNTRIES GLOBALLY

But it remains unclear where unsustainable take and trade is occurring, and most prevalent today, and which populations are being targeted.

SHELLBANK - A TRANSNATIONAL MARINE TURTLE TRACEABILITY TOOL - IS A GAMECHANGER

And the only traceability method we can use to track the covert and underground marine turtle trade. After years of refinement, ShellBank is now ready to be taken from pilot into practice.

IT USES DNA AND FORENSIC ANALYSIS TO TRACK TRADE AND PINPOINT POPULATIONS MOST AT RISK

Like tracing elephant ivory and rhino horn, ShellBank uses DNA and forensic analysis to trace the trade, identify poaching hotspots and pinpoint marine turtle populations most at risk for better enforcement and protection.

SHELLBANK CONSISTS OF A RAFT OF TOOLS

ShellBank's toolkit consists of DNA reference (Rookery Baseline and In-Water) and Confiscation databases, capacity building and training workshops, and other resources such as standard operating protocols.

ITS 'BANKS' OF GENETIC DATA ARE RAPIDLY EVOLVING AND WHEN COMBINED ALLOW TRACEABILITY

ShellBank's transnational genetic databases are a rapidly evolving global repository for marine turtle mitochondrial DNA of the genetically distinct turtle populations. The combined databases are the result of many international partnerships to allow traceability of the marine turtle trade.

SHELLBANK CAN BE USED AND CONTRIBUTED TO BY MANY, FOR RESEARCH CONSERVATION AND LAW ENFORCEMENT

ShellBank can be used by researchers and conservation managers to identify and track a turtle's population origin and its geographic (transmigratory) boundary. It can be used by law enforcers as a line of evidence in investigations or prosecutions.

HAWKSBILL TURTLES ARE THE FOCUS OF THE FIRST SHELLBANK REPORT

Because of the lack of genetic information, their vulnerability to extinction and to the illegal trade, this first ShellBank report focuses on hawksbill turtles in the Asia-Pacific region only.

"Ultimately, our goal is to see ShellBank become a vital resource for law enforcement, researchers and conservation managers, allowing routine identification and protection of marine turtle populations most impacted by the illegal turtle trade".


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KEY RESULTS

SHELLBANK WAS ESTABLISHED IN 2018

ShellBank first showcased DNA shell extraction in *Cracking the Code Report, 2019*, and piloted a project of how ShellBank can work in practice in *Surrender Your Shell Report, 2022*.

SO FAR, COLLABORATORS ACROSS 15 COUNTRIES ARE HELPING BUILD SHELLBANK

The turtle conservation community has tripled the number of sample locations recorded in ShellBank's Asia-Pacific database.

- More than 650 samples from 18 locations have been collected and are in the process or in the queue to be analysed by local research groups across Asia Pacific.
- Several ShellBank training sessions have been provided to over 65 researchers, and over 60 law enforcement officers across multiple countries.

MORE WORK IS NEEDED TO GROW THE DATABASES – THE BACKBONE OF SHELLBANK

Genetic data gaps remain for hawksbill turtles in Asia-Pacific; only seven genetic stocks have been assigned to date. ShellBank collaborations are key to rapidly expanding and improving the reference databases. Without this knowledge, ShellBank will not work.

FUTURE SHELLBANK REPORTS WILL HELP PINPOINT TRADE AND WHERE TARGETED EFFORT IS NEEDED

ShellBank reports are anticipated to be released on an annual basis to provide a snapshot of effort and where targeted enforcement and protection is most needed.

SHELLBANK IS SET TO EXPAND IN 2023

ShellBank's focus will expand to other marine turtle species and regions in 2023.

SHELLBANK HAS A CLEAR VISION FOR GROWTH, READY TO BE TAKEN FROM PILOT TO PRACTICE

Already aligned to policy, we now have a clear vision for ShellBank's refinement, use and uptake as the only traceability toolkit to track the illegal marine turtle trade and guide effective protection of these endangered species.

ShellBank is hosted externally and can be accessed at: www.shellbankproject.org or by emailing: shellbank@wwfint.org

TRACKING THE TURTLE TRADE

"With the help of marine turtle genetics and DNA-based wildlife forensic science, WWF and its partners have built a toolkit to help governments, researchers and conservation managers track the turtle trade from 'sale' back to 'source'".

Six of the seven marine turtle species have been assessed for their risk of extinction in the IUCN's Red List; all are listed as Vulnerable to Critically Endangered. Many factors have contributed to this decline, including bycatch in fisheries, pollution, degradation of nesting and foraging habitats, and climate change, but of significant concern is the ongoing legal and illegal unsustainable take (hunting and use of turtles and turtle parts) and trade. For the Critically Endangered hawksbill turtle *(Eretmochelys imbricata)* alone, its numbers are estimated to be at least 80% lower than historical levels, with approximately only 6,900 nesting females remaining in both the Indian and Pacific Ocean basins (Mortimer and Donnelly, 2008). Whilst it's been reported that around nine million hawksbill turtles were harvested over a 150-year period (1842-1992) for the tortoiseshell trade concentrated in Southeast Asia, hawksbills and green turtles *(Chelonia mydas)* are still subject to significant illegal trade for their eggs, meat and shell globally, even though it's banned under the Convention of International Trade in Endangered Species (CITES) internationally (CITES Secretariat, 2019; Nahill et al., 2020; Kitade, et al., 2021; Lopes et al., 2022; Senko et al., 2022).

Studies continue to suggest overexploitation (harvest or poaching) of marine turtles and links between domestic use and illegal trade (CITES Secretariat, 2019; Miller et al., 2019; Ingram et al., 2022; Lopes et al., 2022). The illegal trade in marine turtles and their parts or products ranges from domestic, small-scale operations where turtles are hunted to support local markets, to large-scale operations where turtles are harvested and trafficked internationally (Gomez and Krishnasamy, 2019; Miller et al., 2019). Although against existing laws prohibiting their use and trade, a recent study has conservatively estimated that 1.1 million marine turtles (excluding shell products and eggs) have been illegally exploited in 65 countries across the world over the last 30 years (1990-2020), of which 22% could be attributed to having been traded internationally (Senko et al., 2022). Noting this is a gross underestimate as no eggs or tortoiseshell products were included in the analysis, only articles in English were used, and the assessment relied on poor or lacking nesting population size or trend data. Combined with legal harvests (Humber et al., 2014), a rough global estimation of marine turtle legal and illegal exploitation since the last decade is approximately 80,000 turtles per year (Senko et al., 2022). A global assessment of the tortoiseshell trade reported 46,000 individual turtle shell items were offered for sale since 2017 alone with substantial illegal markets (Nahill et al,. 2020). This was further substantiated by a study on Japan's undiminishing domestic stockpiles and a rising tortoiseshell market of mostly raw product (since 2015), with illegal sourcing possibly shifting from Southeast Asia to the Caribbean region in recent years (Kitade et al., 2021). There are no global estimates on egg exploitation, but it is considered significant (CITES Secretariat, 2019; Ingram et al., 2022; IOSEA, 2014). To give an indication of poaching levels, in Peninsular Malaysia, a 2019 survey estimated 365,000 eggs are sold at Kuala Terengganu market annually, which generally correlates with the yearly total of 422,000 eggs estimated by TRAFFIC in 2009 (CITES Secretariat, 2019). This is presumably a small fraction of the actual number harvested and sold across other cities of Peninsular and Sabah, Malaysia, let alone other neighbouring countries and those globally targeting eggs for use and trade.

Whilst global studies indicate high-risk exploitation countries (Humber et al., 2014) and populations within broad geographic boundaries (e.g. regional Management Units of the West Pacific and Southeast Asia, East Atlantic, Southwest Atlantic and South Caribbean; Senko et al., 2022), data remains poor, patchy and a gross underestimation. It remains unclear where turtle take and trade is occurring and most prevalent today, and which populations are being targeted. The marine turtle supply chain has changed significantly and seemingly shifted from open markets to a more covert form (CITES Secretariat, 2019; Vuto et al., 2019). This trade continues in many countries globally (CITES Secretariat, 2019; Nahill et al., 2020), where demand is high and increasing through new and re-emerging black markets in Asia, including China, Japan, Viet Nam, Taiwan and Hong Kong (Lam et al., 2012; Senko et al., 2022; Kitade et al., 2021).

1.1 MILLION MARINE TURTLES (excluding shell products and eggs) have been illegally exploited in 65 countries across the world over the last 30 years (1990-2020), of which 22% could be attributed to having been traded internationally.

Global estimation of marine turtle legal and illegal exploitation since the last decade is approximately **80,000 TURTLES PER YEAR**

Marine turtles are traditionally harvested by coastal communities, but links to illegal trade continue to threaten the survival of marine turtles.

A lack of investigation, indictment, compliance and enforcement capacity across the region enables the illegal turtle trade to continue. It cannot be dismantled without knowing where and how turtles, their parts and products are sold or, more importantly, data and evidence of where and what turtles are illegally harvested. As a result, we need to urgently implement and adopt new technologies built to trace the illegal turtle trade. For turtle species and populations at risk of extinction from overexploitation, time may be running out.

WWF and its partners are actively addressing this challenge through ShellBank – a global marine turtle traceability tool.

Following the success of tracking poached populations of elephants and rhinos through the genetic signatures found in their ivory and horns, tracing the marine turtle trade can be achieved via ShellBank. WWF is partnering with researchers, universities, museums, NGOs and governments to continue developing and applying genetic tools that will identify poaching hotspots and pinpoint marine turtle populations that are most impacted by the trade across the Asia-Pacific region and globally. ShellBank, which has been in the pilot phase since 2018, is now ready to be geared up for the next phase, putting it into practice.

SHELLBANK – A TRANSNATIONAL TOOLKIT TO TRACK TURTLE TRADE

ShellBank is a targeted response to marine turtle populations in trouble, where poaching and trade continue to threaten and dampen population recovery.

SHELLBANK IS A GAMECHANGER, A WORLD FIRST.


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It provides a way to not only track trade for use by law enforcers as a line of evidence in investigations or prosecutions, but also to track a turtle's population origin and its geographic (transmigratory) boundary for conservation management, and protection purposes. To pinpoint populations and the geographic region in which they are being targeted in use and trade enables targeted response (e.g. greater compliance and enforcement) and where recovery effort (e.g. further conservation management and protection) can be enacted. Extinction is likely for some turtle populations, particularly in the Asia-Pacific region, and the use and upscaling of ShellBank efforts may be our last line of defence.

THE ROLE OF SHELLBANK IS TO ENABLE GOVERNMENTS, SCIENTISTS, CONSERVATIONISTS AND COMMUNITIES TO:

1. Track the illegal marine turtle trade from "sale to source".
2. Identify populations targeted in trade, especially those most at risk from poaching and require stronger protection.

Ultimately, our goal is to see ShellBank become a vital resource for law enforcement, researchers and conservation managers, allowing routine identification and protection of populations most impacted by the illegal turtle trade.

The ShellBank toolkit consists of rapidly evolving reference and confiscation databases, capacity building and training workshops, and other resources such as standard operating procedures to support implementation.


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SHELLBANK CONTINUES TO:

- Coordinate and build on an open-source transnational genetic database for use by conservation research and law enforcers, through genetic sample collection, analysis, and data sharing throughout the region;
- Advance knowledge of turtle stock structure and composition and specimens sourced, transiting or sold at transaction points using the transnational genetic database;
- Build in-country capacity for genetic sample collection and analysis by providing standard operating protocols, conducting workshops and providing expert advice that can be applied to all marine turtle species and sample types (e.g. meat, eggs, shell, etc.).

ShellBank is one of its kind and currently, the only global traceability method available to track the covert and underground marine turtle trade.[1]

The threat is very real, with ongoing and surging efforts by CITES and the Convention of Migratory Species (CMS) in recent years to assess and activate governments to prioritise tackling the illegal marine turtle trade. With a recently endorsed use and trade focused CMS Single Species Action Plan for Hawksbill Turtles in South-east Asia and the Western Ocean Pacific Region (SSAP), and revised proposals under CITES mandating countries to take genetic samples to track trade, ShellBank is well poised to support action on marine turtle trade and provides the necessary tools, capacity training and programme to do so.

1 This project is part of WWF's Global Protecting Turtles for Tomorrow Strategy and forms part of a larger Marine Turtle Use and Trade Initiative (Cracking the Code for Recovery) to address marine turtle use and trade in the Asia-Pacific, coordinated by the WWF-Coral Triangle Programme. The overarching goal of this initiative is to safeguard marine turtle populations in the Asia-Pacific region so they are no longer at risk of extinction and no longer targeted for trade. This program is currently being expanded globally and beyond hawksbill turtles.

HOW DOES IT WORK, USING DNA?

In addition to physical tagging and satellite transmitters, molecular (DNA) sampling is used as a more time-efficient and cost-effective tracking tool to determine the geographic origin of individuals. To accurately trace traded turtles, their parts or products back to where they were poached, ShellBank uses DNA. Genetic approaches have been useful in research and wildlife forensic investigations. These techniques have been successfully applied to the illegal poaching of elephants, tigers, rhinoceros, birds etc. (Wasser et al., 2008; Ewart et al., 2018; Nishant et al., 2018; Ghosh et al., 2019). For example, DNA extracted from ivory has been used to identify the location of the poaching hotspots for African elephants by statistically matching the genetic signature of confiscated ivory to geographic or population-specific genetic signatures (Ehman et al., 2015). And now, through ShellBank, it can be applied to marine turtles.

We do this by extracting mitochondrial DNA (mtDNA) from turtles and their parts or products and comparing it to the mtDNA variants (called haplotypes) of turtles from known marine turtle populations (a reference database: Figure 1). Because marine turtles exhibit natal homing (return to the region where they were born), each nesting region has a distinctive genetic signature (refer Box 1; Turtle Genetics in Brief). These genetic signatures are our roadmap to trace turtles back to their geographic origin (nesting population). Used by scientists for decades to assign a turtle's nesting origin from foraging areas (Jensen et al., 2016; Read et al., 2015; Velez-Zuazo et al., 2008), those caught as fisheries bycatch or stranded (LaCasella et al., 2013; Rankin-Baransky et al., 1975; Stewart et al., 2016), but only recently applied through ShellBank to the tortoiseshell trade (LaCasella et al., 2021), the 'bank' of all data combined is what allows us to determine the population origin of turtles and their parts or products from 'sale to source'.

Similar to other traceability tools (e.g. tracing elephant ivory using the Elephant Trade Information System (ETIS) and Monitoring Information), or rhino horn using Rhino DNA Index System (RhODIS)), ShellBank relies on a comprehensive reference database, a database of the genetically distinct turtle populations from all over the world. A successful reference database depends on the extent to which all the potentially contributing nesting populations and their foraging and migratory areas have been sampled. In contrast to these visible and relatively accessible land-dwelling species, turtles spend most of their life being invisible and relatively inaccessible as their migratory routes span thousands of kilometres across multiple countries, and as they nest on thousands of mainland beaches and remote islands. Focused on marine turtle species that are targeted in trade – primarily hawksbill and green and, to a lesser extent, leatherback turtles (see Box 2, The Plight of Key Traded Marine Turtles), reference data is exponentially growing but remains poor for some species and some regions. This is particularly so for the Critically Endangered hawksbill turtle, the least studied marine turtle in the world (Limpus, 2009) and the primary turtle targeted for the tortoiseshell trade (Nahill et al., 2020). Because our understanding of the population structure of hawksbill turtles in the Asia-Pacific is the most limited globally, this is where ShellBank began.

This first ShellBank report covers hawksbill turtles in the Southeast Asia and Western Pacific Ocean Region, as we initiate expansion to green and leatherback turtles and beyond the bounds of the Asia-Pacific to the global populations and regions of the Atlantic Ocean Region and Caribbean, Central and Eastern Pacific Ocean Region, Central and West Indian Region starting in 2023. This is critical to enable ShellBank to work at its best.

"ShellBank relies on a reference database, a database of the genetically distinct turtle populations from all over the world so that traded turtles, their parts or products can be accurately traced back to where they were poached."

BOX 1: MARINE TURTLES GENETICS IN BRIEF

Marine turtles are known as the ancient mariners. They are highly migratory and often utilise foraging areas far from where they were born. However, one of the most remarkable facts about marine turtles is their natal homing behaviour, where female (and possibly male) turtles return to their region of birth to breed and lay eggs. The mtDNA is maternally inherited, meaning that it is only passed down from mothers to their offspring, making it the genetic marker of choice for detecting the population structure of marine turtle nesting populations. Because female turtles are highly philopatric to their natal region, they generate a strong genetic similarity between turtles nesting within the same area and significant differences between regions (Jensen et al., 2013). They essentially generate a characteristic genetic signature for each nesting region. These genetically distinct nesting populations are also referred to as genetic stocks or Management Units (MUs). When a comprehensive understanding of the genetic signature of all (or most) nesting populations is available, they can be used to identify the origin of samples collected away from the nesting beaches, such as foraging areas, fisheries bycatch or illegal tortoiseshell products. This approach is known as mixed stock analysis and provides a rigorous statistical approach to estimating the geographic origin of samples. This analysis has been extensively used in marine turtles to determine the rookery origin of turtles sampled at foraging areas (e.g. Gaos et al., 2017; Bell and Jensen, 2018). However, the power of mixed stock analysis depends on the extent to which all the potentially contributing nesting populations have been sampled. For hawksbill turtles in the Asia-Pacific, our understanding of the population structure is limited. Nonetheless, recent studies have made significant advances identifying at least seven distinct genetic stocks (Nishizawa et al., 2016; Vargas et al., 2016), and through ShellBank and other Working Groups (e.g. Asia-Pacific Marine Turtle Genetic Working Group and the Indo-Pacific Hawksbill Genetic Working Group) sampling is well underway by multiple organisations to characterise remaining gaps and collectively develop this transnational genetic baseline database through partnership and capacity building.

BOX 2: THE PLIGHT OF KEY TRADED MARINE TURTLES

Rivers to Reef to Turtles
© Christine Hof / WWF-Aus

HAWKSBILL TURTLES
(Eretmochelys imbricata)

Hawksbill turtles are well known for their beautiful shells and their essential role in maintaining our coral reef ecosystems (León and Bjorndal, 2002). Recent publications state hawksbill turtle exploitation and trafficking is a global conservation priority (Nahill et al., 2020; Madden Hof et al., 2022; Senko et al., 2022) with recent global estimates (excluding eggs and tortoiseshell products) revealing that hawksbill turtles make up over half of the illegal exploitation (where species were reported) over the past decade (2010-2020), and over six times higher in legal harvests that were previously reported (Humber et al., 2014; Senko et al., 2022). The species has never properly recovered, and unfortunately, declines in hawksbill turtle populations continue in many countries globally (Hamman et al., 2022; Madden Hof et al., 2022; Mortimer and Donnelly, 2008). We are concerned that turtle use severely reduces populations, and trade is outstripping a rapidly diminishing supply.

Rivers to Reef to Turtles
© Christine Hof / WWF-Aus

GREEN TURTLES
(Chelonia mydas)

Green turtles are also moving toward a similar fate. Considered Endangered internationally (IUCN Red List, 2004) and facing multiple threats at each life history stage, they are readily consumed and traded across the globe (CITES Secretariat, 2019). While overexploitation continues (Ingram et al., 2022) in many countries, green turtles dominate legal and illegal marine turtle exploitation (Humber et al., 2014; Senko et al., 2022; Vuto et al., 2019). The concern is rising amongst some scientists that the use and trade of green turtles will replace an outstripped or diminishing supply of hawksbill turtles.

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LEATHERBACK TURTLE
(Dermochelys coriacea)

Leatherback turtle populations are also declining in many places globally, where the conservation status of different sub-populations vary from Data Deficient to Critically Endangered (IUCN Red List, 2013). While bycatch in fisheries remains a key threat, leatherback turtles are also subject to a long history of harvesting, with some recent reports of their leathery shells being made into handicrafts. Leatherback population numbers are critically low, with the western Pacific population estimated to be approaching extinction. Only 1,277 nesting females are estimated, with overall numbers declining at about 6% per year (from 2011 to 2017; Benson et al., 2020).

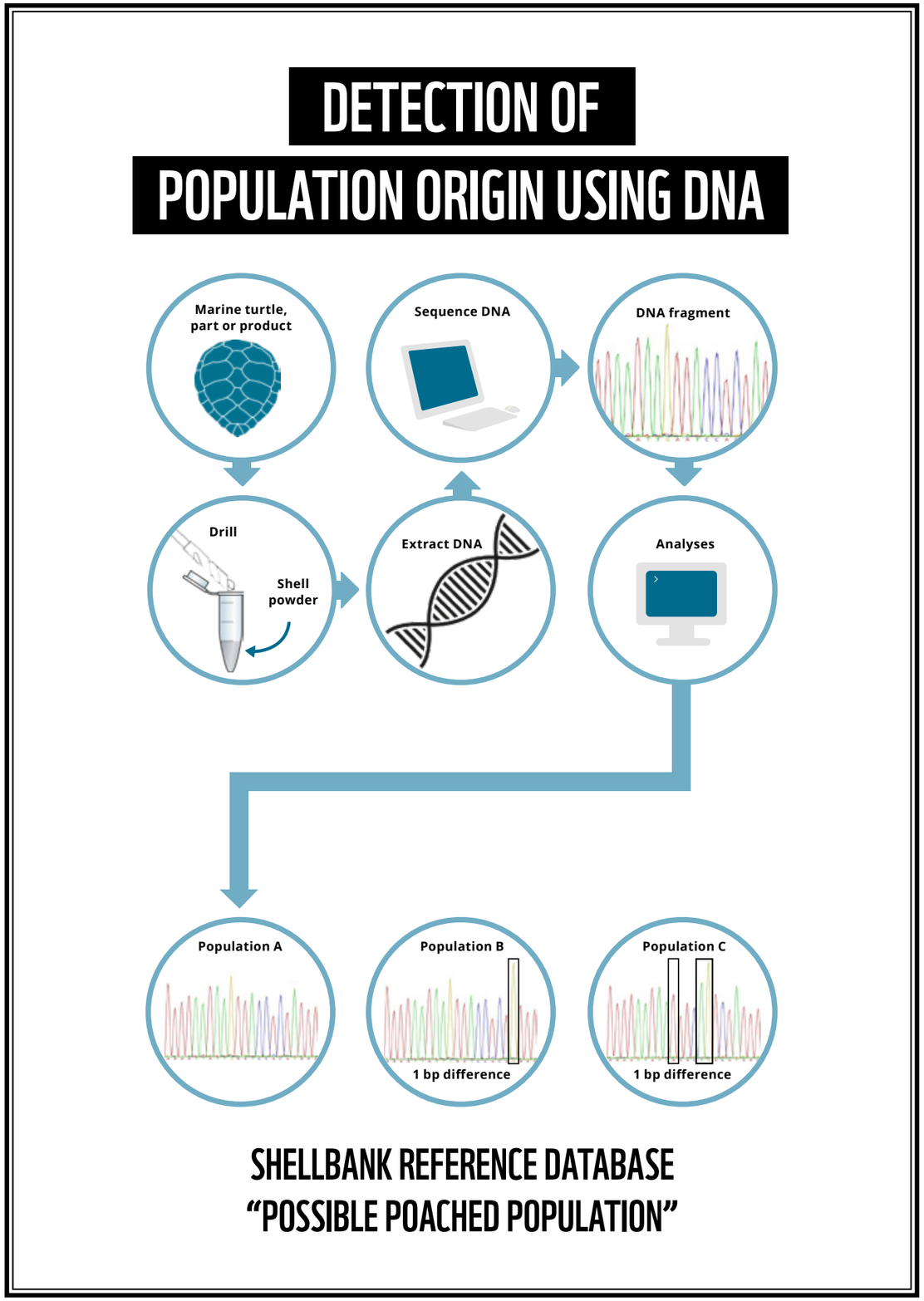


Figure 1: Simplified workflow of ShellBank to determine the population origin of marine turtles, parts or products.

SHELLBANK TRANSBOUNDARY GENETIC DATABASES

The ShellBank Database is a global repository for marine turtle mtDNA haplotype (genetic variant) data that allows routine identification of populations most at risk from unsustainable use and trade and in need of protection.

It includes three genetic databases: Rookery Baseline, In-Water, and Confiscation.

The Rookery Baseline Database and In-Water Database make up the reference database, and the Confiscation Database keeps records of the genetic information on confiscated items, such as jewellery, eggs, or scutes. Together, these three databases allow traceability of the marine turtle trade and conservation research.

The Rookery Baseline contains genetic data from samples collected from known marine turtle nesting populations. This is essential to tracing the origin of traded turtles, their parts and products.

The In-Water category primarily contains genetic data from juvenile and adult hawksbill turtles sampled at foraging areas, but also from stranded turtles or those caught as fisheries bycatch. While not directly used to trace the origin of turtles, parts and products, this data allows for the geographic boundaries of nesting populations to be assessed (a likely poached location, and in turn, helps inform the 'boundaries' of criminal activity).

The final category, Confiscation, contains genetic information on the turtle, part or product collected from warehouse stockpiles, seizures, or citizen science donations. This is the data used to cross-check against the reference database for a genetic stock (likely poached population and location) match. Initially, this database will also help inform what Rookery Baseline data is missing whenever new genetic variants are found in the In-Water or Confiscation databases, but not yet in the Rookery Baseline.

"ShellBank provides a programme of work to address critical population declines, aid in transboundary migratory understanding and identify what populations and sites require protection, whilst tackling the illegal marine turtle trade. With a focus on hawksbill turtles initially, one of the most Critically Endangered marine turtle species on the planet, this programme will truly help both law enforcement and conservation managers to reverse the trajectory of populations struggling to recover."

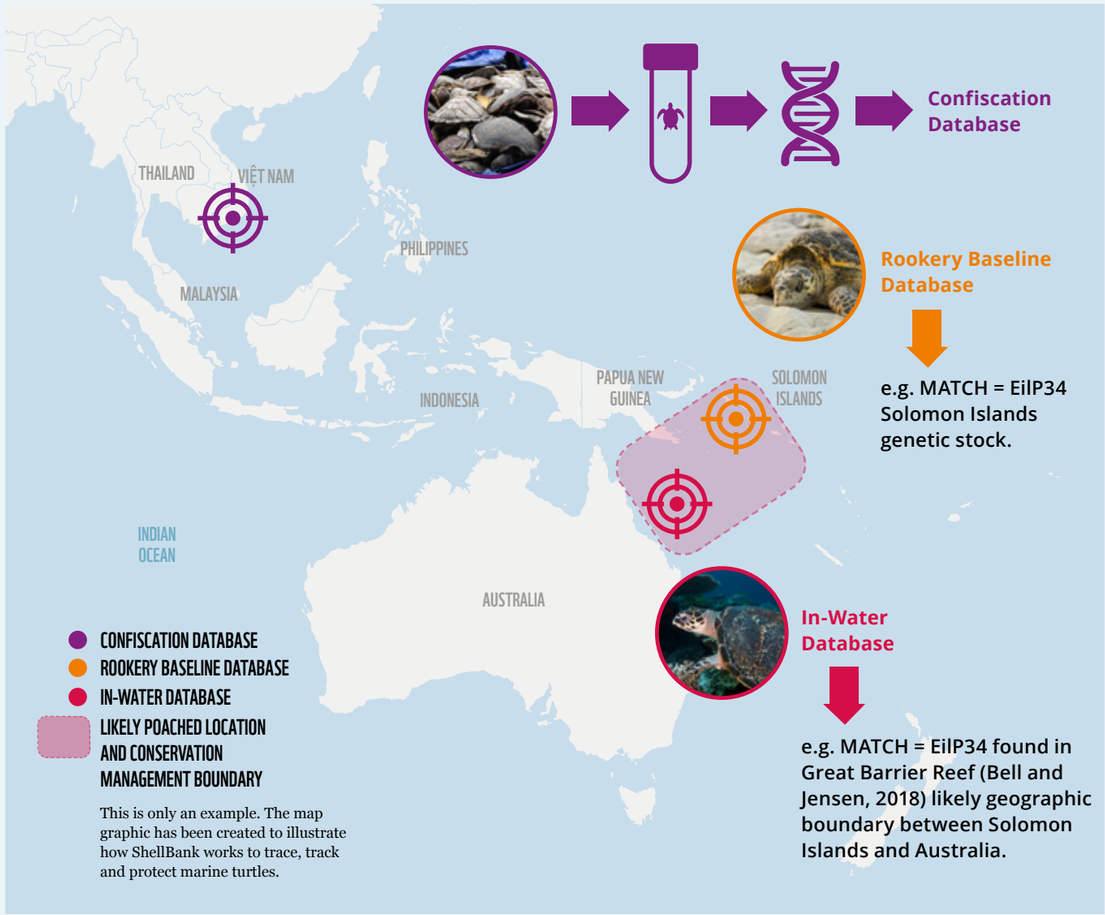
BOX 3: HOW SHELLBANK WORKS

REFERENCE DATABASE

1. **Rookery Baseline Database:** Containing genetic information from samples collected from wild nesting turtles, hatchlings or embryos/eggs used to assign genetic stock (nesting) origin.
2. **In-Water Database:** Containing genetic information from samples collected in-water from wild turtles, including all size classes. These may include foraging, stranded, or bycatch animals (both alive and dead) used to assign genetic stock population boundaries.

TRACK TRADE

3. **Confiscation Database:** Containing genetic information from samples collected from confiscated marine turtles and marine turtle parts or products. These samples may be taken from live animals, meat, eggs, whole stuffed animals or shells, or tortoiseshell products (i.e. raw scutes or highly processed items such as jewellery) to record which genetic stock was traded at what entry point. This database will also initially help us to detect if any orphan (unknown genetic stocks) have been identified in the reference database.



This is only an example. The map graphic has been created to illustrate how ShellBank works to trace, track and protect marine turtles.

SHELLBANK IN PRACTICE

ShellBank has shown that, with complete Rookery and In-Water databases, it will be possible to accurately trace the population origin, enhance a country's enforcement efforts against illegal traders, and advance marine turtle conservation at national and regional levels.

So far, ShellBank participation and contributions have come in many forms (see Case 1, 2 and 3). For example, collecting and sharing genetic data to build and improve the reference database, using newly seized turtles and turtle parts or product samples to identify poaching populations, to creating public awareness from historically donated samples, and implementing as common practice along the law enforcement chain (refer ShellBank Results).

As such, ShellBank can be used and contributed to by many. Whilst ShellBank moves from pilot to practice, it will continue to take coordinated effort and requires many countries to participate. ShellBank collaborations are key to rapidly expanding and improving the reference databases. Without this knowledge, ShellBank will not work.

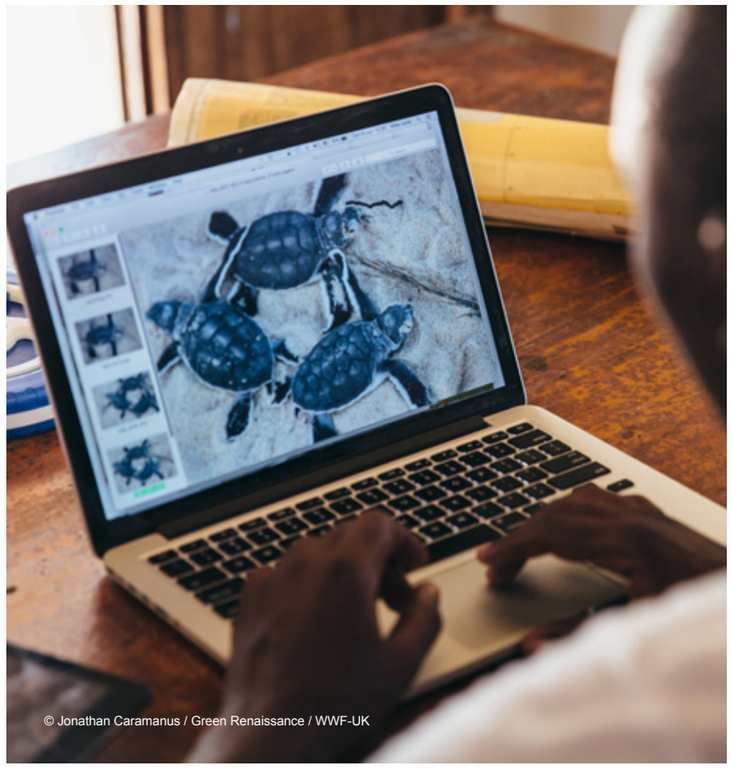
USERS AND CONTRIBUTORS

The current version of the ShellBank transboundary genetic databases are hosted locally with restricted access to ShellBank partners. These databases are still under development but are set for release to the broader research and law enforcement communities in the spring of 2023.

In recognition that ShellBank is multi-collaborative and a trusted repository platform, it is hosted externally from WWF and its partners at: **www.shellbankproject.org**

The website and database integration is currently under construction but the site will be a hub that contains information about ShellBank, resources (e.g. SOPs, publications, etc.), and provide access to the three databases.

You can access ShellBank at:
www.shellbankproject.org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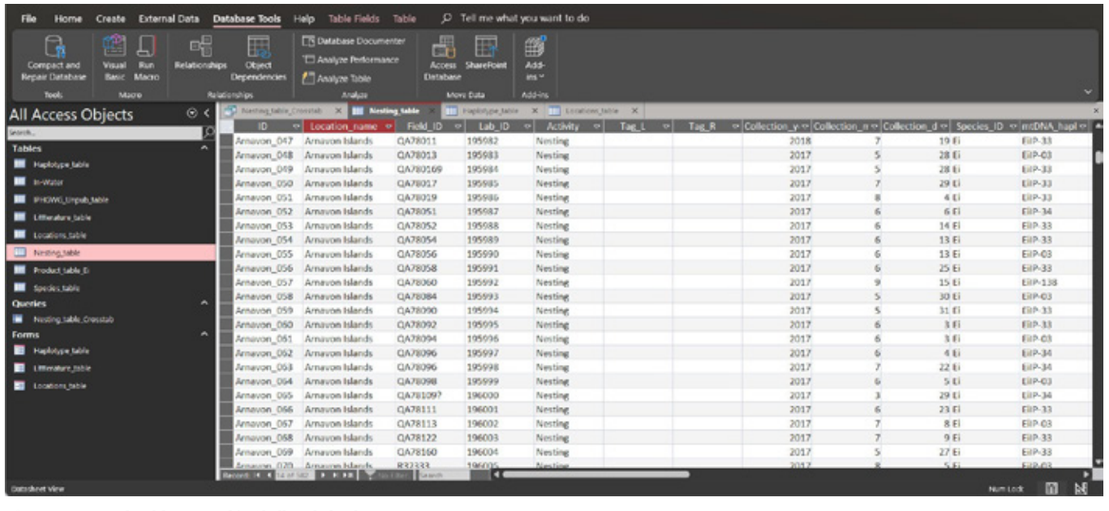

Figure 2: Example of data stored in ShellBank database

DATABASE ENTRY AND ACCESS

ShellBank provides a single point of verifiable reference and repository for genetic data (e.g. Figure 2). The databases contain primarily peer-reviewed and published data. However, at the discretion and only in agreement with the data owners, it can include verifiable unpublished data by direct data submission, including from reports or presentations. As such, there may be different levels of access to the ShellBank databases. ShellBank encourages and provides technical support to unpublished data contributors to aid open-source publication.

Genetic data is both minded and freely provided by data owners in order to keep the database up-to-date. Access to the database is available as open-source (generally containing information on species, collection type (e.g.nesting or foraging), mtDNA haplotype, location, etc.), and can be freely used by anyone; law enforcement, conservation managers, researchers and students alike.

Data entry and access can be made to:
shellbank@wwfint.org

SHELLBANK COLLABORATIONS

Collaborations and working groups are key to the success of ShellBank.

Through instigating the membership of the Indo-Pacific Hawksbill Genetic Working Group (IPHGWG) and assisting to steer the Asia-Pacific Marine Turtle Genetic Working Group (APMTGWG), WWF is part of a growing network of research and science-based organisations throughout the region identifying gaps and coordinating sampling and analysis of new genetic data. WWF has established a number of partnerships directly working on or contributing to ShellBank (refer ShellBank Results below).

WWF has also partnered with a team of forensic experts at TRACE Wildlife Forensics Network and the Australian Museum to work alongside law enforcement officers of various agencies to test, implement, align and embed ShellBank along their law enforcement chains, including through the provision of laboratory and front-line officer confiscation and evidential handling training and capacity building. For both the sample collection and laboratory analysis processes, the partnership is also producing a series of standard operating protocols (due 2023). These will guide ShellBank implementation and assist with validation and verification of data.

Although WWF instigated and led the establishment of ShellBank, its intent is for ShellBank to be managed and operated independently, and if valued and later endorsed as a CITES-mandated programme and traceability tool, on behalf of CITES Parties.

STATUS OF SHELLBANK

SHELLBANK IS CURRENTLY FOCUSED ON HAWKSBILL TURTLES IN THE ASIA-PACIFIC REGION

As we continue to coordinate, build and expand the transnational genetic database, finalise the standard operating protocols, and transform the digital database and platform, we have begun to showcase ShellBank globally as we move from pilot into practice.


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With the support from WWF and the work of local and international partners, we anticipate the collection and analysis of an additional 1000 new marine turtle samples by 2024 for the Asia-Pacific region. We will extend our hawksbill efforts to other regions across the globe. We will also begin incorporating green and leatherback MUs and identifying sampling gaps in 2023 to widen ShellBank's useability.

ShellBank provides the programme and platform in which countries can deliver their mandates or required action on marine turtles for both conservation management and law enforcement purposes. The collection and analysis of genetic samples for marine turtles to determine species involved and populations of origin has been endorsed by CITES Parties' *Turtle Decisions* (2019-2022). Again proposed in the CITES Resolution (from 2022 onwards), the collection and analysis of marine turtle DNA is also included in a number of other regional and national plans and strategies across the Asia-Pacific region (e.g. Indian Ocean South East Asian Marine Turtle Memorandum of Understanding (IOSEA MOU) Work Programme, the Secretariat of the Pacific Regional Environment Programme Pacific Islands Regional Marine Turtle Action Plan, CMS SSAP, etc.) highlighting ShellBank's relevance, importance and need. As such, WWF is further prioritising its efforts to ensure ShellBank becomes operational and fully functional by 2025.

ShellBank reports are anticipated to be released on an annual basis to provide a snapshot of gaps and progress, and identify the key populations and localities targeted by trade - those that are in need of better law enforcement effort and conservation management protection. Over time, ShellBank can be used to establish and assess trends in illicit marine turtle trade and help evaluate if monitoring, enforcement, compliance and protection efforts are effective in dismantling the trade.


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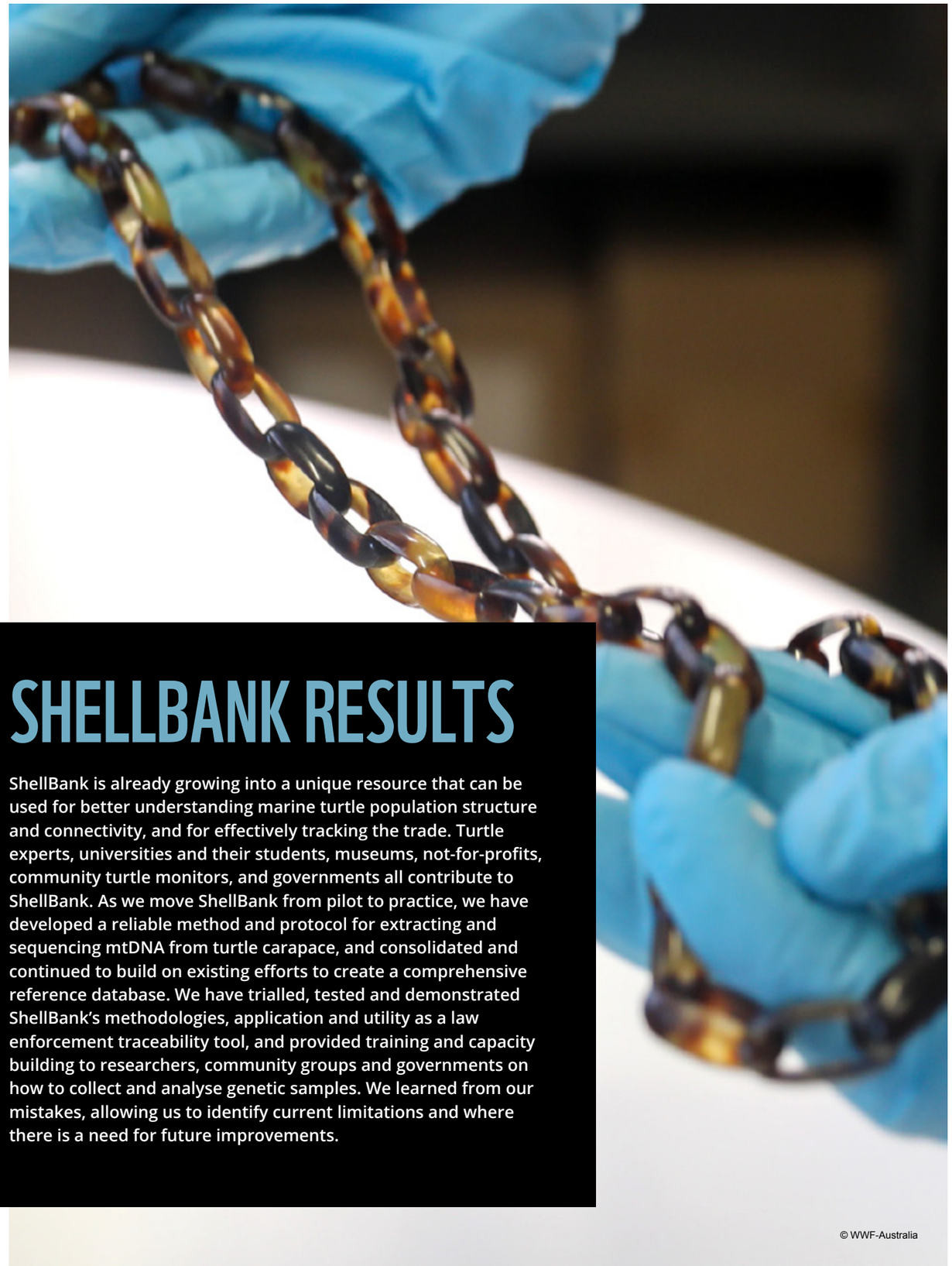

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SHELLBANK RESULTS

ShellBank is already growing into a unique resource that can be used for better understanding marine turtle population structure and connectivity, and for effectively tracking the trade. Turtle experts, universities and their students, museums, not-for-profits, community turtle monitors, and governments all contribute to ShellBank. As we move ShellBank from pilot to practice, we have developed a reliable method and protocol for extracting and sequencing mtDNA from turtle carapace, and consolidated and continued to build on existing efforts to create a comprehensive reference database. We have trialled, tested and demonstrated ShellBank's methodologies, application and utility as a law enforcement traceability tool, and provided training and capacity building to researchers, community groups and governments on how to collect and analyse genetic samples. We learned from our mistakes, allowing us to identify current limitations and where there is a need for future improvements.

HISTORICALLY AND NOW, AT VARIOUS LEVELS, 15 COUNTRIES ARE COLLABORATING, PARTICIPATING OR HAVE EXPRESSED FURTHER INTEREST IN SHELLBANK:

- Papua New Guinea and the Solomon Islands contributed genetic samples for the *Cracking the Code* pilot and helped present the outcomes at CITES Side Event CoP18 (refer Case Study 1) and are now involved in wild tissue sampling. [Partners contributing: University of the Sunshine Coast, Griffith University, The Nature Conservancy, Conflict Island Conservation Initiative, WWF-Australia/Papua New Guinea/Solomon Islands, governments.] The Solomon Island Government has recently expressed interest in furthering its participation in ShellBank.
- Australia supported citizen science and confiscation donations under *Surrender Your Shell*, adding to the confiscation and informing the reference databases and knowledge of prior trade, but also helped refine ShellBank methodology (refer Case Study 2). [Partners contributing: WWF-Australia and Australian Museum.] The Australian Government has confirmed its ongoing participation in ShellBank, and other partners are analysing new wild tissue samples which will help expand the Rookery Baseline and In-Water database (after partners publications). [Partners contributing: Griffith University.]
- The Philippines are collecting wild tissue (nesting, hatchlings, stranded turtles) and historical confiscated samples to inform the reference and Confiscation databases, and provide a snapshot of prior trade. [Partners contributing: WWF-Australia/Philippines, Large Marine Vertebrates Research Institute Philippines (LAMAVE), University of Philippines, government] (refer Case Study 3). National ShellBank training with law enforcers is upcoming in early 2023 under the TRIPOD[2] project.
- Fiji and Vanuatu partners have collected wild tissue samples for analysis and inclusion in ShellBank (some after partners publications). [Partners contributing: University of South Pacific in collaboration with NOAA, Griffith University, Vanuatu Cultural Centre]. Through other existing programs, Fiji has recently expressed interest in furthering its participation in ShellBank via representatives of the Asia-Pacific Marine Turtle Genetic Working Group, SPREP and WWF-Fiji.
- Indonesia has a collection of genetic samples from nesting turtles and some shell products and are currently analysing some of the wild tissue samples (nesting turtles). [Partners contributing: Oceanogen, ELNA, IPB, Syiah Kuala University, Bionesia]. Indonesia has recently expressed interest in furthering its participation in ShellBank under a national consortium of universities and not-for-profits. National ShellBank training with law enforcers from 10 different agencies was completed in September 2022 under the TRIPOD project.
- Timor-Leste, Thailand, Palau, Singapore, Kenya and Sabah, Malaysia have all recently expressed interest in collecting and analysing marine turtle samples primarily for conservation research. However, the latter two countries also expressed interest in ShellBank from the perspective of law enforcement. National training with law enforcers from 10 different agencies in Sabah, Malaysia was completed in July 2022 under the TRIPOD project.
- ShellBank is scheduled to be showcased to Viet Nam in partnership with TRAFFIC in mid-2023 and at a regional workshop with Indonesia, the Philippines and Sabah, Malaysia under TRIPOD in early 2023.

A snapshot of ShellBank country and regional summaries providing further information on the current status of protection, population trends, genetics stocks sampled, and future identified gaps is provided in Appendix 1. Noting, country summaries are only provided for higher density hawksbill populations, those where genetic sampling is underway, and/or those implicated in illegal trade. Future annual reports will showcase additional country summaries as partnerships grow.

2 Targeting Regional Investigation and Policing Opportunities and Development (TRIPOD) project, is a collaboration between Freeland, IFAW and WWF supported by the United States Department of State Bureau of International Narcotics and Law Enforcement Affairs, aimed at combating and disrupting illegal wildlife trafficking across the Sulu Celebes Seas.

ROOKERY BASELINE AND IN-WATER DATABASE

Currently, the Rookery Baseline Database contains information on more than 1,900 published genetics samples collected across 72 hawksbill rookeries globally (Figure 3 and Appendix 2). These samples define a total of 32 individual Management Units (genetic stocks). In addition, more than 650 samples across 18 rookeries and 7 countries represent unpublished data (held by the IPHGWG members) where samples have been collected but not yet analysed and/or published. When these data are published and become open-access in the Rookery Baseline, it will triple the number of ShellBank locations for Asia-Pacific since the project began in 2018. Nevertheless, many genetic gaps remain in Asia-Pacific, as genetic sampling of hawksbill rookeries make up only a fraction of known nesting sites across the region (see Figure 4).

Still under development, the In-Water Database contains only 158 samples from 6 foraging grounds across 3 countries (Australia, Malaysia and Japan) for Asia-Pacific. This is partly caused by the incomplete Rookery Baseline. Several unpublished datasets exist though IPHGWG members that are awaiting publication until a more comprehensive Rookery Baseline becomes available. It is anticipated that this data will be published in the near future. Furthermore, the inclusion of global datasets will see the In-Water Database grow significantly in 2023.

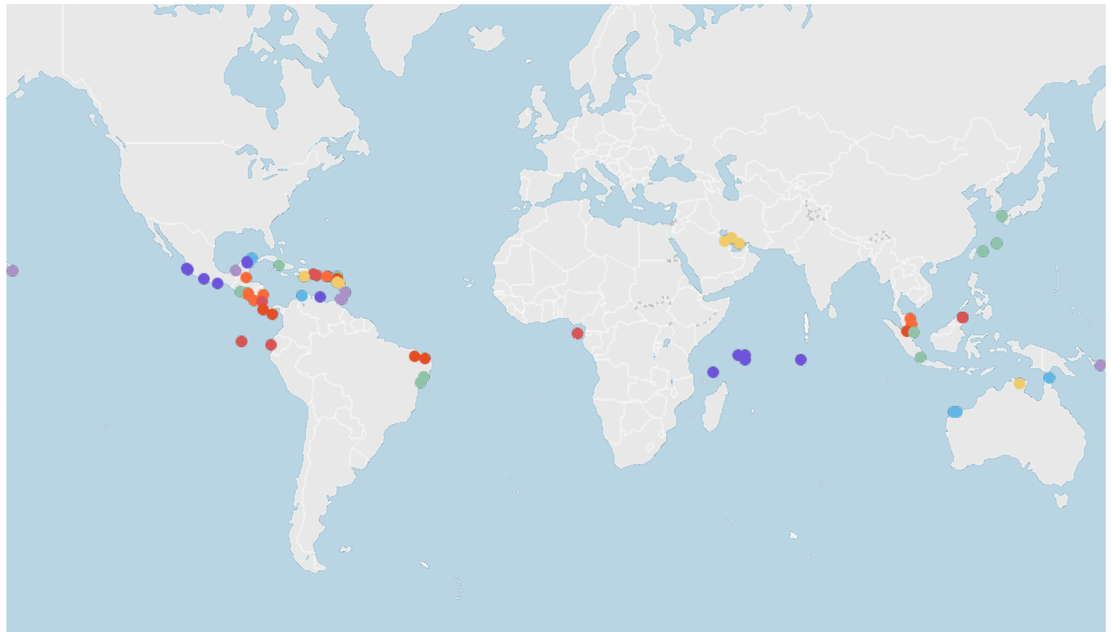

Figure 3: Map of 72 global hawksbill rookeries that have been characterised, identifying 32 Management Units (genetic stocks). Rookeries that belong to the same management unit are colour coded.

CONFISCATION DATABASE

Seventy-five samples are in the Confiscation Database for which genetic information exists. These samples are from Solomon Island and Papua New Guinea (*Cracking the Code* report) and Australia (*Surrender Your Shell* report). It is anticipated that the Confiscation Database will increase significantly in early 2023 as samples have already been collected from the Philippines stockpiles, representing historical and contemporary confiscated or seized marine turtle and shell products.

As we continue to build our collaborations with law enforcement agencies and ShellBank is used for intelligence and investigations, in the future, we will be able to provide maps of likely poached populations and locations targeted in trade.

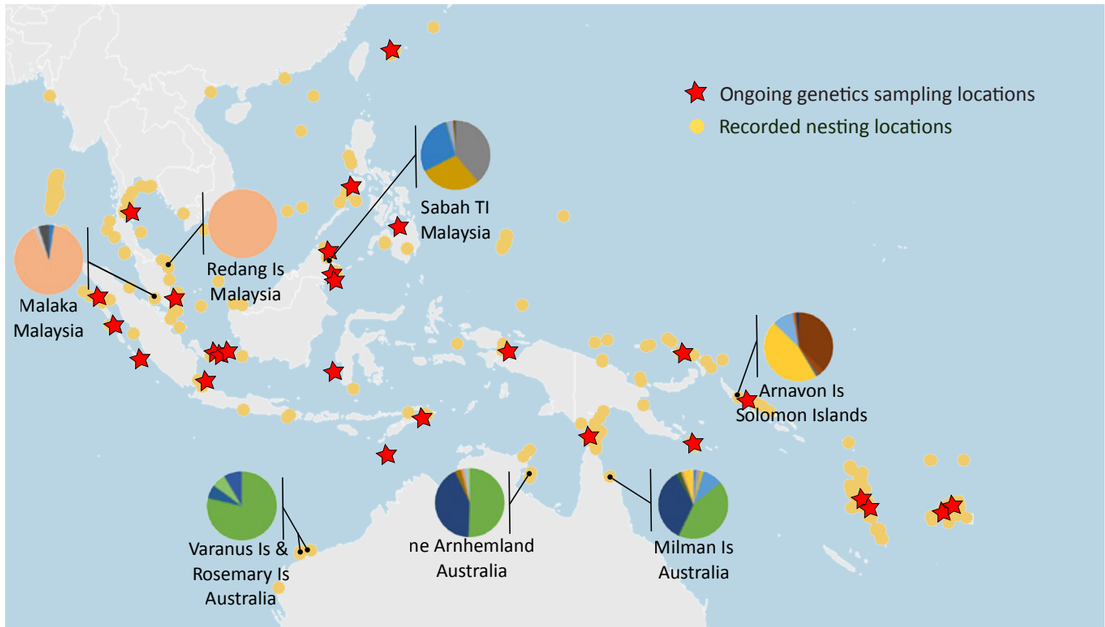

Figure 4: Current status of hawksbill management units defined by mtDNA haplotype frequencies (pie graphs), nesting beach sites (yellow dots), and ongoing genetic sampling sites by local research groups across Asia-Pacific (red stars).

CASE STUDY 1: CRACKING THE CODE | DEVELOPING A TORTOISESHELL DNA EXTRACTION AND SOURCE DETECTION METHOD

The *Cracking the Code* report was released in 2019 and provided the first results on the mtDNA extraction and sequencing of tortoiseshell products for the ShellBank project. The project was completed in collaboration between the Southwest Fisheries Science Center (NOAA) and WWF-Australia to provide a proof of concept.

The study, which was also published in a peer-reviewed scientific journal (LaCasella et al., 2021), describes the development of a standardised method using a commercially available kit to extract DNA and obtain informative mitochondrial DNA (mtDNA) control region sequences. By successfully sequencing ~800 base pairs from hawksbill turtle products, the study was able to trace the sample back to a likely population (stock) origin. In addition, skin samples from nesting females at Milman Island, Australia, and Arnavon Island, Solomon Islands, were added to the Rookery Baseline Database. The results indicate that nine of the 13 tortoiseshell products obtained from Papua New Guinea and the Solomon Islands were from marine turtles with haplotypes found primarily at the Solomon Islands rookery and importantly did not match those from nesting populations in Australia or Southeast Asia, except for one haplotype, also found in 3% of turtles at Milman Island. The study identified that 23% of the market samples had haplotypes only documented in foraging populations. This was the first indication that a more extensive sampling of rookeries to fill gaps in the reference baseline database was needed. Nevertheless, the study results demonstrated an effective methodology for obtaining DNA of sufficient quantity and quality from hawksbill turtles to be used to track the hawksbill turtle trade.

For more information see: Jensen MP, LaCasella EL, Dutton PH and Madden Hof CA. 2019. *Cracking the Code: Developing a Tortoiseshell DNA Extraction and Source Detection Method.* WWF-Australia.

frontiers in Marine Science

METHODS

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Mitochondrial DNA Profiling to Combat the Illegal Trade in Tortoiseshell Products

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Hawksbill turtles (*Eretmochelys imbricata*) are exploited for their beautiful shell known as tortoiseshell or bekko, making them extremely vulnerable in the illegal global trade of tortoiseshell products. In this study, we developed an effective, standardized method using a commercially available kit to extract DNA and obtain informative mitochondrial DNA (mtDNA) control region sequences (~800 bp) from hawksbill turtle products in order to trace the sample back to a likely stock origin. We also sequenced additional skin samples from nesting beaches of Milman Island, Australia and Arnavon Island, Solomon Islands to add to the baseline data for hawksbill turtles in the Indo-Pacific. Our results indicate that nine of the 13 tortoiseshell products obtained from Papua New Guinea and Solomon Islands were from turtles with haplotypes found primarily at the Solomon Islands rookery and did not match those from nesting populations in Australia or SE Asia, with the exception of one haplotype also found in 3% of turtles at Milman Island. We also found that 23% of the market samples have haplotypes only documented in foraging populations, which illustrates the urgent need for more extensive sampling of rookeries to fill gaps in the reference baseline database. Nevertheless, our study results demonstrate an effective methodology for obtaining DNA of sufficient quantity and quality from hawksbill turtle products.

Keywords: mtDNA, DNA extraction, wildlife trade, *Eretmochelys imbricata*, Asia Pacific, tortoiseshell

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INTRODUCTION

The illegal trade in endangered wildlife is having devastating impacts on many of the world's species and is broadly considered a global threat to biodiversity (Veríssimo and Wan, 2019). Among the best known cases are elephant ivory (Gao and Clark, 2014), rhino horn (Milliken and Shaw, 2012), tiger skin and bones (Nowell and Ling, 2007), shark fins (Fields et al., 2020), and bear gall bladder (Johns et al., 2019) to name a few. Rapid globalisation, increased connectivity, complex trade networks, and a continued cultural and social demand for wildlife products will continue to drive populations toward extinction (Miller et al., 2019; Hinchens and Hinkelman, 2020). The illegal wildlife trade is highly profitable and estimated to have an annual value of 20 billion US dollars (Nuwer, 2020).

For decades, genetic approaches have provided a useful tool in wildlife forensic investigations. The use of DNA sampling provides a time-efficient and cost-effective way to determine the species and in some cases geographical origin of wildlife products. Molecular techniques have been

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Source: Frontiers in Marine Science

Lab-ID	Location	Collection date	Haplo	Likely stock origin
196020	Rabaul, Kokopo market, PNG	06-04-16	EiIP03	Solomon Stock
196021	Rabaul, Kokopo market, PNG	06/14/2016	EiIP33	Solomon Stock
196022	Kavieng, Nusa Island markets, PNG	06/16/2018	EiIP33	Solomon Stock
196023	Kavieng, Nusa Island markets,PNG	06/16/2018	EiIP59	"Orphan"
196024	Port Moresby, 4 mile island market, PNG	06/13/2018	EiIP55	"Orphan"
196025	Port Moresby, 4 mile island market, PNG	06/13/2018	Fail	-
196026	Mendana, Honiara, Solomon Is	04-03-17	EiIP33	Solomon Stock
196027	Mendana, Honiara, Solomon Is	05-03-17	EiIP33	Solomon Stock
196028	Central Market, Honiara, Solomon Is	03/28/2017	EiIP33	Solomon Stock
196029	Central Market, Honiara, Solomon Is	03/28/2017	EiIP39	"Orphan"
196030	Central Market, Honiara, Solomon Is	03/28/2017	EiIP34	Solomon Stock
196031	Ladies Market, Honiara, Solomon Is	04-03-16	EiIP39	"Orphan"
196032	Ladies Market, Honiara, Solomon Is	03/28/2017	EiIP33	Solomon Stock

Figure 5: Photos of 13 *E. imbricata* products sampled in Papua New Guinea (n=6) and Solomon Islands (n=7). The table shows the Lab-ID, Location, collection date, mtDNA d-loop haplotype and likely origin for each sample (*the likely origin should be interpreted with caution until a more robust analysis can be completed, see Discussion).

CASE STUDY 2: SURRENDER YOUR SHELL (AUSTRALIA) | DETECTING THE ORIGIN OF TORTOISESHELL PRODUCTS (2022)

In 2022, WWF-Australia, in collaboration with the Australian Museum and support from the Australian Government, established *Surrender Your Shell* (SYS), a citizen science ShellBank approach in which everyday Australians were given the opportunity to contribute to marine turtle conservation.

SYS encouraged Australians to surrender historically purchased tortoiseshell to assist with the development of the Confiscation Database by identifying hawksbill populations directly targeted by the illegal tortoiseshell trade.

SYS was also established to trial WWF's ShellBank in practice – to test the ShellBank toolkit to track marine turtle trade by applying the DNA extraction method and further scrutinising its effectiveness on a greater variety of historical and newly donated tortoiseshell items. This was the first opportunity to improve the process of sample collection, sample handling, chain of custody (a documented process of item handling and transportation between institutions) and laboratory procedures.

To support the SYS initiative, the Australian Government adopted a six-month policy (3 December 2020–3 June 2021) that allowed Australians to send historically purchased tortoiseshell products to WWF-Australia, along with details of where and when the items were purchased, without risk of prosecution. With the Australian Government and in partnership with Australia's only accredited wildlife forensics laboratory (the Australian Centre for Wildlife Genomics at the Australian Museum) the goal for SYS was to gain a snapshot of Australia's contribution to the tortoiseshell trade, including its geographical scale and impact.

REAL OR FAKE?

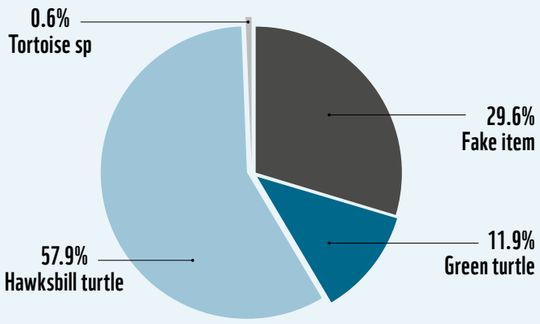

Figure 6: Pie chart showing the proportion of real and fake tortoiseshell received during the *Surrender Your Shell* campaign, including items made from green turtles and tortoises.

The aim of SYS was to:

- Catalogue the type, species and location (city/country) where turtle products were sourced from;
- Identify the location (nesting population/country/region) where illegal hawksbill harvesting has or may still be occurring;
- Increase awareness of hawksbill conservation and the illegal trade in tortoiseshell by informing Australians and regional travellers that buying and importing CITES-listed turtle products is illegal.

The results of SYS highlight the benefits of implementing ShellBank as a traceability tool across the Asia-Pacific region and beyond, with a key priority to continue to build a comprehensive genetic database. It also proved an effective model to engage with the public about the plight of the hawksbill turtle. Despite challenges dealing with the variety of older items that were donated, and a limited baseline, SYS demonstrated the applicability and effectiveness of using mtDNA methods to address the tortoiseshell trade, as donated items enabled us to generate useful information about the regions that were targeted.

- 328 items received during SYS
- 57.9% of the items were from hawksbill turtles, and 29.6% were fake items
- Items ranged from earrings and bracelets to combs and whole stuffed turtles
- Items were initially bought from locations across the globe – most were bought in Asia-Pacific
- Genetics traced items back to origins in:
  - 11.3% Unknown
  - 3.2% Japan foraging
  - 24.2% Southwest Pacific
  - 3.2% Caribbean
  - 8.1% Eastern Malaysia
  - 50% Indian / Pacific Oceans

For more information, see: Madden Hof, C., Jensen, M., Roncolato, F., Frankham, G.J. 2022. *Surrender Your Shell – Detecting the Origin of Tortoiseshell Products*. Report to WWF-Australia and the WWF-Coral Triangle Programme.

Figure 7: A selection of the items received as part of the *Surrender Your Shell* campaign. Items depicted include those made from hawksbill turtle, green turtle, land tortoises and plastic, considered fake tortoiseshell.

CASE STUDY 3: SHELLBANK IN THE PHILIPPINES | CONFISCATIONS AND EXPANDING THE ROOKERY BASELINE

WWF and its partners, the LAMAVE and the University of the Philippines – Institute of Biology (UP-IB), have been working together with the Department of Environment and Natural Resources (DENR) of the Philippines, through the Biodiversity Management Bureau (BMB) and the Palawan Council for Sustainable Development (PCSD), on the collection, analysis, and sharing of hawksbill genetic data to build the Philippines' contribution to ShellBank.

The partnership aims to build on the existing initiatives of DENR in collecting tissue samples from nesting, bycatch, stranded marine turtles, and those confiscated or seized as a result of illegal activity, and to reinforce data collection from other high-priority areas across the country where sampling was previously low. WWF and NOAA have also come together with LAMAVE to roll out genetic skill development training and workshops to key stakeholders across the country.


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In the Philippines, the ShellBank Project aims to aid in the government's efforts by:

1. Identifying the population of origin of the marine turtles that are often seized from the agency's enforcement operations;
2. Classifying the hotspots (or sites) and connectivity of where these populations nest and forage (within and beyond the Philippines);
3. Expanding and intensifying monitoring and compliance efforts at the national and provincial levels;
4. Utilising as a unified platform for the agency to share its existing and prospective turtle data across the country and the Asia-Pacific region;
5. Using the database to inform future in-country publications and support other region-wide publications to help dismantle the illegal marine turtle trade.

Constrained by the COVID-19 pandemic, sampling has resumed and, as of September 2022, DENR-BMB has provided 87 samples to UP-IB for analysis, which consisted of blood, skin, scute or bone samples from hawksbill turtles. These samples were (1) rescued turtles turned over to the BMB-National Wildlife Rescue and Research Center, Quezon City; and (2) from apprehensions in Palawan and stockpiles of the Palawan Council for Sustainable Development in Puerto Princesa City, Palawan. LAMAVE has also collated and provided over 305 samples to DENR-BMB for processing and recorded 220 more samples available for analysis of hawkbill, green and olive ridley turtles as a result of their collaborative research projects over the years. The goal is to analyse 100 samples for ShellBank by the end of 2022 and identify poaching hotspots and populations targeted in trade. Moving forward, DENR-BMB and LAMAVE will refine the database to monitor the samples available and WWF will seek donations from collections held at the National Museum and identify hawksbill nesting and foraging hotspots that require future protection.


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ENHANCED COOPERATION, COLLABORATION AND CAPACITY BUILDING THROUGH REGIONAL AND NATIONAL WORKSHOPS

A key part of ShellBank is to build in-country capacity and provide training. As a result, we undertake and offer various support. We also leverage ShellBank in multiple forums to help with awareness raising and advocacy to aid uptake.

Since taking ShellBank from pilot into practice, we have been providing virtual and face-to-face technical laboratory analysis training by our team of expert geneticists. We have also recently begun law enforcement sampling training by our team of expert forensic scientists.

To date, we have provided expert advice and delivered several technical training sessions to individuals, as well as hosting two regional workshops with over 65 scientists. We have conducted two law enforcement training sessions to over 60 law enforcement officers, across 10 different agencies (e.g. police, wildlife departments, etc.) in two different countries. We also presented the results of ShellBank at a special Illegal Trade workshop at the International Sea Turtle Symposium (ISTS) in 2022, and conducted awareness-raising presentations at more than eight other events.

Other events we presented ShellBank include: Secretariat of the Pacific Regional Environmental Programme (SPREP) marine species action planning and CITES Turtle workshops; CMS SSAP sessions; ISTS Oceania Regional meetings; EU Ocean Governance learning exchange; and various other conferences, including as a keynote speaker.

A snapshot of these are provided on the right.

© Christine Madden Hof

Marine Turtle Traceability and Forensics Training – National Workshops, Sabah, Malaysia (25-28 July, 2022) and Indonesia (5-7 September, 2022).

In 2022, two separate ShellBank national training workshops were held with multiple agencies (e.g. wildlife and/or marine and fishery departments, police, customs, etc.) as part of the TRIPOD project. Half-day workshops were undertaken to introduce ShellBank, the role of forensics including processes of marine turtle evidential handling from collection to analysis. Using mock-up exercises to teach how to identify sample types, individual turtles within a confiscation or seizure, and number of samples to collect. Both events were attended by more than 10 law enforcement agencies and over 60 law enforcement officers. The next TRIPOD ShellBank training is scheduled for 23-26 January 2023 in the Philippines.

Asia-Pacific Marine Turtle Genetics Working Group (APMTGWG) Workshop Online Series (Asia-Pacific) - June 23, 2021.

In 2021, the Asia-Pacific Marine Turtle Genetics Working Group held a series of seven online webinars on the use of genetics for marine turtle conservation. Workshop 6 in the series was titled *Illegal Trade, Forensics and ShellBank* and provided an opportunity to showcase ShellBank to a broad audience across Asia-Pacific. More than 47 participants from 14 countries.


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SHELLBANK HAS ENGAGED

> 60 law enforcement officers

> 65 scientists

Asia-Pacific Marine Turtle Genetics Working Group (APMTGWG) Workshop Online Series (Western Pacific), Online - July 15, 2022.

A second round of workshops was held in 2022 in collaboration with the Secretariat of the Pacific Regional Environment Programme (SPREP), which focused on Western Pacific and hence expanded the membership and network. Workshop 4 in the series was titled *Illegal Trade, Forensics and ShellBank* and included several presentations showcasing ShellBank to a broad audience across the West Pacific region. More than 36 participants from 15 countries.

Combatting the Global Marine Turtle Tortoiseshell Trade (International Sea Turtle Symposium 2022, Perth)

WWF, in collaboration with SEETurtle hosted a special workshop at the International Sea Turtle Symposium held virtually in February 2022. The workshop offered training sessions on a newly developed app that can recognise fake vs real tortoiseshell from photos (refer SEEShell App) and featured several presentations on ShellBank and how we use DNA samples to determine where illegally traded shells are originating. The workshop also allowed groups to share their latest work and project outcomes, with a forum discussion on the efforts required to reduce the illegal trade collectively.

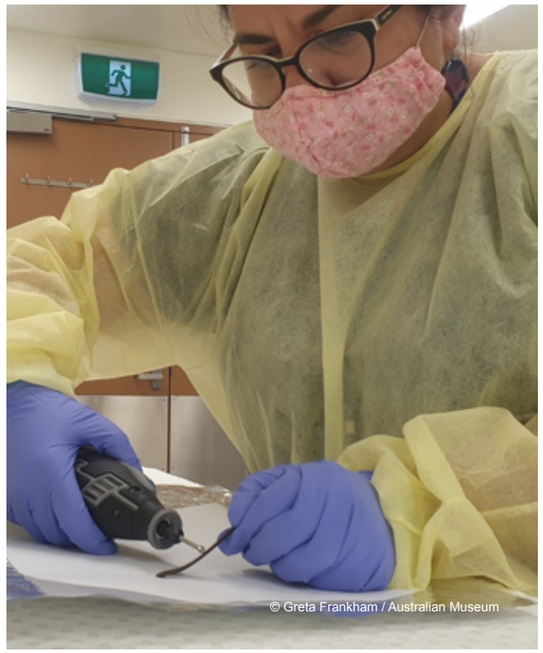
WHERE TO FROM HERE?

ShellBank with all its offering of genetics databases, capacity building, training and how-to tools is a game-changer to track, monitor and evaluate the global illegal marine turtle trade.

Over the years, ShellBank has developed from an idea to proof-of-concept, to being implemented for the first time through the *Surrender Your Shell* campaign. ShellBank provides a new programme and toolkit to help coordinate and implement action to address unsustainable use and illegal trade impacts on marine turtle populations.

Aligned to regional and international policy and mandates, and with greater national, regional and international involvement, together we can further ShellBank to:

- Expand the database to include more locations and other marine turtle species;
- Continue to build capacity and expand the network though regional and national workshops and technical training; and
- Advance the science and provide new solutions.


© Greta Frankham / Australian Museum

EXPANDING THE DATABASE

While the current Rookery Baseline Database is fast improving and will soon contain several new datasets, there are still significant gaps. Concerted efforts should now focus on extending collaborations to enable increased sampling of hawksbill turtle nesting beaches to expand and improve the Rookery Baseline Database; the In-Water Database of foraging, stranded, and bycatch turtles; and the Confiscation Database of surrendered and confiscated products. The continued growth of these databases will refine geographic stock boundaries and provide useful intelligence about where marine turtle trade is most lucrative, to aid in criminal investigations, and help decipher which populations are being targeted and therefore require further protection. This will make ShellBank fit for purpose as a traceability tool to track marine turtle trade.

The need for a genetic database goes beyond just hawksbill turtles. Many threats and conservation needs that impact hawksbill populations are also needed for other species where the exploitations and unsustainable use and trade remain drivers of turtle population declines. For example, egg collection and harvesting for meat are also impacting other species of marine turtles, in particular green and leatherback turtles, and in some localities olive ridley turtles. As such, future versions of ShellBank will incorporate genetics data from other species, in the first instance green and leatherback turtles with sights set on olive ridley and loggerhead turtles further down the track. Although initially focused on the Asia-Pacific region, ShellBank will be applied in other regions (e.g. the Caribbean and Western Indian Ocean) as of 2023. Therefore, the aim is to integrate genetic data for all species globally to make ShellBank an invaluable resource for law enforcement and conservation research alike.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CONTINUE TO BUILD CAPACITY

Participation in ShellBank offers a coordinated approach – with standardised tools, databases, guides, capacity building and some funding (in priority locations and as advised by the IPHGWG). It also offers support and data to help deliver on national, regional and international commitments (e.g. CITES, the CMS, The Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF)), and the IOSEA MOU, as well as enhancing each country's enforcement efforts against illegal traders, and highlighting responsibilities to recover threatened marine turtle populations for people and nature. We will continue to build in-country capacity for genetic sample collection and analysis by conducting more regional and/or national workshops and providing expert advice through technical training. This support will continue to be given over the coming years to help advance the knowledge of marine turtle genetic structure and connectivity in support of effective conservation management and law enforcement action.

ADVANCING THE SCIENCE AND PROVIDING NEW SOLUTIONS

ADVANCING THE METHODS

The cornerstone of ShellBank is to build and apply the best science-based solutions for the conservation of marine turtles. As such, we need to ensure that the best science available is used and methods are advanced in line with our world's fast moving technology. Several new and emerging technologies such as arrays to sequence single nuclear polymorphic markers have the potential for more accurate stock identification of individual turtles or products (e.g. better assignment of poaching to an individual and/or location). These methods will build on and enhance our current mtDNA datasets to update and improve the accuracy of ShellBank as a traceability tool into the future.

WHOLE MITOGENOME SEQUENCING

In some instances, the genetic resolution can be limited, even across broad geographic scales. The current dataset of 780 bp fragments makes up only a small fraction of the >16-kb mitogenome. One solution is to sequence a larger fraction of the mitochondrial genome to uncover additional polymorphism outside the current control region fragments to address the haplotype overlap among some rookeries and improve the resolution of mtDNA population structure. This approach has been useful for Atlantic green turtles, revealing insightful variation in otherwise common and widely spread haplotypes (Shamblin et al., 2012). Similar efforts are underway through the IPHGWG to sequence whole mitogenomes of shared and common haplotypes (project led by NOAA, Southwest Fisheries Science Center, USA).

DEGRADED DNA

Through the *Surrender Your Shell* campaign, many of the items donated were extremely old (over 100 years old). DNA degrades and breaks down over time, so it is harder to recover DNA sequences from older items. Recovering DNA from degraded items requires modification of the protocols used and only a shorter fragment of DNA can be sequenced, reducing the resolution of the genetic marker. This provided both challenges and an opportunity to develop the ShellBank toolkit further to include amplification protocols for degraded DNA. Further work led by the Australian Museum in collaboration with WWF aims to improve the protocol to generate longer fragments of DNA from degraded samples.

CONCLUSION

Despite the challenges of working across multiple countries and with limited ability to collect or analyse samples during a global pandemic, ShellBank is now ready to be taken from pilot to practice.

As we head into the next phase of ShellBank we have a clear vision for its refinement, use and uptake as one of the only traceability tools to track the illegal marine turtle trade. And it couldn't have come at a better time with mounting evidence that unsustainable use and illegal trade is more widespread, likely dampening several marine turtle populations' recovery.

ShellBank is a programme and toolkit fit for purpose, aiding both conservation research and law enforcement at a national, regional and international scale. Starting with hawksbill turtles, through *Cracking the Code* we learnt that we can effectively extract DNA from tortoiseshell products and sequence high quality long fragments of mtDNA to match the methodology long used for sampling wild populations. This gave us the confidence we were onto something worthwhile. Through *Surrender Your Shell* we learned that ShellBank could be put into practice, with some tweaking of methods and the development of logistical and operational protocols. Together, the results of *Cracking the Code* and *Surrender Your Shell* highlighted the benefits of implementing ShellBank as a traceability tool to other marine turtles impacted by trade, across the Asia-Pacific region and beyond. And this is now our priority goal over the coming years.

Collaborations and building networks have been, and will continue to be, at the core of ShellBank. We strongly believe in building capacity, particularly in-country capacity to support and empower local researchers and law enforcers to use genetics as a common identification and population origin tool. Only together are we able to increase sampling of marine turtles to fill the gaps, expand and improve the Rookery Baseline Database of nesting turtles; the In-Water Database of foraging, stranded and bycatch turtles; and the Confiscation Database of surrendered and confiscated products.

Continued growth of these databases is the backbone of ShellBank, as it will refine geographic stock boundaries and provide useful intelligence to aid in criminal investigations, and help decipher which populations are being targeted and therefore require further protection.

From the first four years of ShellBank, we take with us many lessons learnt and a much clearer idea of what needs to be done to further develop ShellBank into an invaluable resource for law enforcement and the research community to guide effective protection of these endangered species.

APPENDIX 1: REGIONAL AND COUNTRY SUMMARIES

A country-by-country summary is provided for hawksbill turtles only in the Southeast Asian and Western Pacific Ocean region below, and are only provided for higher density hawksbill populations, those where genetic sampling is underway, and/or those implicated in illegal trade.

Future annual reports will showcase additional countries as partnerships grow. Regional overviews are provided for the remaining global regions. Due to the lack of quantified nesting census data for most populations and major information gaps, maps of nesting distribution are based on locations where hawksbill nesting has been recorded in the past. Therefore, these maps may not accurately represent nesting abundance nor confirmed nesting in the present day and are not to scale (refer Appendix 2 of data used to create spatial maps and country summaries).

A legend of icons used in these country summaries are provided below, noting the following abbreviations are also used: RMU (Regional Management Unit), TBD (To be determined).

Ei = HAWKSBILL
(Eretmochelys imbricata)

Cm = GREEN
(Chelonia mydas)

Lo = OLIVE RIDLEY
(Lepidochelys olivacea)

Dc = LEATHERBACK
(Dermochelys coriacea)

Cc = LOGGERHEAD
(Caretta caretta)

ND = FLATBACK
(Natator depressus)

TURTLE USE

TURTLE TRADE

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In short, in Southeast Asia and Western Pacific Ocean Region many genetic gaps exist. Most high density or illegally traded countries have a level of protection afforded to hawksbill turtles but most are still threatened by unsustainable use and trade. Whilst there are a number of population statues that remain unknown, turtle populations in demand countries (e.g. Viet Nam and Japan) are considered depleted. In the countries assessed there are only seven genetic stocks assigned. However, through working groups and collaborations more than 650 rookery samples have been collected and are being analysed. Nonetheless, many gaps still remain, highlighting the need to continue to sample and strengthen the mtDNA database for both nesting and in-water studies through focused regional efforts.

For both the Central and East Pacific Ocean, and Atlantic Ocean Region and the Caribbean Regions, no major genetic gaps exist. Where the Central and West Indian Ocean is recognised as an important region for hawksbill turtles, several genetic sampling gaps remain, particularly across smaller rookeries in the Southwest Indian Ocean. Several genetic studies are underway to better assess stock boundaries and connectivity between nesting and foraging areas.

SOUTHEAST ASIA AND WESTERN PACIFIC OCEAN REGION

Hawksbill turtles have been recorded nesting and foraging across the region (Figure 8). Generally, nesting is scattered and at low density (except for the Arnavons in the Solomon Islands), and rookery size estimates are lacking for most populations. Data on annual trends in hawksbill nesting abundance and distribution is also lacking for most Asia-Pacific countries. In the Pacific Ocean, a total of 4,800 nesting females were estimated to be remaining in 2008 (75% lower than historical levels) and 2,100 nesting females in the Indian Ocean (at least 92% lower than historical levels) (Mortimer and Donnelly 2008). Current efforts are underway by several organisations to assess the trends in annual nesting patterns and extinction risk of hawksbill populations across the region (e.g. SPREP).

Countries with known higher density nesting or foraging of hawksbill turtles, and/or implicated in illegal trade in the region include Australia, Fiji, Indonesia, Japan, Malaysia, Papua New Guinea, Philippines, Singapore, Solomon Islands, Thailand, Timor-Leste, Vanuatu, and Viet Nam.

Minor nesting or unquantified foraging has been reported for American Samoa, Cambodia, Cook Islands, Federated States of Micronesia, Kiribati, Brunei, Marshall Islands, New Caledonia, New Zealand, Niue, Palau, Samoa, South Korea, Taiwan, Tonga, and Tuvalu.

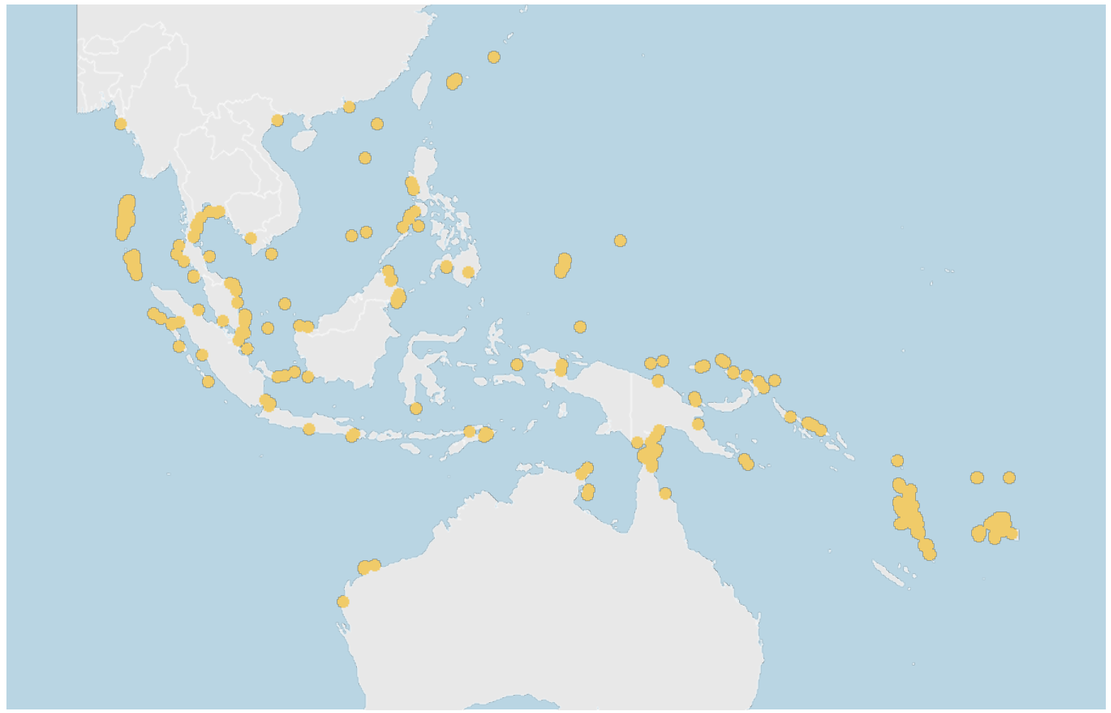
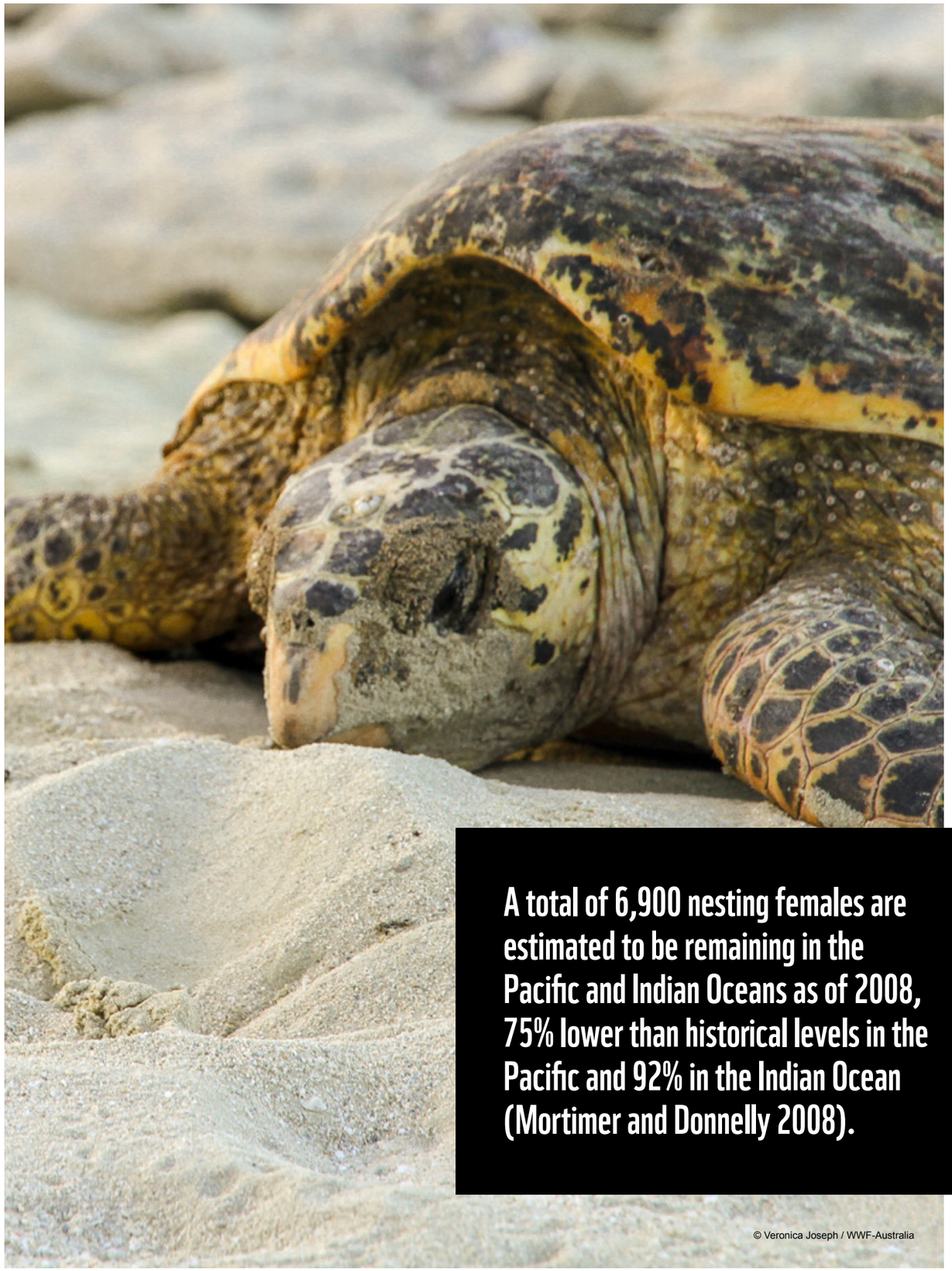


Figure 8: Hawksbill turtle nesting distribution and abundance across Southeast Asia and Western Pacific (map generated from TurtleNet, https://apps.information.qld.gov.au/TurtleDistribution/)



A total of 6,900 nesting females are estimated to be remaining in the Pacific and Indian Oceans as of 2008, 75% lower than historical levels in the Pacific and 92% in the Indian Ocean (Mortimer and Donnelly 2008).

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AUSTRALIA

Marine turtle species:

Genetic stocks/Management Units: 3

RMU: Southeast Indian Ocean and Southwest Pacific

Population status: Western Australia MU (likely stable or increasing); Northeast Queensland MU (decreasing); Northeast Arnhemland MU (unknown)

National legal status: Vulnerable (EPBC Act*)

ShellBank database (published):

Rookery samples: 182 samples/4 locations

In-Water samples: 92 samples/1 locations

Confiscation: 75 items

Ongoing genetics: Yes, refer Gaps

Use and trade summary:

Status of genetic work

Genetic stocks/Management Units – Three genetically distinct Management Units are identified for Australia. Northeast Queensland (Milman Island), Northeast Arnhemland (Truant) and Western Australia (Varanus and Rosemary Islands) (Vargas et al., 2016). The Northeast Queensland and Northeast Arnhemland MUs are genetically indistinguishable, but are considered as separate MUs for management purposes due to differences in nesting phenology (summer and winter nesting) (Vargas et al., 2016).

In-Water - Only one genetic study has been carried out at a single hawksbill foraging area on the Great Barrier Reef (the Howick Group) (Bell and Jensen, 2018). Mixed stock analysis and tagging results show that most turtles at this foraging (83%) originate from nesting beaches in the Bismarck Solomon Sea region and Northeast Queensland rookeries (15%). However, these results are based on an incomplete baseline and should be re-assessed once a complete baseline is available.

Gaps

While main rookeries have been genetically characterised, there are still gaps in the sampling of important rookeries throughout the Torres Strait. For Western Australia, low-density nesting has not been characterised by turtles nesting along the coast of Ningaloo and in the Kimberley. Work is underway to characterise hawksbill nesting at Ashmore Reef and the Torres Strait (N FitzSimmons, pers comm). There are no known or planned studies in the Northern Territory which continues to be a significant gap given its closeness to the Arafua and Timor Seas. There is a lack of foraging studies for hawksbills in Australia. However, genetic studies of multiple foraging areas are underway (N FitzSimmons, pers comm). Genetic information on rookery stock structure and foraging areas is expected to increase in the coming years.

Summary

Hawksbill turtle nesting is well documented across northern Australia, with key nesting sites in Northeast Queensland, Northern Territory and Western Australia (Limpus, 2009). Long-term monitoring at Milman Island shows this population is declining (Bell et al., 2020), while the rookeries in Western Australia are large and stable (Hamann et al., 2022). There are no long-term population estimates for Northern Territory, however the island group off Groote Eylandt was recommended as a possible index beach for the long-term monitoring of the Northeast Arnhem Land stock (Hoenner et al., 2016).

Hawksbills are known to forage across the region, and limited genetic and tagging results show that turtles from neighbouring countries forage in Australia (Hamilton et al., 2021). Recent satellite tracking studies reveal the remaining Northeast Queensland stock does not migrate beyond Australia's continental shelf (Barr et al., 2021; Madden Hof et al., Submitted). Similarly, hawksbills tracked from six rookeries in Western Australia show that turtles remained in WA waters post nesting. In addition, two turtles tracked from Timor-Leste both migrated to foraging grounds in Western Australia (Fossette et al., 2021).

Turtle use and trade

Although the Northern Territory, Queensland and Torres Strait populations were historically harvested for the commercial tortoiseshell trade in significant numbers substantially depleting the stocks (Limpus, 2009), there are reports of an ongoing substantial international harvest of hawksbill turtles for the black market tortoiseshell trade in the broader region that is likely to be a major source of mortality for the Northeast Arnhemland stock (Limpus and Miller, 2008). Due to the likely restricted movement of the Northeast Queensland stock within Australian waters, a review is underway as to the likely threats dampening population recovery (Madden Hof et al., Submitted). The active tortoiseshell trade within Australian waters is likely limited. Most of the tortoiseshell items in Australia are thought to have been brought into the country before the CITES ban (1977). However, confiscation records at Australian border control show that many Australians continue to buy illegal tortoiseshell products while vacationing abroad (Madden Hof et al., 2022).

Harvesting of hawksbills by Indigenous people is legal under the *Native Title Act 1993*. Today, it is thought the hawksbill turtles are not traditionally harvested by Australian Aboriginal and Torres Strait Island peoples, however, there is a noted preference for hawksbill eggs. The harvest of hawksbill eggs has been historically considered unsustainable for some stocks (Department of the Environment and Energy, the NSW Government and the Queensland Government, 2017; Department of Environment and Science, 2021), yet harvest levels remain unquantified and by large, quotas or equivalent, are self managed by community groups.

FIJI

Marine turtle species:

Ei Cm Cc Dc

Genetic stocks/Management Units: TBD

RMU: Southwest Pacific

Population status: Unknown

National legal status: Protected under Regulation 5 of the Offshore Fisheries Management Regulations, 2014

ShellBank database (published):

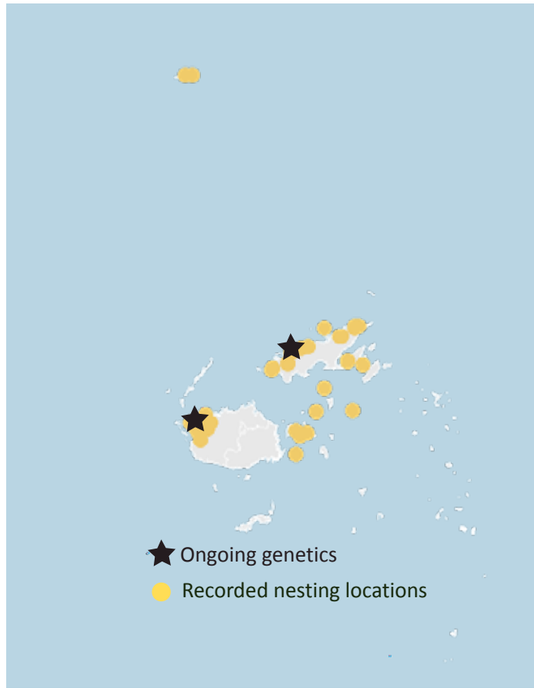
Rookery samples: 0 samples/0 locations

In-Water samples: 0 samples/0 location

Confiscation: 0

Ongoing genetics: Yes, refer Gaps

Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – No genetic work has been published.

In-Water - No genetic work has been published.

Gaps

Current genetic studies are underway to characterise new nesting and foraging sites in Fiji though work led by the University of the South Pacific in collaboration with NOAA and are expected to become available in the near future (P Dutton, pers comm).

Hawksbill distribution

Hawksbill turtles nest on more than 20 beaches across the islands of Fiji, but the number of females is low; likely 100-150 nesting females total across Fiji (Piovano and Batibasaga 2021). Most of the nesting is recorded at Yadua, and Yadua Taba and Namena Lala Island, and the majority of sites have less than ten nests per season (Prakash et al., 2020).

Hawksbills are known to forage in the waters surrounding Fiji; however, little information exists on distribution and abundance and likely includes hawksbills from neighbouring countries. Satellite tracking studies have shown that hawksbill turtles nesting in American Samoa use foraging areas in Fiji (Madden Hof et al., 2022).

Turtle use and trade

National legislation in Fiji imposes a ban on the harvest, sale, possession and transportation of marine turtles, their eggs or any part or product (Madden Hof et al., 2022). The ban applies to the killing, landing, taking, selling or offering or exposing for sale, transporting, dealing in, receiving or possessing any marine turtle species, but an amendment of this legislation is currently underway to allow for permits to be issued to authorise limited cultural harvest by local iTaukei communities (Madden Hof et al., 2022).

Kitolelei et al., (2022) report that parallel management systems for marine turtles coexist in Fiji, with both the (unwritten) customary iTaukei rules and the (written) national legislation determining the quantity and the time of marine turtle harvest. Marine turtles have been embedded in the iTaukei culture as spiritual deities, totems, myths and chiefly tributes for millennia (Morgan 2007; Kitolelei et al., 2022). However, the sacredness of these animals started to diminish when tortoiseshell trade began in the 1840s (Kitolelei et al., 2022). Tortoiseshell products for sale have been reported as declining but still prevalent in local markets (from 2006-2010; WWF, 2010). Recent surveys confirm the target of hawksbill and green turtles, using fishing nets, spearfishing, and specialised target methods and use in trade (Kitolelei et al., 2022; WWF-Fiji, In Prep), but quantified numbers still remain unpublished. Where the estimated number of female hawksbill turtles breeding per year is around 20-30 (Madden Hof et al., 2022), there is cause for concern.

INDONESIA

Marine turtle species:

Ei Cm Lo Cc Dc Nd

Genetic stocks/Management Units: 1?

RMU: West Pacific and Southeast Asia

Population status: Unknown

National legal status: Protected under government regulation No 7/1999

ShellBank database (published):

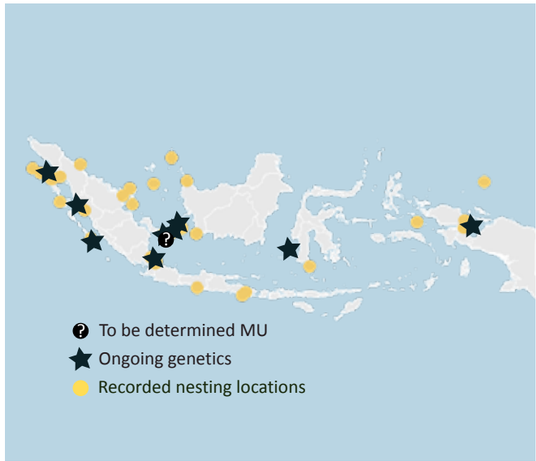
Rookery samples: 9 samples/1 locations

In-Water samples: 0 samples/0 locations

Confiscation: 0

Ongoing genetics: Yes, refer Gaps

Use and trade summary:



Status of genetic work

Until recently, genetic work on hawksbill turtles was extremely rare in Indonesia.

Rookery stock structure - Only one rookery has been genetically characterised at Kimar Island, Belitung (Bangka Belitung Islands Province) using a small sample size (n=9) (Wahidah MA and Syed Abdullah SAK 2009). It is recommended that a larger sample size is used to define the stock.

In-Water - No genetic work has been published.

Gaps

There are currently many gaps in the genetic structure and connectivity for Indonesia. Samples have been collected from several islands which are Segama Island, Kimar Island, Penambun and Momperang Island, and Pesemut Island that located between the mainland of Sumtera and Kalimantan (led by ELNA and YPLI) as well as Tidung Island and Harapan Island (near Jakarta) and Kapoposang Island (West Sulawesi) (led by IPB University and Oceanogen). Priority sites for genetic sampling have been identified for Aceh (Selaut Island and Bankaru Island), Sumatra (Simuk Island, Gosong Pandan, and Sanding Island) and Anambas (Durai Island and Pahat Island). Many of these gaps are being actively addressed by local NGOs and research institutions (Universitas Syiah Kuala, Oceanogem, Bionesia, UNIPA and others) working across the region, and analysis of some already collected samples are now underway. Genetic information on rookery stock structure and foraging areas is expected to increase significantly in the coming years.

Hawksbill distribution

Indonesia hosts several globally significant marine turtle populations. Hawksbill turtles have been recorded nesting across the entire country but many populations are depleted and host only low level nesting. Nesting is recorded from several sites in the South China Sea, Aceh Province, West Sumatra Province, Bangka Belitung Islands Province, Bengkulu Province, Banten Province, Java Sea, East Java Province, West Java Province, West and South Sulawesi, North and Central Sulawesi, Southeast Sulawesi, West Kalimantan, East Kalimantan and Sulawesi Sea regions, Bali and Nusa Tenggara Sea regions, Maluku Province, North Maluku Province, West Papua Province, and Papua Provinces (Hamann et al., 2022).

There is little information on foraging areas of hawksbills across the region, however, coral reef habitats across Indonesia should provide foraging for hawksbills.

Turtle use and trade

Indonesia has a long history of turtle use and trade, and is still widely prevalent across the archipelago today. Although take, use and trade in marine turtles are prohibited, Indonesia continues to play an important role as a source and consumer country, supplying eggs, meat, and processed and unprocessed forms of turtle carapace. Specimens are used domestically and are internationally traded, destined for Malaysia, China, and Viet Nam (CITES Secretariat, 2019). Although the open sale of turtles and their carapace has likely reduced over time, possibly due to increased enforcement efforts and media coverage of incidents, reports suggest the trade is now largely underground and significantly shifted to online platforms (for example, 213 online trade advertisements were recorded in the span of a one month survey) (CITES Secretariat, 2019).

Traditional practices continue to be used to capture marine turtles and their eggs, taken at sea, or from beaches during nesting season with reports of fishermen sometimes engaging in targeted expeditions, and some hatcheries possibly acting as conduits through which meat and eggs are sold more easily (Firliansyah et al., 2017 cited in CITES Secretariat, 2019). Kalimantan remains a hotspot for egg collection alongside Sumarta and Java (the later also reported as a hotspot for the take and trade of meat), whereas Bali remains a hub for live turtle trade with possible lead exporter trade shifts to Makassar in Sulawesi, which retains an active trade in live turtles, turtle meat, eggs, taxidermied specimens, as well as handicrafts (CITES Secretariat, 2019; IOSEA, 2014).

Indonesia still appears to be a major source of shells for the illegal international trade (Nahill et al., 2020), notably with trade in tortoiseshell souvenirs reportedly on the rise in East Kalimantan (Profauna, 2016 in Gomez and Krishnasamy, 2019). Several NGOs (e.g. WWF-Indonesia, Turtle Foundation, PROFAUNA Indonesia, Yayasan Penyu Indonesia) are working collaboratively and carrying out campaigns to educate about the plight and trade of hawksbill turtles.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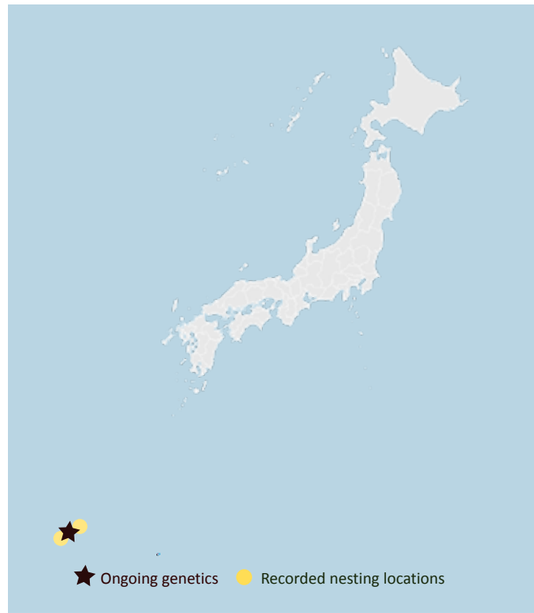
JAPAN

Marine turtle species:

Genetic stocks/Management Units: 1?
RMU: West Pacific and Southeast Asia
Population status: Depleted
National legal status: Protected
ShellBank database (published):
Rookery samples: 6 samples/3 locations
In-Water samples: 44 samples/1 location
Confiscation: 0
Ongoing genetics: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – There is no recent information on the genetic structure of hawksbill rookeries in Japan due to low nesting numbers. Historic genetic information exists from Japan, but low sample size, Okinawa (n=1), Osaki beach (n=2), Arasaki beach (n=3), preclude any stock structure analysis (Okayama et al., 1999). Nishizawa et al., (2012) only reported haplotypes from four samples in Ishigaki-jima.

In-Water - Genetic studies suggest that the foraging hawksbill turtles around the Yaeyama Islands likely comprise individuals from multiple rookeries throughout Southeast Asia and the Western Pacific (Nishizawa et al., 2010); however, a more complete baseline is needed for a robust analysis.

Gaps

Updated sampling and analysis of nesting samples from Japan are needed to assess the genetic stock status of hawksbill turtles nesting in Japan, especially given that they represent the northern limit for the species in this region. Current efforts are underway to collect and analyse hawksbill samples, but given the low number of nesting turtles it may take several years (H Nishizawa, pers comm).

Hawksbill distribution

Hawksbill turtle nesting in Japan is rare and occurs in low numbers. Only ten nests annually have been observed in the Yaeyama Islands, which include nests recorded on the islands of Ishigaki-jima, Kuroshima, Aragusuku-jima, Iriomote-jima, Irabu-jima, Minna-jima, Okinawa-jima, Zamami, Akajima, Kumejima, Kakeroma-jima, and Amamioshima (Inoguchi and Ishihara, 2021).

Hawksbills are known to forage in Japan and the reefs surrounding the Yaeyama Islands are considered important foraging habitats for hawksbills. Strandings, bycatch and diver observations also show that hawksbills forage as far north as Niigata Prefecture and the Kanto region (Inoguchi and Ishihara, 2021). This is likely the northern limit of hawksbill foraging.

Turtle use and trade

Japan has been a major player in the worldwide trade in tortoiseshell over the past two centuries, with the imports of bekko from Southeast Asia from 1844 to 1992 estimated to equate to nearly nine million individual hawksbill turtles. Japan is reported responsible for up to 80% of the global tortoiseshell trade (Nahill et al., 2020). Since Japan removed its reservation to the CITES marine turtle trade ban in 1994, the domestic trade in tortoiseshell was allowed to continue legally, however, only using stockpiles that existed prior to the cessation of imports, meaning pre-1993 tortoiseshell stocks (Kitade et al., 2021). Even though experts predicted that these stockpiles should have been exhausted by now (Kitade et al., 2021, Nahill et al., 2020), they still exist to date. Serious doubts are cast as to whether the reported stockpile figures are correct, especially seeing that domestic legislation relies primarily on manufacturers self-reporting their stockpile balance and transaction records (Kitade et al., 2021).

Between 2000 and 2008, 11,080 bekko items, including combs, glasses frames, jewellery, and traditional ornaments were found for sale in shops visited in Tokyo, Nagasaki, and Okinawa (Nahill et al., 2020). Seizures continued in subsequent years, with Japan customs reporting 564 kg of hawksbill tortoiseshell seized between 2000 and 2019, representing about 530 hawksbill turtles. A 2019 survey by Kitade et al., (2021) of major online auction platforms found more than 8,200 sales of hawksbill products, with a total value of close to US$1 million.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MALAYSIA

Marine turtle species:

Genetic stocks/Management Units: 3

RMU: West Pacific and Southeast Asia

Population status: Sulu Sea (likely decreasing), Western Peninsula Malaysia (stable), Terengganu and Pahang States (putative Gulf of Thailand MU) (stable) [Hamman 2022]

National legal status: Protected in some States

ShellBank database (published):

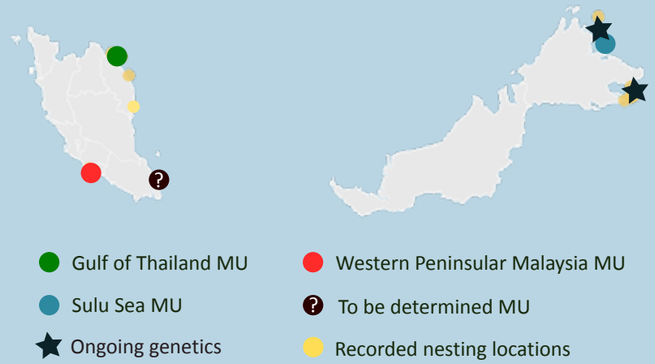
Rookery samples: 92 samples/8 locations

In-Water samples: 23 samples/4 locations

Confiscation: 0

Ongoing genetics: Yes, refer Gaps

Use and trade summary:



Status of genetic work

Rookery stock structure - Malaysia has identified at least three MUs (Nishizawa et al., 2016). Rookeries in Terengganu and Pahang States (e.g. Pulau Redang and Pulau Tioman) form a single MU (Gulf of Thailand) putatively with the rookery at Ko Khram in Thailand. Rookeries on the west coast of Peninsular Malaysia in Melaka form a distinct MU, the Western Peninsula Malaysia stock, although they share a common haplotype with rookeries across Peninsular Malaysia. The rookery at Johor on the southern tip of Peninsular Malaysia has only been assessed using a very small sample size (n=3) but includes two unique haplotypes and should be assessed using a larger sample size. The third genetic stock is in the Sulu Seas, with samples only taken from the Sabah Turtle Islands (Pulau Gulisan and Pulau Selingan) (FitzSimmons and Limpus 2014; Nishizawa et al., 2016) noting there are other rookeries in close proximity which remain to be sampled, e.g. in southern Philippines and islands in Indonesian waters of the Sulu Sea (Hamman et al., 2022).

In-Water - Genetic studies have been carried out at four hawksbill foraging areas across Malaysia (Sakaran Marine Park, Pulau Sipadan, Pulau Tiga, and Melaka) (Nishizawa et al., 2016). However, very low sample sizes (2-8 samples) and an incomplete baseline for hawksbills in the region precludes firm conclusions from being drawn at this point.

Gaps

There are a few significant sampling gaps of hawksbill rookeries in Malaysia, including rookeries in Semporna and Johor (currently low sample size). However, hawksbill nesting occurs in low numbers. Genetic sampling of hawksbill nesting (Lankayan and Pompom Island) and foraging areas (Tun Mustapha Park and Semporna) is ongoing (J Joseph, pers comm).

Hawksbill distribution

Hawksbill turtles have been recorded nesting at several rookeries in the Turtle Islands Heritage Protected area (TIHPA) in Sabah with the majority of nesting occurring on Pulau Gulisaan. Low level nesting also occurs on the Semporna region islands. Nesting along the east coast of Peninsular Malaysia is low (1-10 nesting females per year) at Pulau Tioman, Pulau Redang and Johor Islands. On the west coast of Peninsular Malaysia, hawksbills primarily nest on several beaches in the state of Melaka (Hamann et al., 2022).

Flipper tagging and satellite telemetry studies show that turtles nesting in Sabah utilise foraging areas within Sabah, but also in the southern Philippines, and the east coast of Kalimantan in Indonesia. Turtles tracked while nesting in Melaka migrated mostly south to Singapore and the Riau Islands (Hamann et al., 2022).

Turtle use and trade

Historically, Malaysia was one of the largest exporters of tortoiseshell to Japan (Nahill et al., 2020). Today, the protection of marine turtles and their derivatives differs within the country, and falls under the jurisdiction of each of the country's 13 states. In most of Peninsular Malaysia, marine turtle eggs are freely and legally traded in the local markets (CITES Secretariat, 2019). Exceptions are Perak, Melaka, and leatherback turtle egg trade in Pahang (CITES Secretariat, 2019). In addition, the Terengganu state recently passed an amendment that bans the sale of all turtle eggs in June 2022. In Sabah and Sarawak, marine turtles are listed as totally protected animals, meaning both states ban all trade and consumption of marine turtles and their specimens (CITES Secretariat, 2019). It was found that, because of these differing legislations, there is often confusion regarding what activities are legal, what restrictions exist for legal take, and for whom (CITES Secretariat, 2019).

Even though turtle egg trade is prohibited in Sabah and Sarawak, marine turtles and their eggs are illegally taken from these states and traded with other states in Malaysia, or are imported from or to other countries. Domestic trade seems to focus mainly on turtle meat and eggs for consumption, with meat appearing to cater mainly for foreign tourists and eggs catering for locals (CITES Secretariat, 2019). Especially in Sabah, an active local egg demand was found, however, with trade having shifted to more underground locations in recent years, and traders adopting coded hand signals to attract potential buyers (CITES Secretariat, 2019).

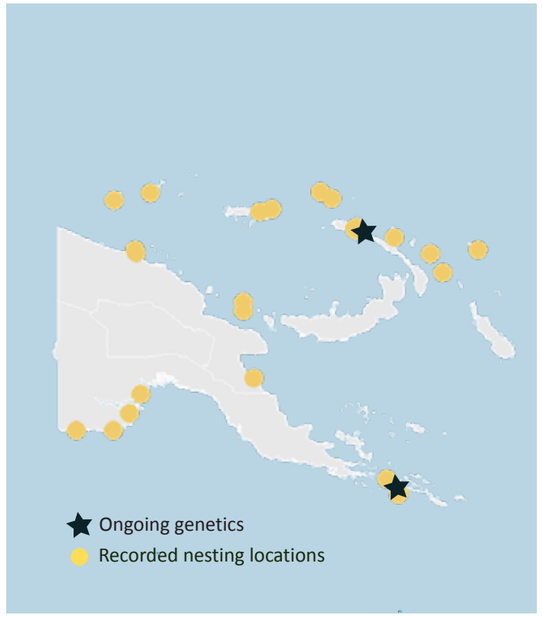
Illegal trade also occurs with China, the Philippines, Viet Nam, and Indonesia, with Kalimantan highlighted as a hotspot with significant volumes of turtle eggs being exported to East Malaysia (Sabah and Sarawak and IOSEA, 2014 in CITES Secretariat, 2019). The majority of the illegal trade in marine turtles in Malaysia at the international level has been attributed to take by foreign fishing fleets (in most cases Chinese and Vietnamese vessels), which seem to concentrate in the waters off the western coast of Sabah (CITES Secretariat, 2019). Whilst the demand in Malaysia for taxidermied turtles or tortoiseshell products seems to be low, and online trade seems to be conducted largely on an opportunistic basis (CITES Secretariat, 2019), more recent reports suggest online platforms are increasingly used to sell marine turtle products, including hawksbill turtle shell (Hamman et al., 2022).

PAPUA NEW GUINEA

Marine turtle species:

Ei Cm Lo Cc Dc Nd

Genetic stocks/Management Units: TBD
RMU: Southwest Pacific
Population status: Unknown
National legal status: Not protected
ShellBank database (published):
Rookery samples: 0 samples/0 locations
In-Water samples: 0 samples/0 locations
Confiscation: 0
Ongoing genetic: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – No genetic work has been published.

In-Water - No genetic work has been published.

Gaps

There are important sampling gaps in Papua New Guinea. Current genetic work is underway to characterise rookeries in the Conflict Islands and New Ireland (85 Rookery samples) as well as a small number of In-Water samples (6 In-Water samples) (C Madden Hof, pers comm) as well as samples being collected when harvested under a community-based survey (Turtle Use Project) from across Milne Bay Province. Genetic information on rookery stock structure and foraging areas is expected to increase significantly in the coming years.

Hawksbill distribution

Hawksbill turtle nesting has been recorded in multiple provinces throughout Papua New Guinea, although population densities are unknown. Historic surveys mention East Sepik Province at Laboin Island, Muschu Island, Kairuru Island, Wuvulu Island, and Kaniet Island; Manus Province at Pak Island, Los Reyes Islands, Harengan Island, Paluwak Island, Bipi Island, and the Ninigo Group of Islands; New Ireland Province in the Boloma Group of Islands, Emirau and Mussau Islands, and the Tanga Islands; East New Britain at Nuguria; Madang Province on the north and south coasts,and at Long Island; and in Western Province along the whole coast. Recent reports of hawksbill nesting include islands in the Jomard Passage and Conflict Islands groups in Milne Bay Province (Madden Hof et al., 2022).

Hawksbills can be found foraging on reefs across PNG but data on distribution and abundance is lacking. There are records of foraging hawksbills at Fishermen's Island (Central Province), several locations within Milne Bay Province, including Tagula Island, and Tureture Reef in Western Province, Kavieng in New Ireland Province, and on the northern coast of Papua New Guinea (Kinch 2021; Madden Hof et al., 2022). Juvenile foraging hawksbills have been recorded on the reefs in the Conflict Islands, and samples have been collected for genetic analysis (Madden Hof, unpublished).

Turtle use and trade

Papua New Guinea is one of the top three countries globally for the highest legal harvest of marine turtles, estimated at around 5,000 turtles annually, with the highest take occurring in Manus Province, Western Province, and Milne Bay Province (Opu, 2018 in Madden Hoff et al., 2022). When mtDNA was extracted from tortoiseshell products for sale at local markets in Solomon Islands and Papua New Guinea, most of the tortoiseshell products were assigned to turtles found primarily in the Solomon Islands MU, but no genetic assessments have been made to Papua New Guinea populations as yet (LaCasella et al., 2021). Hawksbill turtles are not protected under Papua New Guinea law, only leatherback turtles are protected via the Fauna Act (Pilcher, 2021).

Subsistence harvest of hawksbill turtles for eggs, meat, carapace and other products is widespread throughout the country (Humber et al., 2014). Turtles and turtle parts are used as food, selling for cash, barter trade, personal consumption, and as part of cultural activities and celebrations (Opu, 2018 in Madden Hof et al., 2022). Hawksbill turtles are caught to produce tortoiseshell items, such as jewellery, which are mainly targeting international tourists and are sold in major provincial centres, such as Port Moresby, and popular tourist spots including international departure lounges, despite Papua New Guinea being a Signatory to CITES (Kinch and Burgess 2009 and Opu, 2018 in Madden Hof et al., 2022; Nahill et al., 2020).

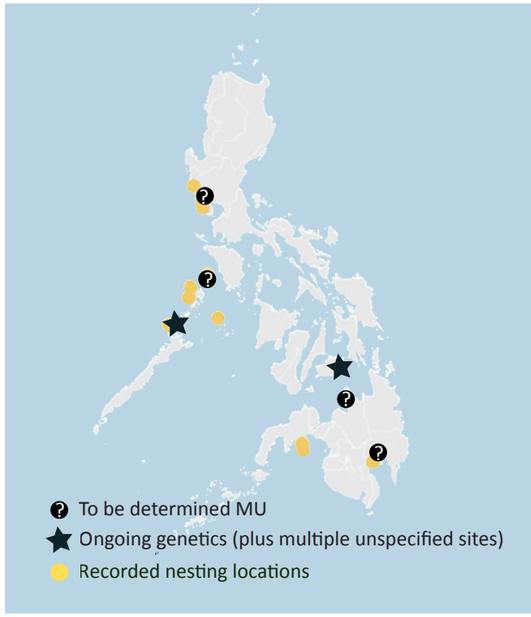
It was estimated that around 5,000 turtles (non-species specific) were landed each year in 2016-2017 in various Papua New Guinea markets, however, given the scarcity of data, this figure is most likely underestimating the true extent of marine turtle exploitation (Opu, 2018 in Madden Hof et al., 2022). Another figure was put forward by Work et al., (2020), who estimated that the country harvests about 15,000 turtles per year (Work et al., 2020 in Ingram et al., 2022). An annual harvest estimate assessment is underway under WWF/SPREP Turtle Use Project.

PHILIPPINES

Marine turtle species:

Ei Cm Lo Cc Dc

Genetic stocks/Management Units: TBD
RMU: West Pacific and Southeast Asia
Population status: Unknown
National legal status: Protected under the Wildlife Resources Conservation and Protection Act, 2001
ShellBank database (published):
Rookery samples: 8 samples/4 locations
In-Water samples: 0 samples/0 locations
Confiscation: 0
Ongoing genetics: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – To date no robust genetic studies have been done for nesting or foraging hawksbill turtles in the Philippines. Small datasets are available from the Davao Gulf (n=2), APO Reef Natural Park (n=4), Misamis Oriental (n=1) and Bataan (n=1) (Wahidah and Syed Abdullah (2009). While haplotypes appear to be unique to the Philippines, it is likely that several Management Units exist. Small sample size prevents population frequencies from being calculated.

In-Water - No genetic work has been published.

Gaps

There are substantial gaps for hawksbills in the Philippines and it is highly recommended that more samples be collected from key rookeries and foraging areas throughout the country. Extensive genetic sampling and analysis is underway from key sites across the country including from nesting, foraging, bycaught and confiscated turtles (led by LAMAVE, WWF-Philippines, University of the Philippines and DENR). It is expected that genetic information from the Philippines will significantly increase in the near future.

Hawksbill distribution

Hawksbill turtles are known to nest in low numbers on Panikian Islands (Sagun, 2002) and the Calamian Islands (Poonian et al., 2016), and the Philippine Turtle Islands (Cruz, 2002). Generally, nesting numbers are very low.

Hawksbill turtles are known to forage on many coral reefs that make up the Philippine archipelago. Hawksbills have been reported foraging at the Calamian Islands, El Nido-Taytay Managed Resource Protected Area, Tubbataha Reefs Natural Park, the Turtle Islands Wildlife Sanctuary, Lagonoy Gulf, Romblon Island, Magsaysay in Misamis Oriental, and the Davao Gulf (Hamann et al., 2022).

Turtle use and trade

Marine turtles are protected under the country's Wildlife Resources Conservation and Protection Act of 2001, with trade in marine turtles and their derivatives prohibited. The Philippines established the world's first transboundary protected area for marine turtles: the Turtle Islands Heritage Protected Area (Ocean Ambassadors, n.d.). However, there are several reports indicating that the country is a major source of hawksbill shells destined for other countries, such as China and Viet Nam, and it appears there is no significant domestic market for these products (Nahill et al., 2020).

An unquantified increase in the illegal harvest of marine turtles in several regions was reported by the Philippines in 2019, as well as continued high levels of egg harvesting (IOSEA, 2019 in Ingram et al., 2022). Some cases of turtle meat consumption were also observed. Key hotspots for marine turtle trade are the Balabac Municipality in southern Palawan, and the Turtle Islands Municipality in Tawi-Tawi. In Balabac, turtles have been reported to be stockpiled or chained to rocks underwater until foreign buyers signal interest (Fischer et al., 2021). Marine turtles were said to be poached for the consumption of their meat and cartilage, or used for jewellery and combs (Antonio and Matillano, 2016). Kudat, Malaysia, was also reported to act as a stocking area and transshipment point of marine turtles collected in the waters of the Balabac Strait (Antonio and Matillano, 2016). The Turtle Islands are known as a source for illegally harvested marine turtle eggs mostly exported to Malaysia, with some of these activities orchestrated through an illegal egg harvest permit lottery, others taking place ad-hoc (Fischer et al., 2021). It was also stated that in Calamianes, in the north of Palawan, some opportunistic hunting and egg collection by indigenous communities takes place (Poonian et al., 2016).

SINGAPORE

Marine turtle species:

Ei Cm

Genetic stocks/Management Units: TBD
RMU: Western Pacific and Southeast Asia
Population status: Unknown
National legal status: Protected
ShellBank database (published):
Rookery samples: 0 samples/0 locations
In-Water samples: 0 samples/0 locations
Confiscation: 0
Ongoing genetics: None
Use and trade summary:

Status of genetic work

Genetic stocks/Management Units – No genetic work has been published.

In-Water - No genetic work has been published.

Gaps

While very small, turtle populations nesting in Singapore represent a gap. Genetic studies are needed to assess if Singapore represents a single management unit or if these rookeries group with rookeries in Melaka or Johor states (Malaysia), or rookeries in Indonesia.

Hawksbill distribution

Hawksbill turtles nesting in Singapore is recent and occurs in low numbers (tens of turtles nesting annually). Hawksbills have been recorded nesting along East Coast Parkway sections, Small Sister Island, Big Sister Island, and on Changi (Hamann et al., 2022).

Turtle use and trade

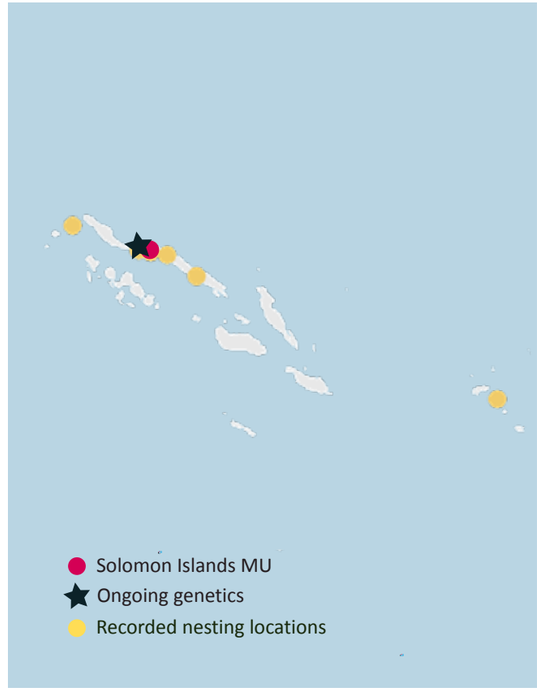
Marine turtles are protected by national legislation in Singapore, which prohibits the use of turtles or their eggs, with nesting sites monitored and managed by National Parks Board staff recording each clutch of eggs (Hamman et al., 2022). Historically, Singapore has been implicated as a transit and receiver of turtle shell products and eggs (IOSEA, 2014). But turtle smuggling cases seem to be rare, such as in 2013, when a woman was caught by the Singapore customs authority with 60 kilograms of hawksbill turtle shells in her luggage (Nahill et al., 2020; e.g. Seychelles Weekly, 2013). A recent article published that between April and October 2018, 22 cases of smuggled marine turtle eggs meant for personal consumption were detected at checkpoints.

SOLOMON ISLANDS

Marine turtle species:

Ei Cm Lo Cc Dc

Genetic stocks/Management Units: 1
RMU: Southwest Pacific
Population status: Likely increasing at the Arnavon Islands (only stock assessed)
National legal status: Protected
ShellBank database (published):
Rookery samples: 70 samples/1 locations
In-Water samples: 0 samples/0 locations
Confiscation: 0
Ongoing genetics: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – One MU has been identified from the Solomon Islands (Arnavon Islands). However, more sampling is needed to assess this stock's geographic boundaries, which may extend into Papua New Guinea.

Foraging areas - No genetic work has been published.

Gaps

Published rookery samples from the Solomon Islands are all from the Arnavon Islands. It should be a priority to collect samples from other rookeries within the Solomon Islands as well as from neighbouring countries (e.g. Papua New Guinea) to assess the geographic boundary of this MU. Genetic work is underway to analyse additional samples from nesting and foraging hawksbills in the Solomon Islands and Papua New Guinea (N FitzSimmons, R Hamilton, C Madden Hof, pers comm).

Hawksbill distribution

The main nesting sites of hawksbill turtles in the Solomon Islands are in Arnavon Islands (Big Maleivona Island, small Maleivona Island, Kerihikapa Island, and Sikopo Island) and form the largest nesting population in the region (Hamilton et al., 2015; Prakash and Piovano 2021; Pilcher 2021; Madden Hof et al., 2022).

Hawksbill turtles are known to forage throughout the Solomon Islands. Known foraging areas include Marovo Lagoon in New Georgia and Kolombangara (Prakash and Piovano 2021). Recent satellite telemetry studies show that hawksbill turtles nesting in the Solomon Islands (Arnavon Islands) migrate long distances to foraging areas in Papua New Guinea, New Caledonia, the Torres Strait, and the Great Barrier Reef (Hamilton et al., 2021).

Turtle use and trade

In the past, the export of tortoiseshell from the Solomon Islands was among the ten highest globally (Miller et al., 2019). The Solomon Islands banned the trade in turtle products in 1993, and only allows turtles to be harvested for subsistence purposes (Vuto et al., 2019), but prohibits the harvesting of turtle eggs or a nesting turtle (Madden Hof et al., 2022). Despite this legislation, marine turtle harvest is common in the country; it was estimated that small-scale fisheries harvest approximately 10,000 turtles per year, with hawksbill turtles comprising 26% of all turtle captures, of which 24% are adult-sized (Vuto et al., 2019 in Madden Hof et al., 2022). Adult turtles are often harvested near or on nesting grounds (Vuto et al., 2019). Over 90% of these turtles were harvested by free-diving spear fishers (Vuto et al., 2019). Other harvesting figures are estimated to range from 5,000-22,000 turtles per year (Pilcher, 2021).

The use of tortoiseshell in jewellery and artwork and the consumption of turtle meat remain a central aspect of contemporary Solomon Islands culture (Nahill et al., 2020). Hawksbill turtles and eggs are mainly harvested for subsistence purposes, consumed by the family of the fisher that captured the turtles (Vuto et al., 2019). Commercial harvesting and subsistence use have caused some historically important hawksbill nesting beaches to become functionally extinct (Madden Hof et al., 2022). The majority of the shells of the turtles, however, are first sold from local communities to local buyers, who then sell them to Asian buyers or in some cases local buyers are being outcompeted by Asian buyers in Honiara (Vuto et al., 2019 in Madden Hof et al., 2022).

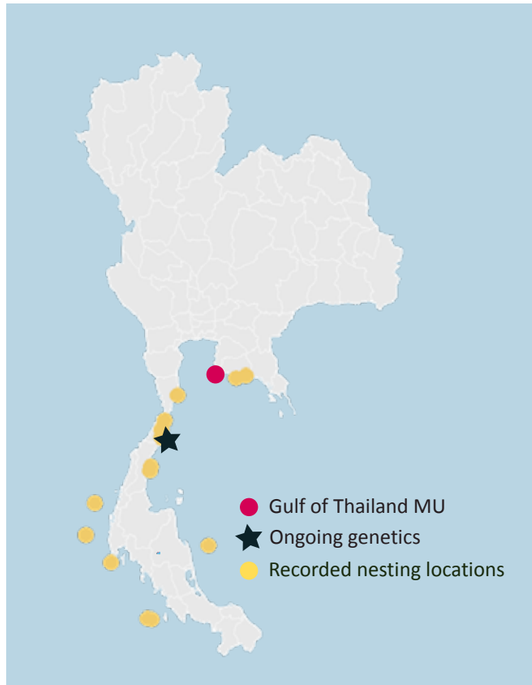
Fishers indicated the presence of two markets for hawksbill shell in the Solomon Islands: a local market that supplies carvers and shell money makers; and an international market, with hawksbill scutes purchased by Asian buyers before being exported (Nahill et al., 2020). There were reports of hawksbill scutes being sold to logging ships (Nahill et al., 2020), and hawksbill jewellery was also observed for sale in the international departure lounge in Honiara, despite the Solomon Islands being a Signatory to CITES (Vuto et al., 2019).

THAILAND

Marine turtle species:

Ei Cm Lo Cc Dc

Genetic stocks/Management Units: 1 – Gulf of Thailand MU (putative)
RMU: Western Pacific and Southeast Asia
Population status: Possibly increasing
National legal status: Protected
ShellBank database (published):
Rookery samples: 19 total samples/1 locations
In-Water samples: 0 total samples/ 0 locations
Confiscation: 0
Ongoing genetics: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – It is currently unclear if turtles nesting in Thailand belong to a distinct genetic stock (Ko Kram) or if grouped with the NW Peninsular Malaysia rookeries. Hence it is currently grouped with a putative Gulf of Thailand stock (FitzSimmons and Limpus, 2014). Additional sampling is needed to determine the boundary of this stock.

In-Water - No genetic work has been published.

Gaps

Limited genetic information exists from Thailand. However, ongoing efforts are underway through international and local collaborations to sample and analyse nesting and foraging hawksbills from multiple sites in Thailand, as well as turtles used to stock head-starting facilities (S Dunbar, pers comm).

Hawksbill distribution

Hawksbill turtles in Thailand have been recorded nesting at Ko Khram but at relatively low numbers (100 to 150 clutches per year) as well as Ko Kra. On the west coast, hawksbills have been recorded nesting along several islands including Surin and Similan Islands (Hamann et al., 2022). Low numbers of nesting have also been reported on Ko Rawi, Ko Adang, and Talu (IOSEA, 2019).

Limited satellite tracking of nesting turtles from Ko Ira and Ko Charn showed short migrations to foraging areas within Thailand (Monanunsap et al., 2002). Hawksbill turtles are likely to forage on coral reefs throughout Thailand.

Turtle use and trade

The selling of hawksbill shell products has been strictly outlawed in Thailand by the government (Nahill et al., 2020). It seems that despite local shopkeepers and market sellers widely recognising the ban, there is a minor black market for marine turtle meat and eggs (Nahill et al., 2020). Experts believe it is likely that, based on impacts to other marine turtle species that are nesting in the region, hawksbill populations have equally been impacted by egg harvesting, which have almost certainly caused significant declines in nesting populations (Hamann et al., 2022). It was reported that eggs that were previously sold in bulk in Terengganu were usually sourced from Sabah or imported illegally (via land, air, boat or post) from the Philippines or Thailand, and elsewhere. Moreover, some reports pointed to Thailand being one of the countries where marine turtle meat is consumed (Ingram et al., 2022). Hawksbill Items, in contrast, were not listed among the marine turtle items sold (Nahill et al., 2020), and in a 2018 – 2019 survey of local markets and tourist outlets by Dunbar et al., (2019) along the eastern Gulf of Thailand, they encountered no hawksbill shell, meat, or egg products.

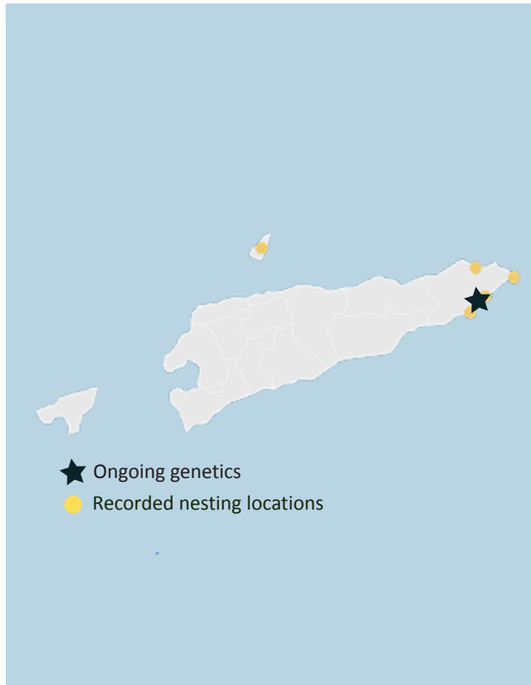
In the 2019 IOSEA National Report, Thailand indicated that its national Fisheries Law prohibits direct harvest and domestic trade in marine turtles, their eggs, parts and products, and protects important turtle habitats, and that the Department of Fisheries has also mechanisms in place to identify international illegal trade routes (IOSEA, 2019). The country also considers international cooperation essential to address poaching and illegal trade in turtle products (IOSEA, 2019).

TIMOR-LESTE

Marine turtle species:

Ei Cm Lo

Genetic stocks/Management Units: TBD
RMU: West Pacific and Southeast Asia
Population status: Unknown
National legal status: Protected
ShellBank database (published):
Rookery samples: 0 samples/0 locations
In-Water samples: 0 samples/0 locations
Confiscation: 0
Ongoing genetics: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – No genetic work has been published.

In-Water - No genetic work has been published.

Gaps

Timor-Leste represents a significant gap in genetic samples to improve the Rookery Baseline, although nesting numbers are likely to be low. No genetic studies have been conducted on nesting or foraging turtles, but efforts are underway to support sample collection and analysis through WWF-Australia and Conservation International, in collaboration with local partners.

Hawksbill distribution (nesting and foraging)

Hawksbill turtle nesting has been reported at low numbers at Com, Tutuala-Jaco Island, Nino Konis Santana National Park (Muapitine and Lore 1), and Atauro Island (A Amaral, Conservation International, pers comm.). Hawksbill turtles are known to forage in the waters of Timor-Leste, but abundance and distribution remain unpublished and unquantified. Two nesting female hawksbill turtles satellite-tagged, while nesting in Timor-Leste both migrated to forage on the coast of Western Australia,>1000 km away, highlighting the international connectivity between some nesting and foraging areas (Fossette et al., 2021).

Turtle use and trade

All marine turtle species are protected by law in Timor-Leste; however, there are reports that trade in turtle meat, parts and eggs is still vibrant, especially around Dili locations. It seems that the fishers and the community in the municipality of Dili are engaged in a high level of turtle egg removal from nesting beaches and the hunting and selling of them at the local markets, local shops or at individual levels (e.g. in community houses). Hawksbill turtle products are priced the highest (Anonymous, n.d). Illegal turtle harvesting was also reported as a major challenge in the Nino Konis Santana National Park and Marine Park (Edyvane et al., 2009 in Pilcher et al., 2021). Moreover, there are anecdotal reports that an international company incentivises community members to provide turtle shells directly.

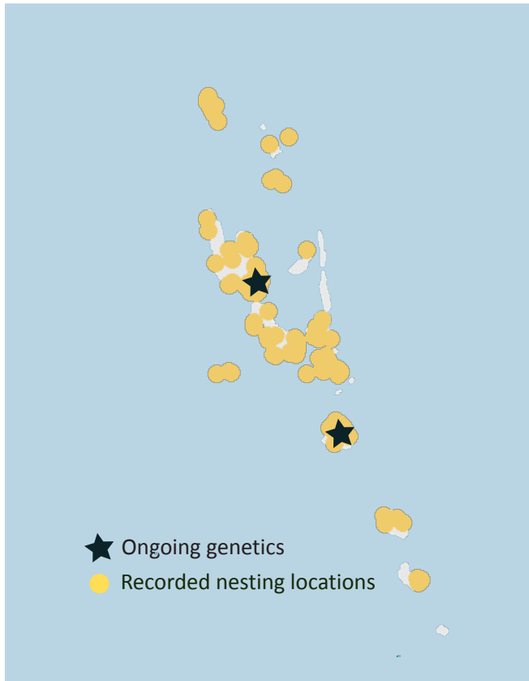
A brisk trade in ornaments made from tortoiseshell was observed in community houses in Tasi Tolu, Dolok Oan, and Bebonuk, and in and around Dili. Ornaments were sold in local markets, supermarkets and street stalls, with products originating from Manatutu, Liquica, Same, Lospalos, Viqueque and Suai/Zumalai (Pilcher et al., 2021). A more systematic slaughtering and cooking of turtles was reported to take place on Jaco Island (Pilcher et al., 2021). Marine turtle egg collection was observed in the Aru Islands (Dethmers 2010), in the Nino Konis Santana National Park and Marine Park (Edyvane et al., 2009 in Pilcher et al., 2021), and in and around Dili, with infrequent but year-round nesting activity (Sealife Trust, 2018 and Eisemberg et al., 2014 in Pilcher et al., 2021). Bebonuk Beach and Pantai Kelapa were also listed as turtle egg sale locations.

VANUATU

Marine turtle species:

Ei Cm Lo Cc Dc

Genetic stocks/Management Units: TBD
RMU: Southwest Pacific
Population status: Likely declining (Madden Hof et al., 2022)
National legal status: Protected
ShellBank database (published):
Rookery samples: 0 samples/0 location
In-Water samples: 0 samples/0 locations
Confiscation: 0
Ongoing genetics: Yes, refer Gaps
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units - No genetic work has been published.

In-Water - No genetic work has been published.

Gaps

Given the extensive (low-density) nesting that has been recorded across Vanuatu's unsampled rookeries, multiple stocks could potentially be present within Vanuatu, the focus of additional sample collection. In particular, samples from the large rookery on Moso Island and Bamboo Bay. Samples of nesting hawksbills have been collected from Bamboo Bay and are currently being analysed for publication (F Hickey and N FitzSimmons, pers comm). Ad-hoc and opportunistic samples have also been collected in various locations during the past couple of years and are now ready for analysis (F Hickey, pers comm). It is expected that new information from Vanuatu will be available in the near future.

Hawksbill distribution

Hawksbill turtles are known to nest throughout Vanuatu. Approximately 300 female hawksbills nest in the country annually (Mortimer and Donnelly, 2008), with the highest density recorded at Moso Island (off north Efate) and Bamboo Bay as well as Wiawi (West coast Malekula). Extensive but low-level nesting is recorded across the Islands of Ambrym, Efate, Epi, Espiritu Santo, Malekula and Moso, Aneityum and Tegua, Torres Islands (Hickey, 2021).

Vanuatu hosts essential foraging habitats for hawksbills. Coral reef habitats across many islands have recorded hawksbill turtles, although none have been quantified (Hickey, 2021). Tagging and satellite telemetry work shows that many hawksbills nesting in Vanuatu use distant foraging areas. For example, one turtle tagged while nesting in Bamboo Bay was recaptured in New South Wales, Australia (Hickey, 2021) and from seven hawksbills satellite tagged after nesting on Moso Island, three were tracked to foraging grounds along the Great Barrier Reef, Australia, three to foraging areas in New Caledonia and one to distant islands within Vanuatu Rice (Rice et al., 2021).

Turtle use and trade

The harvesting of nesting and foraging hawksbill turtles continues in Vanuatu, despite laws prohibiting turtle take (Rice et al., 2018). However, where turtle take in the past may have amounted to about 1,500 turtles per year, it is suggested that much of this harvest has ceased (Pilcher, 2021). There is an active programme in Vanuatu of local turtle monitors that aid in protecting turtles and convincing local communities to participate in turtle conservation efforts (Pilcher, 2021).

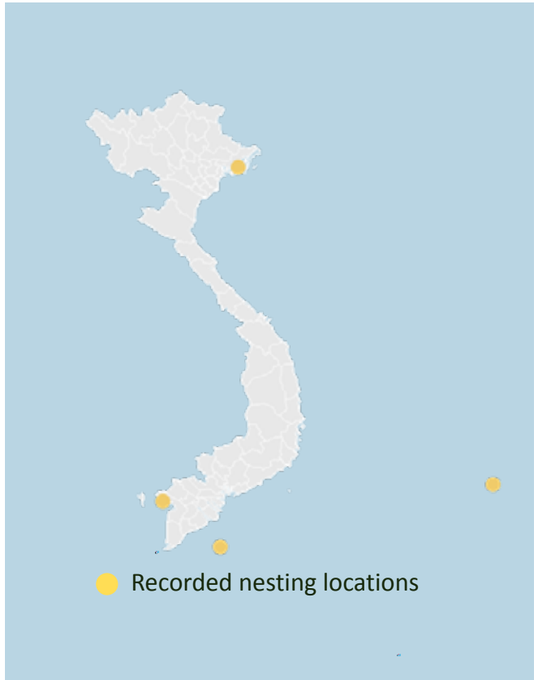
There are limited records of illegal take and trade. It was observed that adult hawksbills are occasionally kept in tanks for tourism purposes and hawksbill turtle hatchlings are caught and retained for headstarting programs on Efate, with high hatchling mortality due to poor water quality (Hickey, 2021). Most turtles caught were reported to be used for consumption, followed by using the meat for trade, and selling the meat (Pilcher, 2021).

VIET NAM

Marine turtle species:

Ei Cm Lo Cc Dc

Genetic stocks/Management Units: TBD
RMU: Western Pacific andAsia-Pacific
Population status: Depleted
National legal status: Protected
ShellBank database (published):
Rookery samples: 0 samples/0 locations
In-Water samples: 0 total samples/0 locations
Confiscation: 0
Ongoing genetics: None
Use and trade summary:



Status of genetic work

Genetic stocks/Management Units – No genetic work has been published.

In-Water - No genetic work has been published.

Gaps

With very low numbers of hawksbill turtles left in Viet Nam, there are no significant gaps. However, nesting (Con Dao) samples and foraging and bycaught hawksbill samples will be valuable to assess the genetic variation in the region.

Hawksbill distribution

Hawksbill turtle nesting used to be common in Viet Nam, but today, there are no recent records of hawksbills nesting in the country. Foraging hawksbills are also rare in Viet Nam. There are records of hawksbill turtles being caught as bycatch on nearshore reefs (Hamann et al., 2006). Con Dao is recognised as an important site for foraging hawksbill turtles,although abundance remains unquantified.

Turtle use and trade

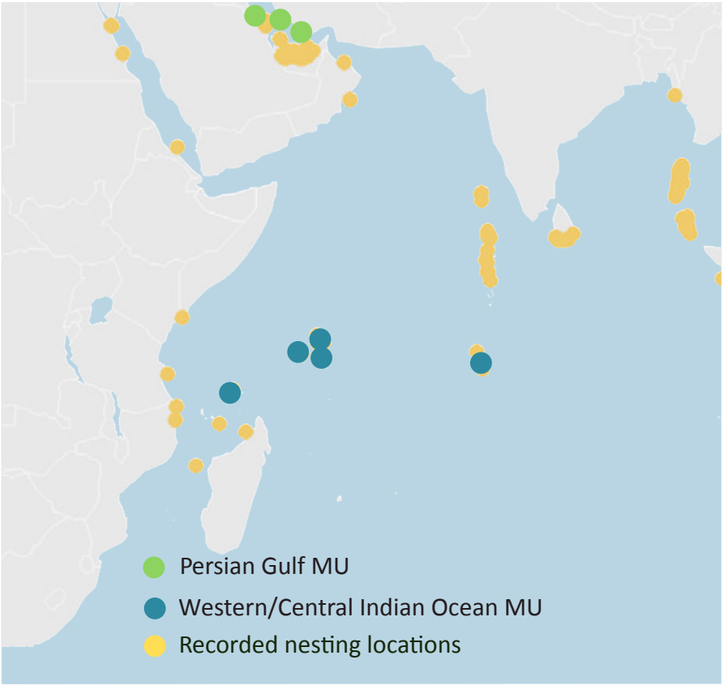
All marine turtle species are prohibited from domestic exploitation under Decree 59 and its related and incorporated documents (CITES Secretariat, 2019). Still, illegal hunting of turtles in the waters of Viet Nam and within the Coral Triangle has been observed at least since the early 2000s, with regular occurrences of fisherpeople caught in this location, who were involved in smuggling marine turtles to Viet Nam (IOSEA, 2014 in CITES Secretariat, 2019; e.g. articles by TRAFFIC in 2008 and National Geographic in 2018). Hunting equipment has evolved from traditional boats and simple fishing gear to large motorised fishing boats and modern equipment, sometimes sponsored by middlemen (CITES Secretariat, 2019).

Viet nam is a source, transit and destination country for marine turtle products. China was indicated as a destination of several shipments originating in Viet Nam, and Viet Nam was implicated as a destination with the origins of turtles mostly reported as Malaysia, followed by Haiti, Indonesia and the Philippines (CITES Secretariat, 2019). Domestic sales in outlets were observed to take place mostly in Nha Trang, Ha Tien, and Ho Chi Minh City, but were also sold in physical markets and online, with most products – bekko ornaments, bangles, bracelets and taxidermied turtles – made out of hawksbill, followed by green turtles (CITES Secretariat, 2019; Ingram et al., 2022). Taxidermied turtles are thought to bring luck when buried in a house's basement (CITES Secretariat, 2019). Meat and eggs are domestically consumed as a delicacy and as an aphrodisiac.

In addition to the domestic demand, there is increasing demand from Chinese nationals, who travel to Viet Nam, buying wildlife products including combs and hair clips made of carapace (CITES Secretariat, 2019). Marine turtles are mainly taxidermied in Viet Nam before being exported, whereas prosecuted individuals also claimed to have exported large amounts of processed marine turtles to Chinese wholesalers for local consumption (CITES Secretariat, 2019).

CENTRAL AND WEST INDIAN OCEAN REGION

Countries with recorded hawksbill turtle nesting and/or foraging areas include the Comoros (FRA), India, Iran, Kenya, Madagascar, Maldives, Mauritius, Mozambique, Oman, Seychelles, Somalia, South Africa, Sri Lanka, Tanzania, the United Arab Emirates, Yemen, Kuwait, and Pakistan.



SUMMARY

Status of genetic work

Genetic stocks/Management Units – Three MUs are identified for the Central and West Indian Ocean region (Vargas et al., 2016). At least one MU is found within the Persian Gulf (Iran NW, Iran SE and Saudi Arabia), but the results are ambiguous, and more MUs may exist within the Persian Gulf. One large MU in the Western/Central Indian Ocean MU includes Aldabra Atoll, Platte, Granitics and Amirante Islands (Seychelles), and the Chagos Archipelago. These latter MUs include rookeries that are separated by more than 2,800 km (e.g. Chagos and Aldabra). Using more informative genetic markers would likely add resolution and identify additional structure within the current MU.

Gaps

Several gaps in genetic sampling exist, particularly across smaller rookeries in the SWIO where hawksbills are known to nest. Foraging studies are also lacking to better assess stock boundaries and connectivity between nesting and foraging areas. However, several genetic studies are underway. The TImOI project (Hawksbills of the Indian Ocean) is currently undertaking a genetic study to look at stock structure and connectivity among 13 countries and territories (Jeanne A. Mortimer et al., 2022) and ongoing foraging studies including samples from Chagos and Seychelles (N FitzSimmons, pers comm).

Hawksbill distribution

The Central and West Indian Ocean is recognised as an important region for hawksbill turtles (Mortimer and Donnelly, 2008), with nesting occurring across the Indian Ocean, including the Persian Gulf, Red Sea and throughout the Mozambique Channel (Comoros, Madagascar, Mozambique, Tanzania, Kenya, Mauritius and Mayotte) (Hamann et al., 2022). The largest nesting populations are found in the Seychelles and Chagos, accounting for 97% of nesting in the Southwest Indian Ocean (Mortimer et al., 2020).

CENTRAL AND EASTERN PACIFIC OCEAN REGION

Countries with recorded hawksbill nesting and/or foraging areas include the USA, Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, and Chile.

SUMMARY

Status of genetic work

Genetic stocks/Management Units – Six MUs have been identified across the Central and Eastern Pacific; Hawaii Island, Mexico Pacific (Costa Careyes, Oaxaca, Guerrero, Jalisco); Nicaragua Pacific (Estero Padre Ramos, Aserradores, Southern Rivas); Costa Rica/Panama Pacific (Osa Peninsula, Azuero Peninsula), El Salvador (Los Cobanos, Bahia de Jiquilisco, Punta Amapala); and Ecuador (Machalilla and Isla San Cristobal) (Gaos et al., 2016, 2020).

Gaps

Recent genetic studies have characterised the genetic structure of major rookeries and foraging areas throughout the Central and Eastern Pacific. No major gaps exist.

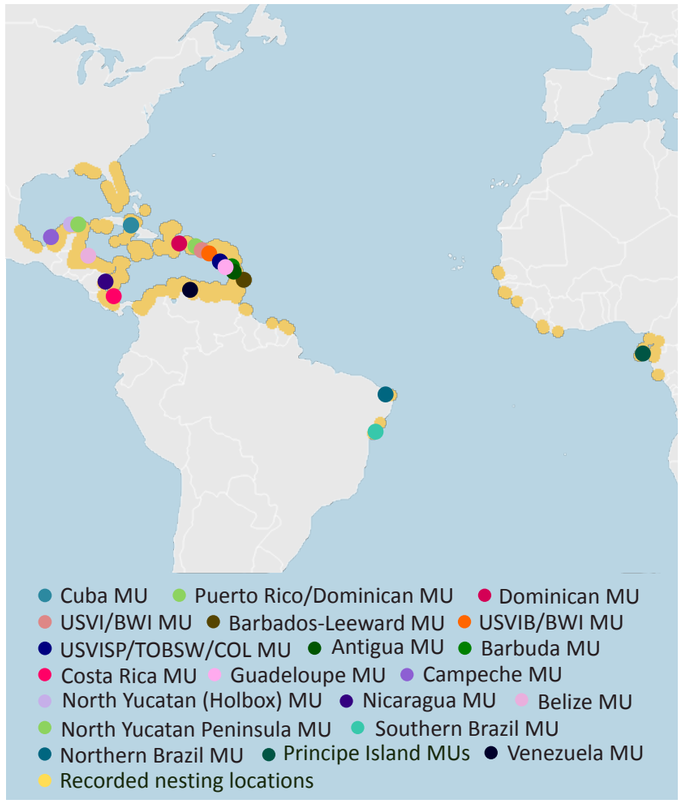
Hawksbill distribution

Hawksbill turtles are known to nest in the Hawaiian Islands within the Central Pacific and at more than 40 nesting sites in Mexico, El Salvador, Nicaragua, Panama, and Ecuador. The largest rookeries identified to date are located in Bahia de Jalisco and Los Cóbanos (El Salvador), and Padre Ramos and Aserradores (Nicaragua) (Rguez-Baron et al., 2021).

Hawksbills in the Eastern Pacific primarily inhabit neritic foraging areas in close proximity to their natal rookeries and undergo limited migration compared to hawksbills in other regions. Another unique feature of Eastern Pacific hawksbills is that many foraging aggregations primarily inhabit mangrove estuaries. Important foraging aggregations have been identified at San Jose and Isla Espiritu Santo in Mexico; Los Cobanos, Jiquilisco Bay and Punta Amapala in El Salvador; Gulf of Fonseca in Honduras; Estero Padre Ramos and Aserradores in Nicaragua; Gulf of Nicoya and Sweet Gulf in Costa Rica; Coiba Island in Panama; Isla Gorgona in Colombia; Jambeli Archipelago in Ecuador; and the Tumbes sanctuary in Peru (Rguez-Baron et al., 2021).

ATLANTIC OCEAN REGION AND THE CARIBBEAN

Countries with recorded hawksbill turtle nesting and/or foraging areas include the Azores (POR), Portugal, Angola, Benin, Cameroon, Canary Islands (ESP), Cape Verde, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Madeira (POR), Mauritania, Morocco, Namibia, Nigeria, Republic of the Congo, Saint Helena, Ascension and Tristan da Cunha (UK), São Tomé and Príncipe, Senega, Sierra Leone, South Africa, Togo, Argentina, Brazil, Colombia, French Guiana (FRA), Guyana, Suriname, Uruguay, Venezuela, Bahamas, Belize, Bermuda (UK), Costa Rica, Guatemala, Honduras, Mexico, Nicaragua, Panama, Saint Pierre and Miquelon (FRA), United States, Anguilla (UK), Antigua and Barbuda, Aruba (NED), Barbados, Bonaire (NED), British Virgin Islands (UK), Cayman Islands (UK), Cuba, Curaçao (NED), Dominica, Dominican Republic, Guadeloupe (FRA), Grenada, Haiti, Jamaica, Martinique (FRA), Montserrat (UK), Saba (NED), Puerto Rico (USA), Saint Barthélemy (FRA), Saint Kitts and Nevis, Saint Lucia, Sint Maarten (NED), Saint Martin (FRA), Saint Vincent and the Grenadines, Sint Eustatius (NED), Trinidad and Tobago, Turks and Caicos Islands (UK), and United States Virgin Islands (USA).



SUMMARY

Status of genetic work

Genetic stocks/Management Units – Hawksbill rookeries in the Atlantic are some of the best studied with multiple genetic studies having been published characterising the genetic structure of hawksbills. At least 20 MUshave been identified for the Atlantic (Arantes et al., 2020)

Gaps

No apparent major gaps in sampling across the Atlantic but numerous ongoing genetic studies continue to build knowledge.

Hawksbill distribution

Hawksbill turtles have been reported to nest extensively across the wider Caribbean region. These include 23 major nesting sites (>20 nests/yr AND >10 nests/km/yr) located in Bonnaire, Colombia, Cuba, Guadeloupe, Mexico, St. Eustatius, St. Lucia, and St. Martin. In addition, 88 minor sites are found throughout the region.

In the Southwest Atlantic, hawksbills have only been recorded nesting in Brazil, with the main rookeries located in the northeast of Bahia state and Rio Grande do Norte. In the Southeast Atlantic, hawksbills nest along the coast of Cameroon, Equatorial Guinea, Gambia, Guinea-Bissau, Liberia, Sao Tome and Principe, and Sierra Leone.

APPENDIX 2: MARINE TURTLE DATASETS

(DISTRIBUTION, TREND, THREATS AND CONSERVATION)

TITLE	DESCRIPTION	SOURCE
Marine Turtle Breeding and Migration Atlas - TurtleNet	TurtleNet was developed by the Queensland Government and CMS. It is an interactive map and contains data on nesting distribution and abundance by species based on tagging and nesting census studies and migration between breeding and foraging areas based on flipper tag data, and breeding migration based on satellite telemetry.	https://apps.information.qld.gov.au/TurtleDistribution/
SWOT Online Map and Sea Turtle Database	Interactive map and database of marine turtle biogeography. The database contains thousands of data records on marine turtle nesting data, satellite telemetry data, species distributions, Regional Management Unit boundaries, genetic data (mtDNA and nDNA), and more.	https://www.seaturtlestatus.org/online-map-data
TREDS Database - Turtle Research and Monitoring Database System	The Turtle Research and Monitoring Database System (TREDS) provides invaluable information for Pacific Island countries and territories to manage their marine turtle data resources. TREDS can be used to collate data from strandings, tagging, nesting, emergence, and beach surveys as well as other biological data on marine turtles.	https://www.sprep.org/thetreds
Assessment of the conservation status of the hawksbill turtle in the Indian ocean and south-east asia region	Assessment of the conservation status of hawksbill turtles throughout the IOSEA Region. The report provides information on the ecological range and geographic spread of nesting and foraging sites, threats to hawksbill turtle populations, management and governance actions, and biological data for breeding and foraging populations.	Hamann et al., 2022 (https://www.cms.int/iosea-turtles/en/publication/assessment-conservation-status-hawksbill-turtle-indian-ocean-and-south-east-asia-region)
IUCN-SSC MTSG - REGIONAL REPORTS	Regional reports are annual publications from the Marine Turtle Specialist Group summarising published and unpublished data for every country and region in which marine turtles occur. Yearly Regional Reports can be viewed and downloaded from the site.	https://www.iucn-mtsg.org/regional-reports
Assessment of the Conservation Status of the Hawksbill Turtle in the Western Pacific Ocean Regions	Assessment of the conservation status of hawksbill turtles throughout the Western Pacific Region. The report provides information on the ecological range and geographic spread of nesting and foraging sites, threats to hawksbill turtle populations, management and governance actions, and biological data for breeding and foraging populations.	Hof et al., 2022 (https://www.cms.int/en/document/assessment-conservation-status-hawksbill-turtle-western-pacific-ocean-region)

APPENDIX 3. HAWKSBILL TURTLE GENETIC STOCKS/MANAGEMENT UNITS

MANAGEMENT UNIT	LOCATIONS	RMU	CITATION/SOURCE
ATLANTIC OCEAN			
Cuba	Doce Aguas	NW Atlantic	LeRoux et al., 2012; Diaz-Fernandez et al., 1999; Arantes et al., 2020
Puerto Rico and Dominican Republic	Mona Is. (and Monito Is.), Saona Is.	NW Atlantic	Velez-Zuazo et al., 2008; LeRoux et al., 2012; Arantes et al., 2020; Carreras et al., 2013
Dominican Republic	Jaragua National Park	NW Atlantic	Arantes et al., 2020; Carreras et al., 2013
USVI/BWI	Barbados, Windward (Bath)	NW Atlantic	Browne et al., 2010; Arantes et al., 2020; LeRoux et al., 2012
Barbados-Leeward	Barbados, Leeward	NW Atlantic	Browne et al., 2010; Arantes et al., 2020; LeRoux et al., 2012
USVIBI/BWI	Buck Island	NW Atlantic	LeRoux et al., 2012; Hill et al., 2018; Arantes et al., 2020
USVISP/TOBSW/TOBNE/COL	Sandy Point, Cabo de la Vela, Southwest coast, Northeast coast	NW Atlantic	Cazabon-Mannette et al., 2016; Arantes et al., 2020; Levasseur et al., 2019; Hill et al., 2018; LeRoux et al., 2012
Antigua	Antigua	NW Atlantic	Levasseur et al., 2019; Arantes et al., 2020; LeRoux et al., 2012
Barbuda	Barbuda (North, South)	NW Atlantic	Levasseur et al., 2019; Arantes et al., 2020; LeRoux et al., 2012
Costa Rica	Tortuguero	NW Atlantic	LeRoux et al., 2012; Arantes et al., 2020; Lavasseur et al., 2019
Guadeloupe	Trois Ilets, Marie Galante, Galet Rouges, Basse-Terre	NW Atlantic	LeRoux et al., 2012; Arantes et al., 2020; Lavasseur et al., 2019
North Yucatan Peninsula	Holbox	NW Atlantic	LeRoux et al., 2012; Arantes et al., 2020; Labastida-Estrada et al., 2019; Arantes et al., 2020
Campeche	Chenkan	NW Atlantic	Labastida-Estrada et al., 2019; Arantes et al., 2020
North Yucatan Peninsula	El Cuyo, Las Coloradas	NW Atlantic	Labastida-Estrada et al., 2019; Arantes et al., 2020
Nicaragua-Atlantic	Pearl Cays	NW Atlantic	LeRoux et al., 2012; Arantes et al., 2020; Lavasseur et al., 2019
Northern Brazil	Pipa, Fortaleza	SW Atlantic	Vilaça et al., 2013; LeRoux et al., 2012; Arantes et al., 2020
Southern Brazil	Bahia, Pirambu	SW Atlantic	Vilaça et al., 2013; LeRoux et al., 2012; Arantes et al., 2020
Venezuela	Los Roques	NW Atlantic	Bowen et al., 2007; Monzon et al., 2011
Belize	Belize	NW Atlantic	Bass et al., 1996; Monzon et al., 2011
Principe Island	Praia Grande, Praia Ribeira Izé, Praia Sêca, Ponta Marmita, Praia Bom-Bom	SW Atlantic	Monzon et al., 2011

MANAGEMENT UNIT	LOCATIONS	RMU	CITATION/SOURCE
INDIAN OCEAN			
Northwest Iran	Nakhiloo, Ommolkaram	NW Indian Ocean	Vargas et al., 2016; Arantes et al., 2020
Southwest Iran	Sheedvar, Hendourabi	NW Indian Ocean	Vargas et al., 2016; Arantes et al., 2020
Saudi Arabia	Saudi Arabia	NW Indian Ocean	Vargas et al., 2016; Arantes et al., 2020
Western Australia	Rosemary Islands, Varanus Islands	SE Indian Ocean	Vargas et al., 2016; Arantes et al., 2020
Western/Central Indian Ocean	Amirantes Is., Platte Is., Granitics Is., Chagos Archipelago, Aldabra	SW Indian Ocean	Vargas et al., 2016; Arantes et al., 2020
SOUTHEAST ASIA			
Peninsular Malaysia	Pulau Redang, Melaka, Geliga	SE Asia/West Pacific	Vargas et al., 2016; Arantes et al., 2020, Nishizawa et al., 2016
Sabah Turtle Islands	Redang Island, Melaka	SE Asia/West Pacific	Vargas et al., 2016; Arantes et al., 2020, Nishizawa et al., 2016
WESTERN PACIFIC			
Solomon Islands	Arnavon Islands	SW Pacific	Vargas et al., 2016; Arantes et al., 2020; LaCasella et al., 2020
NE Arnhemland	Northeast Arnhem Land	SW Pacific	Vargas et al., 2016; Arantes et al., 2020
NE Queensland	Milman Island	SW Pacific	Vargas et al., 2016; Arantes et al., 2020; LaCasella et al., 2020
CENTRAL AND EASTERN PACIFIC			
Hawaii	Hawaii Islands	SW Pacific	Gaos et al., 2020
Pacific Mexico	Costa Careyes, Oaxaca, Guerrero, Jalisco	East Pacific	Gaos et al., 2016, Zuñiga-Marroquin and Monteros, 2017
Nicaragua	Estero Padre Ramos, Aserradores, Southern Rivas	East Pacific	Gaos et al., 2016
Costa Rica-Panama Pacific	Osa Peninsula, Azuero Peninsula	East Pacific	Gaos et al., 2016
El Salvador	Los Cobanos, Bahia de Jiquilisco, Punta Amapala	East Pacific	Gaos et al., 2016
Ecuador	Machalilla, Isla San Cristobal	East Pacific	Gaos et al., 2016

REFERENCES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Antonio RAS, Matillano JD. 2016. Nesting incidence, exploitation and trade dynamics of sea turtles in Balabac Strait Marine Biodiversity Conservation Corridor, Palawan, Philippines. Available from https://aquadocs.org/handle/1834/17928 (accessed October 13, 2022).

Arantes LS, Vargas SM, dos Santos FR. 2020. Global phylogeography of the Critically Endangered hawksbill turtle (*Eretmochelys imbricata*). *Genetics and Molecular Biology* **43**(2): e20190264.

Bass AL, Good DA, Bjorndal KA, Richardson JI, Hillis-Starr ZM, Horrocks JA, Bowen BW. 1996. Testing models of female reproductive migratory behaviour and population structure in the Caribbean hawksbill turtle, *Eretmochelys imbricata*, with mtDNA sequences. *Molecular Ecology* **5**:321–328.

Barr CE, Hamann M, Shimada T, Bell I, Limpus CJ, Ferguson J. 2021. Post-nesting movements and feeding ground distribution by the hawksbill turtle (*Eretmochelys imbricata*) from rookeries in the Torres Strait. *Wildlife Research*. **48**(7) 598-608.

Bell IP, Jensen MP. 2018. Multinational genetic connectivity identified in western Pacific hawksbill turtles, *Eretmochelys imbricata*. *Wildlife Research* **45**:307–315.

Bell IP, Meager JJ, Eguchi T, Dobbs KA, Miller JD, Madden Hof CA. 2020. Twenty-eight years of decline: Nesting population demographics and trajectory of the north-east Queensland endangered hawksbill turtle (*Eretmochelys imbricata*). *Biological Conservation* **241**:108376.

Benson SR, Forney KA, Moore JE, LaCasella EL, Harvey JT, Carretta JV. 2020. A long-term decline in the abundance of endangered leatherback turtles, Dermochelys coriacea, at a foraging ground in the California Current Ecosystem. *Global Ecology and Conservation* **24**:e01371.

Bowen BW, Karl SA. 2007. Population genetics and phylogeography of sea turtles. *Molecular Ecology* **16**:4886–4907.

Browne DC, Horrocks JA, Abreu-Grobois FA. 2010. Population subdivision in hawksbill turtles nesting on Barbados, West Indies, determined from mitochondrial DNA control region sequences. *Conservation Genetics* 11:1541–1546.

Cazabon-Mannette M, Browne D, Austin N, Hailey A, Horrocks J. 2016. Genetic structure of the hawksbill turtle rookery and foraging aggregation in Tobago, West Indies. *Journal of Experimental Marine Biology and Ecology* 485:94–101.

Carreras C, Godley BJ, León YM, Hawkes LA, Revuelta O, Raga J A., Tomás J. 2013. Contextualising the Last Survivors: Population Structure of Marine Turtles in the Dominican Republic. PLoS ONE 8:e66037.

CITES Secretariat, 2019. *Status, scope and trends of the legal and illegal international trade in marine turtles, its conservation impacts, management options and mitigation priorities.* Page 105 Eighteenth (18th) meeting of the CITES Conference of the Parties (Geneva, August 2019), Document CoP18 Inf. 18.

Cruz RD. 2002. *Marine Turtle Distribution in the Philippines*. Pages 57–66 in Kinan I, editor. Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop. Honolulu, HI: Western Pacific Regional Fishery Management Council, Honolulu, Hawaii, USA.

Dethmers K. 2010. *Ecology and phylogeography of Australasian green turtle (Chelonia mydas) populations; A case study for conservation from Aru, Indonesia*. Ph.D. thesis. Radboud University Nijmegen, the Netherlands.

Department of Environment and Science. 2021. *Queensland Marine Turtle Conservation Strategy* (2021–2031). Queensland Government, Brisbane.

Department of the Environment and Energy, the NSW Government and the Queensland Government. 2017. *Recovery Plan for Marine Turtles in Australia*.Commonwealth of Australia.

Diaz-Fernandez R, Okayama T, Uchiyama T, Carrillo E, Espinosa G, Márquez-Millán R, Diez CE, Koike H. 1999. Genetic sourcing for the hawksbill turtle, *Eretmochelys imbricata*, in the northern Caribbean region. Chelonian Conservation and Biology: *Journal of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and International Bulletin of Chelonian Research* 3:296–300.

Dunbar SG, Chansue N, Smithiwong S, Haetrakul T, Vanarin C, Sakaew C, Sahang S. 2019. Progress report to the United States Fish and Wildlife Service for the rapid nesting and threats assessments for the recovery of hawksbill nesting in the Gulf of Thailand. *A mid-term progress report 2018, United States Fish and Wildlife Services 2019*.

Ehman EC, Johnson GB, Villanueva-meyer JE, Cha S, Leynes AP, Eric P, Larson Z, Hope TA. 2015. Genetic assignment of large seizures of elephant ivory reveals Africa's major poaching hotspots. *Science* **46**:1247–1262.

Ewart KM, Frankham GJ, Mcewing R, The DT, Hogg CJ, Wade C, Lo N, Johnson RN. 2018. *A rapid multiplex PCR assay for presumptive species identification of rhinoceros horns and its implementation in Vietnam:* 1–10. PLOS ONE 13(8): e0202433.

Fischer C, Trono RB, Salinas RAF. 2021. Addressing gaps in socio-economic and natural assets to halt marine turtle egg poaching: A livelihood feasibility study in the Turtle Islands Wildlife Sanctuary, Philippines. *Global Ecology and Conservation* **32**:e01913.

FitzSimmons NN, Limpus CJ. 2014. *Marine turtle genetic stocks of the Indo-Pacific: Identifying boundaries and knowledge gaps.* Indian Ocean Turtle Newsletter.

Fossette S, Ferreira LC, Whiting SD, King J, Pendoley K, Shimada T, Speirs M, Tucker AD, Wilson P, Thums M. 2021. Movements and distribution of hawksbill turtles in the Eastern Indian Ocean. *Global Ecology and Conservation* **29**:e01713.

Gaos AR et al., 2016. Hawksbill turtle terra incognita: Conservation genetics of eastern Pacific rookeries. *Ecology and Evolution* **6**:1251–1264.

Gaos AR et al., 2017. Natal foraging philopatry in eastern pacific hawksbill turtles. *Royal Society Open Science* **4**.

Gaos AR, LaCasella EL, Kurpita L, Balazs GH, Hargrove S, King C, Bernard H, Jones TT, Dutton DL. 2020. Hawaiian hawksbills : a distinct and isolated nesting colony in the Central North Pacific Ocean revealed by mitochondrial DNA. *Conservation Genetics.* **21**, 771–783 (2020). Springer.

Ghosh A, Basu S, Khatri H, Chandra K. 2019. Ascertaining species of origin from confiscated meat using DNA forensics. Mitochondrial DNA Part B: *Resources* **4**:329–331.

Gomez L, Krishnasamy K. 2019. *A Rapid Assessment on the Trade in Marine Turtles in Indonesia, Malaysia and Viet Nam.* Available from https://www.traffic.org/site/assets/files/12524/se-asia-marine-turtle-trade.pdf.

Hamann M, Cuong CT, Hong ND, Thuoc P, Thuhien BT. 2006. Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. *Biodiversity and Conservation* **15**:3703–3720.

Hamann M, Flavell F, Frazier J, Limpus CJ, Miller JD, Mortimer JA. 2022. *Assessment of the Conservation Status of the Hawksbill Turtle in the Indian Ocean and South-East Asia Region*. CMS. Available from https://www.cms.int/sites/default/files/publication/iosea_hawksbill_assessment_2022.pdf.

Hamilton, Richard J., Tomas Bird, Collin Gereniu, John Pita, Peter C. Ramohia, Richard Walter, Clara Goerlich, and Colin J. Limpus. 2015. *Solomon Islands Largest Hawksbill Turtle Rookery Shows Signs of Recovery after 150 Years of Excessive Exploitation.* Edited by Gordon M. Burghardt. PLoS ONE 10 (4): 1–16.

Hamilton RJ, Desbiens A, Pita J, Brown CJ, Vuto S, Atu W, James R, Waldie P, Limpus C. 2021. Satellite tracking improves conservation outcomes for nesting hawksbill turtles in Solomon Islands. *Biological Conservation* **261**:109240.

Hickey F. 2021. Vanuatu. Pages 655–371 in Work TM, Parker D, Balazs GH, editors. 2021 *Marine Turtle Specialist Group Regional Report.* MTSG.

Hill JE, King CM, Stewart KR, Paladino FV, Dutton PH. 2018. Genetic Differentiation of Hawksbill Turtle Rookeries on St. Croix, US Virgin Islands. *Chelonian Conservation and Biology* 17:303–308. Chelonian Research Foundation and Turtle Conservancy.

Hoenner X, Whiting SD, Enever G, Lambert K, Hindell MA, McMahon CR. 2016. Nesting ecology of hawksbill turtles at a rookery of international significance in Australia's Northern Territory. *Wildlife Research* **43**:461–473. CSIRO Publishing.

Humber F, Godley BJ, Broderick AC. 2014. So excellent a fishe: a global overview of legal marine turtle fisheries. *Diversity and Distributions* **20**:579–590.

IUCN, 2004. The IUCN Red List of Threatened Species for Green Marine Turtles. http://www.iucnredlist.org/species/4615/11037468

IUCN, 2013. The IUCN Red List of Threatened Species for Leatherback Marine Turtles. https://www.iucnredlist.org/species/6494/43526147

REFERENCES CONTINUED

Ingram DJ et al., 2022. Widespread Use of Migratory Megafauna for Aquatic Wild Meat in the Tropics and Subtropics. *Frontiers in Marine Science* **9**.

Inoguchi E, Ishihara T. 2021. Japan. Page in Ng CKY, Matsuzawa Y, editors. *Sea Turtles in the East Asia Region*. MTSG Annual Regional Report 2021. Draft report to the IUCN SSC Marine Turtle Specialist Group. MTSG.

IOSEA. 2014. *Illegal take and trade of marine turtles in the IOSEA region. Memorandum of understanding on the conservation and management of Marine Turtles and their habitats of the Indian ocean and South-East Asia*. IOSEA report.

IOSEA. 2019. Thailand – National report 2019. CMS/IOSEA/MOS8/Inf.7.1.w. *Memorandum of understanding on the conservation and management of marine turtles and their habitats of the Indian Ocean and South-East Asia*. IOSEA report.

Jensen MP, Bell IP, Limpus CJ, Hamann M, Ambar S, Whap T, David C, FitzSimmons NN. 2016. Spatial and temporal genetic variation among size classes of green turtles (*Chelonia mydas)* provides information on oceanic dispersal and population dynamics. *Marine Ecology Progress Series* **543**:241–256.

Jensen MP, FitzSimmons NN, Dutton PH, Michael P. 2013. Molecular genetics of sea turtles. Page in J. Wyneken, K. J. Lohmann, and J. A. Musick, editor. *The Biology of Sea Turtles*. CRC Press.

Jensen MP, LaCasella L E, Dutton PH, Madden Hof CA. 2019. *CRACKING THE CODE Developing a tortoiseshell DNA extraction and source detection method*. WWF-Australia.

Kinch J. 2021. Papua New Guinea. Page in Work TM, Parker D, Balazs GH, editors. *Sea turtles in the OCEANIA region*. 2021 Marine Turtle Specialist Group regional report.

Kitade, T., M. Sakamoto and C.A. Madden Hof. 2021. *Shell Shocked: Japan's Role in the Illegal Tortoiseshell Trade*. WWF Japan.

Kitolelei S, Soderberg A, Qaqara N, Prakash SS, Tuiono M, Veitayaki J, Piovano S. 2022. *Conservation status and cultural values of sea turtles leading to (un)written parallel management systems in Fiji*. Ambio.

Labastida-Estrada E, Machkour-M'Rabet S, Díaz-Jaimes P, Cedeño-Vázquez JR, Hénaut Y. 2019. Genetic structure, origin, and connectivity between nesting and foraging areas of hawksbill turtles of the Yucatan Peninsula: A study for conservation and management. *Aquatic Conservation: Marine and Freshwater Ecosystems* **29**:211–222.

LaCasella E, Epperly S, Jensen MP, Stokes L, Dutton PH. 2013. Genetic stock composition of loggerhead turtles Caretta caretta bycaught in the pelagic waters of the North Atlantic. *Endangered Species Research* **22**:73–84.

LaCasella EL, Jensen MP, Madden Hof CA, Bell IP, Frey A, Dutton PH. 2021. Mitochondrial DNA Profiling to Combat the Illegal Trade in Tortoiseshell Products. *Frontiers in Marine Science* 7.

Lam T, Ling X, Takahashi S, Burgess EA. 2012. *Market forces: An examination of marine turtle trade in China and Japan*. TRAFFIC East Asia, Hong Kong.

León Y, Bjorndal KA. 2002. Selective feeding in the hawksbill turtle, an important predator in coral reef ecosystems. *Marine Ecology Progress Series* **245**:249–258.

LeRoux RA et al., 2012. Re-examination of population structure and phylogeography of hawksbill turtles in the Wider Caribbean using longer mtDNA sequences. *The Journal of Heredity* **103**:806–820.

Levasseur KE, Stapleton SP, Fuller MC, Quattro JM. 2019. Exceptionally high natal homing precision in hawksbill sea turtles to insular rookeries of the Caribbean. *Marine Ecology Progress Series* **620**:155–171.

Limpus CJ. 2009. *A Biological Review of Australian Marine Turtles*. Page 53. Queensland Government - Department of Environment and Resource Management - Freshwater and Marine Sciences.

Limpus CJ, Miller JD. 2008. *Australian hawksbill turtle population dynamics project*. Queensland Government Environm.:1–140. The Queensland Environmental Protection Agency.

Lopes LL, Paulsch A, Nuno A. 2022. Global challenges and priorities for interventions addressing illegal harvest, use and trade of marine turtles. *Oryx: the Journal of the Fauna Preservation Society* **56**:592–600.

Madden Hof CA, Riskas KA, Jensen M, Pilcher N, Gaos A, Hamann M. 2022. *Assessment of the conservation status of the hawksbill turtle in the western Pacific Ocean region*. Convention of Migratory Species.

Madden Hof, C. Jensen, M. Roncolato, F. Frankham, G. J. 2022. *Surrender Your Shell – Detecting the origin of tortoiseshell products*. Report to WWF-Australia and the WWF-Coral Triangle Programme.

Miller EA, McClenachan L, Uni Y, Phocas G, Hagemann ME, Van Houtan KS. 2019. The historical development of complex global trafficking networks for marine wildlife. Science advances **5**:eaav5948.

Monanunsap S, Charuchinda M, Tatsukawa K. 2002. *Satellite tracking for nesting hawksbill turtles (Eretmochelys imbricata) in the gulf of Thailand*. Proceedings of the 3rd Workshop on SEASTAR2000:23–25.

Monzón-Argüello C, Loureiro NS, Delgado C, Marco A, Lopes JM, Gomes MG, Abreu-Grobois FA. 2011. Príncipe island hawksbills: Genetic isolation of an eastern Atlantic stock. *Journal of Experimental Marine Biology and Ecology* **407:**345–354.

Morgan R. 2007. Property of Spirits: Hereditary and Global Value of Sea Turtles in Fiji. Human Organization **66**:60–68. Society for Applied Anthropology.

Mortimer JA, Donnelly M. 2008. Eretmochelys imbricata. In: IUCN 2013. *IUCN Red List of Threatened Species*. Version 2013.1.

Mortimer JA, Esteban N, Guzman AN, Hays GC. 2020. Estimates of marine turtle nesting populations in the south-west Indian Ocean indicate the importance of the Chagos Archipelago. *Oryx: the journal of the Fauna Preservation Society* 54: 332 - 343.

Mortimer, Jeanne A., Katia Ballorain, Carlos E. Diez, Nicole Esteban, Nancy Fitzsimmons, Alexander R. Gaos, Graeme Hays, et al., 2022. *Hawksbills: The Most Beautiful of Sea Turtles. SWOT* 17.

Nahill B, von Weller P, Barris-Garrido H. 2020. *The global tortoiseshell trade*. SEETURTLE.

Nishant K, Vrijesh KY, Ajay KR. 2018. Wildlife Forensic: Current Techniques and their limitations. *Journal of Forensic Science and Criminology* **5**.

Nishizawa H, Okuyama J, Abe O, Kobayashi M, Arai N. 2012. Mitochondrial DNA Variation in Hawksbill Turtles *(Eretmochelys imbricata)* Nesting on Ishigaki Island, Japan. *Marine Turtle Newslatter* **132**:1–2.

Nishizawa H, Joseph J, Chong YK. 2016. Spatio-temporal patterns of mitochondrial DNA variation in hawksbill turtles (*Eretmochelys imbricata*) in Southeast Asia. Journal of Experimental Marine Biology and Ecology **474**:164–170.

Nishizawa H, Okuyama J, Kobayashi M, Abe O, Arai N. 2010. Comparative phylogeny and historical perspectives on population genetics of the Pacific hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*), inferred from feeding populations in the Yaeyama Islands, Japan. *Zoological Science* **27**:14–18. Zoological Society of Japan.

Okayama, Diaz-Fernandez, Baba, Halim. 1999. Genetic diversity of the hawksbill turtle in the Indo-Pacific and Caribbean regions. *Conservation and Biology **3**:362–367*..

Pilcher NJ. 2021. *Review of the Status of Sea Turtles in the Pacific Ocean 2021*. Secretariat of the Pacific Regional Environment Programme, Apia, Samoa.

Piovano S, Batibasaga A. 2021. Fiji. Pages 95–115 in Work TM, Parker D, Balazs GH, editors. 2021 *Marine Turtle Specialist Group regional report*. MTSG.

Poonian CNSS, Ramilo RV, Lopez DD. 2016. Diversity, habitat distribution, and indigenous hunting of marine turtles in the Calamian Islands, Palawan, Republic of the Philippines. *Journal of Asia-Pacific Biodiversity* **9**:69–73.

Prakash SS, Tuiono M, Clay S, Qarau P, Philip C, Miller K, Meo S, Tamata L, Sharma-Gounder S, Piovano S. 2020. *Temporal and geographic distribution of hawksbill turtle (Eretmochelys imbricata) nests in Fiji, South Pacific*.

Prakash S, Piovano S. 2021. Solomon Islands. Pages 95–115 in Work TM, Parker D, Balazs GH, editors. *2021 Marine Turtle Specialist Group regional report*. MTSG.

Rankin-Baransky K, Williams CJ, Bass AL, Bowen BW, Spotila JR. 1975. Origin of Loggerhead Turtles Stranded in the Northeastern United States as Determined by Mitochondrial DNA Analysis. *Journal of Herpetology* **35**:1988–1995. Society for the Study of Amphibians and Reptiles.

Read TC et al., 2015. Mixed stock analysis of a resident green turtle, *Chelonia mydas,* population in New Caledonia links rookeries in the South Pacific. *Wildlife Research* **42**:488.

Rguez-Baron J, Kelez S, Liles M, Zavala-Norzagaray A, Amorocho D, Gaos AR. 2021. *Sea turtles in the Eastern Pacific region. MTSG Annual Regional Report 2021*. Draft Report to the IUCN-SSC Marine Turtle Specialist Group.

Rice MR, Jim LMR, Hickey FR, Balazs GH. 2018. *Post Nesting Migrations of Hawksbill Turtles (Eretmochelys imbricata) Nesting at Moso Island, Republic of Vanuatu*. Reports to the Fisheries Department. Government of the Republic of Vanuatu.

Rice MR, Jim LMR, Hickey FR. 2021. *Post Nesting Migrations of Hawksbill Turtles (Eretmochelys imbricata) Nesting at Moso Island, Republic of Vanuatu*. Reports to the Fisheries Department. Government of the Republic of Vanuatu.

Sagun VG. 2002. Updates on Marine Turtle Conservation in the Philippines. Pages 87–93 Proceedings of the 3rd Workshop on SEASTAR2000.

Senko JF, Burgher KM, del Mar Mancha-Cisneros M, Godley BJ, Kinan-Kelly I, Fox T, Humber F, Koch V, Smith AT, Wallace BP. 2022. Global patterns of illegal marine turtle exploitation. *Global Change Biology*.

Shamblin BM, Bjorndal KA, Bolten AB, Hillis-Starr ZM, Lundgren I, Naro-maciel E, Nairn CJ. 2012. Mitogenomic sequences better resolve stock structure of southern Greater Caribbean green turtle rookeries. *Molecular Ecology* **21**:2330–2340. Wiley.

Stewart KR, Lacasella EL, Roden SE, Jensen MP, Stokes LW, Epperly SP, Dutton PH. 2016. Nesting population origins of leatherback turtles caught as bycatch in the U.S. pelagic longline fishery. *Ecosphere* **7**.

Wahidah MA and Syed Abdullah SAK (2009). Identification of the stock/population of green and hawksbill turtles in Southeast Asian region. In *Report on the Third Regional Technical Consultation on Research for Stock Enhancement of Sea Turtles (Japanese Trust Fund IV Program)*. Syed Abdullah bin Syed Abdul Kadir OA, editors. Southeast Asian Fisheries Development Center, Kuala Lumpur, Malaysia.

Vargas SM et al., 2016. Phylogeography, genetic diversity, and management units of hawksbill turtles in the indo-pacific. *The Journal of Heredity* **107**:199–213.

Velez-Zuazo X, Ramos WD, van Dam RP, Diez CE, Abreu-Grobois FA, McMillan WO. 2008. Dispersal, recruitment and migratory behaviour in a hawksbill sea turtle aggregation. *Molecular Ecology* **17**:839–853.

Vilaça ST, Lara-Ruiz P, Marcovaldi MA, Soares LS, Santos FR. 2013. Population origin and historical demography in hawksbill (*Eretmochelys imbricata*) feeding and nesting aggregates from Brazil. *Journal of Experimental Marine Biology and Ecology* **446**:334–344.

Vuto S, Hamilton R, Brown C, Waldie P, Pita J, Peterson N, Hof C, Limpus C. 2019. *A report on turtle harvest and trade in Solomon Islands*. The Nature Conservancy, Solomon Islands.

Wasser SK et al., 2008. Combating the illegal trade in African elephant ivory with DNA forensics. *Conservation Biology: the Journal of the Society for Conservation Biology* **22**:1065–1071.

Zuñiga-Marroquin T, de los Monteros AE. 2017. Genetic characterization of the Critically Endangered hawksbill turtle *(Eretmochelys imbricata)* from the Mexican Pacific region. Lat. Am. J. Aquat. Res., 45(3): 555-562, 2017 45:555–562.

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