US Pacific Islands Research Plan for Green (excluding Hawaii) and Hawksbill Turtles

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Statement of Research Goals

The goal of this research plan is to achieve a comprehensive stock assessment of green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles found nesting and using coastal forage habitats within US possessions in the Central and Western Pacific (Midway Atoll, Johnston Atoll, Palmyra Atoll, Howland Island, Baker Island, Jarvis Island, Wake Island), US territories (American Samoa and Guam), Commonwealth Areas in Political Union with the US (Commonwealth of the Northern Mariana Islands; CNMI), and the surrounding US EEZ waters (for convenience we will refer to all of these areas as US Pacific Flag Areas throughout this document). As very little is known about these species outside of the Hawaiian archipelago, a great deal of basic demographic information will need to be collected before we can gain an understanding of the status of these populations.

The US Pacific Flag Areas fall under the area of research responsibility of the National Marine Fisheries Service Pacific Islands Fisheries Science Center (PIFSC) and the management jurisdiction of the Pacific Islands Regional Office (PIRO). As such, PIFSC and PIRO have a keen interest in fulfilling this research plan. However, the PIFSC currently has insufficient personnel and funding to carry out this ambitious program. This plan, then, outlines the PIFSC perspectives on *what* ought to be done, rather than identifying *which* individuals or institutions should carry out the proposed program of research. Preferrably, this will develop into a collaborative effort involving a number of governmental agencies, academic institutions and non-governmental organizations.

Species inventories

This plan will focus on green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles. These two species are the only ones likely to be found nesting and using coastal forage areas in the waters surrounding the US Flag Areas. This plan will not include green turtles in the Hawaiian Archipelago because a separate research plan for that population is being prepared by the Marine Turtle Research Program (MTRP) of PIFSC. This plan will include hawksbill turtles within the Hawaiian archipelago.

The green turtle in this region is currently listed as threatened under the US Endangered Species Act although Craig et al. (2004) suggest that green turtles in US-affiliated Pacific islands outside of Hawaii should likely be classified as endangered. The hawksbill is listed as endangered. Determining where each species occurs, both foraging and nesting, within the US Pacific Flag Areas will be an important first step.

Three other species, loggerheads (*Caretta caretta*), leatherbacks (*Dermochelys coriacea*) and olive ridleys (*Lepidochelys olivacea*), may be found foraging in or migrating through US EEZ waters surrounding US Pacific Flag Areas and Hawaii (Balazs 1982, Pritchard 1982) and all are know to interact with US high-seas fisheries, however the nesting rookeries for all of these species are outside of the US Pacific Flag Areas and Hawaii and these populations are being monitored and assessed by other projects such as the Marine Turtle Program of NMFS/SWFSC and projects funded by the Turtle Advisory Committee of the Western Pacific Regional Fisheries Management Council. Formal research plans that bring together the various projects would benefit these species as well, however their distribution and habitat use are different enough from those of greens and hawksbills to warrant separate consideration.

Stock structure

For the inhabited islands of the US Pacific Flag Areas there appears to be very limited nesting of greens and hawksbills, though there may be substantial nesting in uninhabited areas that have not been surveyed (Figs. 2&3). In addition, US Pacific Flag Areas are in proximity to other nations where considerable nesting is known to occur, at least for greens (Figs. 2&3). Therefore is it quite likely that juvenile turtles using forage habitats in US EEZ waters are from rookeries outside of the US and its associated areas. A comprehensive sampling of individuals found within US EEZ waters together with nesting females from rookeries throughout the Pacific for genetic analysis will be important for elucidating the stock structure of these species.

Population status

Once an understanding of stock structure is gained, focus can shift to understanding and assessing individual stock distribution and abundance. This would include determining the distribution and abundance of each stock throughout all life-stages, from hatchling/pelagic habitats, to nearshore juvenile forage habitats to sub-adult and adult migrations between forage and nesting habitats.

Through continued monitoring of critical stages, *i.e.* in-water juvenile and nesting beach surveys, populations trends can be established and life-stage- and region-specific survival rates can be estimated. Together with this work should be an evaluation of anthropogenic impacts on each life-stage of each stock and a prioritization of mitigation measures developed that will maximize the recovery potential of the stocks.

Introduction

Very little is known about the populations of green and hawksbill turtles in the US Pacific Flag Areas and surrounding US EEZ waters throughout the central and western Pacific Ocean (Fig. 1). The first step in understanding the dynamics of these populations is to understand their stock structure. Based upon limited survey effort reported in the literature, there does not appear to be substantial nesting within these regions. However, there are (or in recent years have been) substantial rookeries in the Philippines, Federated States of Micronesia (Yap), Republic of the Marshall Islands, Republic of Palau, Japan, Western Samoa, Fiji and French Polynesia, all of which may contribute to the turtles using forage habitats in US EEZ waters (Moritz et al. 2002, Craig et al. 2004; Figs. 2&3). Hence it is quite likely that these populations cross international boundaries and use migration corridors and coastal forage habitats that have the potential to interact with multiple stressors on international levels, including coastal and pelagic fisheries, forage and nesting habitat destruction, and coastal pollution. A stock assessment of US EEZ turtles cannot be adequately addressed without the broader context of Pacific wide turtle stocks

The recent takes of green turtles by the American Samoa-based longline fishery highlight the hazards of our lack of knowledge of these stocks. We have no knowledge of the source or the status of the stocks from which those turtles originated and cannot make an assessment of the population-level impacts of those or future takes. The purpose of this document is to summarize the current state of knowledge of greens and hawksbills in the US Pacific Flag Areas and to outline steps that need to be taken in order to broaden this knowledge to a point where quantitative stock assessments can be done to better understand the status of these turtle stocks.

Background

Tables 1 and 2 indicate where the lack of data for green and hawksbill turtles in the US Pacific Flag Areas exists. For areas that consist of multiple islands with some uninhabited, such as American Samoa and CNMI, there are generally only data for portions of those Areas. Also, some of the existing data are over a decade old and may not be representative of current conditions (see Appendix Tables).

Summary of current knowledge of green and hawksbill turtles in the US Pacific Islands

<u>Hawaiian Archipelago</u>

The Hawaiian archipelago supports a large population of green turtles. Juveniles are monitored through mark-recapture programs conducted by the Marine Turtle Research Program of PIFSC (Balazs and Chaloupka 2004a, Chaloupka and Balazs 2005) and adult nesting is monitored jointly by PIFSC and the US Fish and Wildlife Service (Balazs and Chaloupka 2004b). Linkages between this population and the other nearby US Pacific Flag Areas such as Johnston Atoll, Palmyra Atoll and Wake Island are as yet not well understood. One turtle tagged at Midway was recovered in poor condition at Wake Island (Balazs 1980). Three turtles tagged at Johnston Atoll have been resighted at French Frigate Shoals, two as nesting females and one as a basking male (Balazs et al. 1990).

The Hawaiian archipelago also supports a small population of hawksbill turtles, with the primary nesting beaches occurring on the island of Hawaii. The Volcanoes National Park Hawksbill Turtle Project (US National Park Service) has been monitoring the primary nesting beaches for 18 years. In total, 73 individual nesting females have been tagged over all years (W. Seitz, personal communication[1]). Although the level of monitoring is inconsistent from year-to-year, making a trend assessment difficult, the numbers of nesting females (or nests) appears to be stable or increasing (W. Seitz, personal communication[1]). Threats to the nesting habitat include beach development, recreational use of beaches causing nests to be driven over or trampled by foot, and photopollution

[1] Will Seitz, Wildlife Research Supervisor-Pacific Cooperative Studies Unit, Hawksbill Turtle Project-Resources Management Division, Hawaii Volcanoes National Park, HI 96718

sources from campfires, lanterns and flashlights, which disorient hatchlings and disrupt nesting females (W. Seitz, personal communication[1]). Satellite tracking of 2 nesting females showed both animals stayed within the coastal region of Hawaii for 7 and 8 months which was well after the nesting season ended (Balazs et al. 2000). There are no data on juvenile migration or habitat use. The Hawaii Sea Turtle and Stranding Network, run by the MTRP, receive the occasional hawksbill stranding, providing some information on size distribution and sex ratio. Humeri have been collected from these animals for assessment of age and growth rates.

Midway Atoll

While geographically part of the Hawaiian Archipelago, Midway Atoll is an unincorporated territory of the US. Green turtles are found both in the water around and basking ashore at Midway (Balazs 1982b, Balazs et al. 2004). Recaptures of tagged juveniles over periods of 0.5-3 yr. indicate that there may be a resident population (Balazs 1982b). The size composition of these turtles has changed over the years with 97% juveniles and 3% subadults and adults found in the 1970-80's to 60% juveniles, 16% subadults and 24% adults found in the 1990's (Balazs et al. 2004). Resident adult females from this population have been noted migrating to and returning from French Frigate Shoals to nest (Balazs et al. 2004). The turtles found at Midway are likely are all part of the Hawaiian Archipelago meta-population. Rare nesting events have been noted at Midway (Balazs 1980).

There is no recorded information for hawksbill turtles at Midway.

Johnston Atoll

Surveys were made of Johnston Atoll in 1983, 1985 and 1987 (Balazs 1985, Balazs and Forsyth 1986, Balazs et al. 1990). In all of the surveys, turtles were captured by means of a large-mesh tangle net along the south shore of Johnston. Capture rates for green turtles were similar in the 1983 and 1985 surveys (one turtle per 1.172 meter hours (length of net times hours fished, MH) and one turtle per 1.269 MH respectively) but declined in the 1987 survey (one turtle per 4.574 MH; Balazs and Forsyth 1986, Balazs et al. 1990). However, visual censuses from shore and by boat do not support a decline in the size of the foraging aggregation over that time period and show the concentration of turtles to be similar in all years.

In 1983, two surveys of Johnston Atoll were made totaling 28 days (Balazs 1985). During this time, a total of 21 turtles were captured, measured, tagged and released. Captured turtles ranged from 57.1 – 100.1 cm straight carapace length (SCL) with 60% of the turtles being of adult size. No turtles were recaptured during the two surveys. In 1985, 10 turtles were captured during the 14 day survey, none of which were recaptures (Balazs and Forsyth 1986). Of these turtles, 30% were juveniles, 50% were subadults and 20% were adults. In 1987, a total of two turtles were captured over the 14 day survey, one of which was a recapture from 1983. These turtles measured 68.5 and 80.5 cm SCL (Balazs et al. 1990).

No evidence of nesting was noted in any of the surveys. Three of the tagged turtles from the 1983 and 1985 surveys have been resighted at French Frigate Shoals, two were nesting females and one was a basking male (Balazs et al. 1990). It is possible, then, that turtles in the foraging aggregation at Johnston Atoll may be part of the Hawaiian archipelago meta-population.

No turtle species other than greens were noted during the surveys, however, Balazs (1985) notes that there have been unsubstantiated reports of hawksbill sightings at Johnston Atoll.

Palmyra Atoll

A new study is currently underway as part of a project being conducted by Columbia University and the American Museum of Natural History. Individuals involved in this study are in communication with both MTRP and MTAP of PIFSC. Preliminary reports from this study indicate 'large' numbers of turtle sightings with resting and foraging behaviors (Sterling and Naro-Maciel 2006). No evidence of nesting was found though the possibility of rare events remains.

Both greens and hawksbills were observed although there was no indication as to the relative abundance of each (Sterling and Naro-Maciel 2006).

Howland Island

Howland Island was inhabited by Americans, civilian and military from 1935-1942[2] (Balazs 1982). During that time green turtles were reported to be 'abundant' (Balazs 1982). There are no recent data for this island.

There is no information on hawksbills for this island.

Baker Island

There is no information on either turtle species for this island. Feral cats were once there but have been eradicated[3].

Jarvis Island

A low level of green turtle nesting was noted by inhabitants in 1935. Feral cats were once there but have since been eradicated[3].

There is no information on hawksbills.

[2] http://www.umsl.edu/services/govdocs/wofact2003/geos/hq.html
[3] http://www.fws.gov/pacificislands/wnwr/pbakernwr.html

Wake Island

Juvenile and adult green turtles have been noted foraging, there has been no recorded nesting (Balazs 1982). As noted earlier, one turtle tagged at Midway was recovered in poor condition at Wake (Balazs 1980).

There is no information on hawksbills.

American Samoa

American Samoa consists of seven islands in the central south Pacific Ocean. Tutuila has the highest human population with over 95% of the population living there. For the other islands, only Manu’a and Swains have permanent residents (Tuato’o-Bartley et al. 1993).

A project titled ‘Investigations into the status of marine turtles in American Samoa” was initiated by the Department of Marine and Wildlife Resources (DMWR) of American Samoa and financially supported by a grant from NOAA. This project focuses efforts on Tutuila. Progress reports on the grant for the time period of 2003-3005 contained the following findings:

- One hawksbill female was confirmed nesting on the main island of Tutuila. She was satellite tagged as well as flipper tagged. No information on nest success rate was reported (DMWR 2006).
- 24 turtles were confiscated alive by DMWR enforcement, tagged and released. Of the 24 turtles, 13 were hawksbills, 10 were greens and one was unidentified. An additional five turtles were recovered dead, two hawksbills, two greens and one possible olive ridley (DMWR 2005).
- Tissue samples from one green and one hawksbill were taken for genetics (DMWR 2005).
- Benthic habitat maps using NOAA mapping data have been used to identify potential forage sites for turtles to help identify primary forage sites (DMWR 2005).
- An incidental in-water sighting form was distributed to DMWR staff resulting in 77 reported sightings, 34 greens, 21 hawksbills and 22 unidentified (DMWR 2005).
- Beach mapping of Tutuila islands identified 29 potential nesting beaches with suitable habitat. 13 of these beaches were confirmed active, although the report does not indicate how this was determined (DMWR 2005).

An earlier study by Tuato’o-Bartley et al. (1993) interviewed locals to gain an understanding of general historical trends in turtles. From these surveys they estimated that 50 adult females used nesting beaches at Tutuila in 1990-1991. If this number is accurate, current sighting levels of nesting females would indicate that the population has declined dramatically (Utzurrum 2002).

Rose Atoll

Rose Atoll, American Samoa, supports a nesting population of green turtles. Historic records suggest this population is small (24-36 females per year; Tuato'o-Bartley et al. 1993) but there have been no recent surveys to confirm or to suggest increases or declines in these numbers. Craig et al. (2004) summarize post-nesting migration patterns for turtles from Rose Atoll based on 7 satellite tagged females and recaptures of flipper tagged females. Six of the seven satellite tagged turtles migrated west to Fiji and the seventh migrated east to French Polynesia. Of 46 flipper tagged turtles, three were recovered and all traveled to the west, two in Fiji where they were harvested for food and one found dead in Vanuatu. Craig et al. (2004) deployed six drifter buoys throughout American Samoa in 2002. These remained in the Samoan Islands for one to ten months and eventually all six traveled west towards Fiji. These results provide suggestions for post-hatchlings movements from nests in these islands. There has not been a recent thorough survey of Rose Atoll to determine current nesting levels.

Guam

Guam's Sea Turtle Recovery Program was initiated in 1999 with the primary objectives of collecting baseline population data (abundance, distribution, age distribution, sex ratio and genetics) and surveying for nesting activity. Progress reports for the time period of 2003-3005 contained the following findings:

- Between 2004 and 2006, a total of 27 green turtle nests were documented over 6 beaches with the highest number, 17, recorded for 2005 (DAWR 2006). Nest surveys were not exhaustive so this number is a minimum value for nesting activity. Green turtles typically lay three clutches during a nesting season (Miller 1997), hence 17 nests would represent five to six nesting females. During this time period, four nesting females were tagged with external flipper and/or PIT tags (DAWR 2006).
- In June, 2000 a nesting green turtle was satellite tagged. She was tracked to the Philippines and the tag was recovered by the Philippine government with no information on the turtle (DAWR 2004).
- No hawksbill nesting activity was noted (DAWR 2006).
- Between 2003 and 2006, a total of ten turtles were recovered as either alive or dead strandings or as unauthorized takes. Two of these were hawksbills, the rest were greens. Both hawksbills and five greens were released alive, five with tags. The rest were recovered dead or died shortly after recovery (DAWR 2006). Three of the greens were speared, apparently intentionally, and one of the hawksbills was incidentally hooked with rod and reel. Causes of strandings for the remaining turtles could not be determined (DAWR 2006).
- DAWR (2006) also initiated a volunteer program to assist with beach monitoring.
- Although they are proposed in the grant proposal, in-water surveys of foraging turtles have yet to be conducted (DAWR 2006).

Since 1990 the DAWR has been conducting bi-monthly aerial surveys, primarily to monitor fishing activity, but turtle sightings are also recorded (Cummings 2002). Raw observations of these data indicate an increasing trend although no information was given as to effort level, etc. From 1976 to 1979, aerial surveys were also made although the year-to-year effort was inconsistent (data reported in Pritchard 1982). Statistical comparisons of these datasets may yield insights into abundance trends for foraging turtles around Guam.

Commonwealth of the Northern Mariana Islands

CNMI is part of the Mariana archipelago which consists of 15 islands including Guam. Over 99% of the human population lives in the Southern Mariana Islands, primarily on Saipan but to a lesser extent on Rota and Tinian (Kolinski et al. 2004).

A project investigating the status of sea turtles in CNMI was initiated by the Division of Fish and Wildlife (DFW) of CNMI and financially supported by a grant from NOAA. This project focuses efforts on Saipan. Progress reports on the grant for the time period of 2003-3005 contained the following findings:

- From April to September 2006, nine juvenile turtles (seven greens and two hawksbills) were hand-captured by free-diving. The turtles were measured, flipper tagged (external) and biopsies were taken for genetics. One additional turtle was tagged, measured and biopsied after being confiscated from fishermen (DFW 2006).
- A total of 16 green turtle nests were documented between April and September 2006 on four beaches. Of these nests, two were poached, eight successfully hatched and six have no data (DFW 2006).
- One in-water tow survey was conducted on 20 September 2006 off Saipan, seven turtles were observed, six greens and one hawksbill (DFW 2006).
- One set of cliff surveys was conducted in September 2006. Five locations off Saipan were surveyed, 30 turtles were observed, all greens (DFW 2006).

Kolinski et al. (2001) reported 15 green turtle nest crawls and six nests during limited nesting surveys on Saipan in 1999. They also estimated a total of 169 individual turtles over 28 surveys that covered 54% of the outer reef and perimeter of Saipan. No species other than greens were observed.

Using data from diver surveys of Tinian and Aguijan, Kolinski et al. (2004) estimated that 351 individual green turtles were observed in surveys that covered 59% of Tinian's shore and outer reef perimeter. For Aguijan, 95% of the shore and reef perimeter were surveyed and 14 green turtles were observed. Kolinski et al. (2004) analyzed survey data from all southern-arc islands of the Mariana's and suggest that green turtle densities, especially for juveniles, are highest at Tinian, followed by Saipan then Rota. Aguijan and Farallon de Medinilla appear to have only low densities of turtles.

During diver surveys around Rota, Kolinski et al. (2006) observed 73 individual green turtles in transects that covered 67% of the shoreline and outer reef perimeter. No other turtle species were observed.

Stock Structure

In a broad-scale genetics study on green turtles encompassing the western Pacific and Southeast Asia, 17 genetically divergent populations were identified using mtDNA (Moritz et al. 2002). Each of these populations represents a management unit (MU) to be the focus of separate recovery actions. Larger countries such as Australia, Indonesia and Malaysia have several separate MUs within their borders with no need for joint, international management. However, genetic homogeneity across MUs of the Philippines and Malaysia indicate a regular interchange of females and therefore suggests a joint management plan. (Moritz et al. 2002).

Within this region of the Pacific, the NMFS marine turtle molecular lab program of the SWFSC received samples and analyzed mtDNA data from green turtles of American Samoa, Guam, the CNMI, Federated States of Micronesia, Republic of the Marshall Islands, and the Republic of Palau. (Dutton 2006) An earlier population genetics study identified three rookeries from the FSM, Elato, Ngulu, and Yap to be counted as one of 17 genetically distinct management units of green turtles in the Pacific. (Moritz et. al. 2002)

The only molecular data for hawksbills in this region is from NMFS marine turtle molecular lab program of the SWFSC which received samples and analyzed mtDNA data from hawksbill turtles of the CNMI, RMI, Palau, and Hawaii. A total of 17 samples were taken throughout the Pacific, compared to almost 1,000 samples in the Caribbean (Dutton 2006). As this type of data is very limited, the information is vital and illustrates a need for additional hawksbill research in the Pacific.

Research Tools

Genetics for stock structure

Currently, the best technique available for ascertaining stock structure of marine turtle populations is the analyses of mitochondrial DNA from skin biopsies (Bowen and Karl 1997, Moritz et al. 2002). These would be collected from juveniles captured in foraging habitats and from nesting females or hatchlings. Analyses of these data will reveal the genetic distinctness of different nesting regions (Figs. 2&3) and provide insights into the source rookery for the sampled juveniles.

Nesting surveys for abundance, survival, growth, trends

Nesting surveys are the most common method used to monitor marine turtle populations. As marine turtle exhibit high nesting site fidelity (Miller 1997), appropriately designed nesting beach surveys can provide information on the size of the adult female population, hatchling production, and interannual variability in production (Schroeder and Murphy 1999). These surveys can also highlight threats to these life-stages (nesting adult females and nests/hatchlings) including poaching of adults and eggs, nest destruction through predation and wave inundation, photopollution, and nesting habitat loss through beach erosion or development.

To establish nesting beach surveys, first primary nesting beaches and seasons need to be identified through broad-scale monitoring. Once this is accomplished, index beaches need to be established, both within the US Pacific Islands, and, ideally with international cooperation, at international sites that are important components of the stock structure of Pacific greens and hawksbills. Survey designs for index beaches include establishing a specific beach site and length of beach, identifying the peak season of nesting and monitoring for nesting during a specified time during that season which would allow for statistical inference about total nesting activity over the entire season (i.e. Wetherall et al. 1998). To ensure that there are no shifts in either beach use or timing of the nesting season, occasional extended monitoring both spatially and temporally will be needed.

The extent of monitoring for index beaches depends on the type of information desired. For questions relating to adult growth, survival, clutch frequency, and remigration intervals, extensive nightly surveys are required spanning the full length of the nesting season and would include tagging (either with external metal tags or internal passive integrated transponder tags; Balazs 1999) and measuring as close to every adult female as possible (saturation tagging). For questions relating to hatchling productivity, these monitoring programs would be continued through the end of the nest hatching season to monitor nest success rates. This level of monitoring should be conducted on as many identified nesting beaches for which such a monitoring program is feasible (e.g., logistically easy to access and staff).

For beaches where extensive monitoring is not feasible, beaches can be patrolled once per day, early morning, and turtle emergences noted (via tracks in the sand), hopefully with a determination of whether the emergence resulted in a nest, though this can sometimes be difficult to determine (Schroeder and Murphy 1999).

For population trends, generally at least 10 years of such nesting beach survey data are required before an adequate assessment of trend can be made (Schroeder and Murphy 1999, Gerodette power analysis, TEWG in review).

In-water (nearshore) surveys for abundance, survival, growth, trends

Most abundance trends for marine turtle populations are from nesting beaches, however, this only monitors a small portion of the population. Both green and hawksbill turtles have late ages at first reproduction with green turtle estimates of >35 year (Balazs and Chaloupka (2004b). There are no estimates for hawksbills, however, their slow growth rates (generally < 2cm/yr for post-pelagic juveniles; Chaoulpka and Limpus 1997) would indicate a late age at first reproduction. Hence, there would be a long time lag before increases in juvenile stage mortality would be manifested on nesting beaches. This makes monitoring juvenile foraging habitats for abundance trends critical to assessing the status of populations. This can be accomplished through well designed monitoring studies that include in-water surveys (i.e. using SCUBA or snorkel) or above water surveys from observation platforms, or from aerial transect surveys.

In-water surveys that include a mark-recapture program can provide additional valuable information beyond abundance counts. Individual tagging through a combination of external flipper tags and internal passive integrated transponder (PIT) tags can provide information on growth, recruitment into the forage habitat, residency, and survival rates (i.e. Chaloupka and Limpus 1998, Chaloupka 2002, Balazs and Chaloupka 2004a). Typical means of capture for marine turtles include hand-capture using snorkel and tangle netting (Ehrhart and Ogren 1999).

Stranding Network

The establishment of standing networks in all populated US areas is important as well as having trained staff to perform necropsies. Such networks can provide information on relative numbers and locations of mortalities (Shaver and Teas 1999). DNA from stranded animals can also augment stock structure studies. Necropsies provide information on mortality causes, health status (presence of disease or parasites) and sex ratios. In addition the collection of humeri from dead turtles can be used for skeletochronology studies (i.e. Zug et al. 2002), which can provide rapid information (as compared to mark-recapture programs) on growth rates, habitat shifts and estimates of age at first reproduction.

Aerial Surveys

Aerial surveys are another useful tool for assessing presence/abundance in forage habitats and identifying nesting activity (Henwood and Epperly 1999, Schroeder and Murphy 1999). Though it may be difficult to identify to species, likely turtle habitats can be identified using this technique and ground-truthed with additional studies.

Satellite tracking for distribution, movement, stock structure

Satellite tracking of both juveniles and adults from nesting beaches has become a standard tool in studying the distribution and movements of marine turtles (i.e. Craig et al. 2004). These studies can provide information on juvenile residency within foraging habitats, if juveniles appear to have long residency time in forage habitats without annual migrations, satellite tracking may prove to provide minimal information and efforts should be focused on large juveniles that may be likely to migrate to breeding grounds. Satellite tracking of nesting females late in the nesting season can provide valuable information on the linkages between foraging and breeding grounds (Craig et al. 2004).

Remotely sensed and in situ oceanographic sampling as correlates for distribution, density

Generally very little is known about the post-hatchling/pelagic stages of most marine turtles. Detailed studies of currents throughout the Pacific Islands Region may provide insights to the general locations where small turtles originating from different nesting beaches are likely to be found and may be linked to the near-shore forage habitats they ultimately recruit to.

Modeling

Once an understanding of the stock structure, spatial distribution and survival rates is gained, population models can be implemented to assess status and to and compare management strategies to maximize stock recoveries.

Research Plan

Long-term vision

The purpose of this plan is to lay out the steps necessary to collect the types of data that will be needed to gain an understanding of the stock structure and status of marine turtles in the Pacific Islands.

Priorities

<u>Distribution</u>

A first step is to determine where the concentrated regions of juvenile foraging and adult nesting occur. For juvenile foraging, the Coral Reef Ecosystem Division of PIFSC had made near-shore surveys using diver tow transect surveys of all of the US Pacific Islands and noted where and when turtles were observed. An analysis of these data together with published accounts will help direct initial efforts for focused turtle surveys.

Exploratory surveys of all US Pacific Flag Areas for presence of turtles will be needed to gain an understanding of relative abundance, both in-water and nesting. Such a survey is already underway at Palmyra as part of a project being conducted by Columbia University and the American Museum of Natural History. Local governments are conducting such surveys on populated islands in American Samoa, CNMI and Guam and these efforts should be supported both financially and through capacity-building to ensure that the projects are expanded, that they continue, that they run efficiently and effectively.

<u>Stock structure</u>

There is a need to obtain skin biopsy samples from a large sample size of juveniles in the US Pacific Flag Areas and from nesting females both within US Pacific Islands and throughout the Pacific for analysis of mitochondrial DNA to assess the stock structure of these turtles. In part, this sampling can be done in conjunction with the exploratory surveys described above. International collaboration needs to be developed to obtain genetics samples from the non-US areas.

A second tool for the study of stock structure is through movements and migrations discovered through tagging. For external or PIT tags, tag returns or resightings of animals with tags provides valuable information. Satellite tracking animals can also be used to corroborate or enhance genetic analysis of stock structure and trans-boundary movements.

Focused efforts for monitoring

Once the stock structure and abundance patterns are understood, areas that are important either because of presence of larger numbers of juveniles or nesters, or due to notable changes from past information, will require focused monitoring efforts to better quantify abundance, trends, and threats.

Adapt a more comprehensive research plan

At this point, it is difficult to develop a comprehensive longer-term research strategy, while we lack so much information on stock structure, distribution, abundance and trends. Eventually, key sites will likely appear and these should be the subject of long-term monitoring. We can then begin to evaluate abundance trends, survival, and growth. Subsequently, a more formal, detailed and comprehensive research plan can be developed. This plan will need to involve multiple partners as such a broad area cannot be comprehensively covered by PIFSC or any other single institution alone.

International integration

Once a better understanding of the stock structure is gained, the extent of the international cooperation necessary will become clearer. Pacific Islands Region turtles for which the US has responsibility are embedded in what will likely prove to be a complex structure of stocks with cross-boundary relationships mediated through, for example, annual migration, and long-term evolutionary patterns of isolation. To understand PIR turtles we will need to understand this larger complex through collaborations with international partners.

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Table 1. Information that is known regarding the presence of foraging or nesting turtles in US Pacific Flag Areas and Comapacts of Free Association. Details regarding the source of these studies can be found in Appendix Tables 1&2. As noted in the Appendix Tables, much of the information is relatively old.

	GREEN			**HAWKSBILL**		
US Flag Areas / Territories	*Occur*	*Nesting*	*Foraging*	*Occur*	*Nesting*	*Foraging*
Midway Atoll	yes	unknown	yes	unknown	unknown	unknown
Johnston Atoll	yes	unknown	yes	unknown	unknown	unknown
Palmyra Atoll	yes	yes	yes	yes	unknown	yes
Howland I	yes	unknown	unknown	unknown	unknown	unknown
Baker I	yes	unknown	unknown	unknown	unknown	unknown
Jarvis I	yes	yes	unknown	unknown	unknown	unknown
Wake I	yes	unknown	yes	unknown	unknown	unknown
American Samoa	yes	yes	yes	yes	yes	unknown
Guam	yes	yes	unknown	yes	yes	yes
Commonwealth in Political Union with USA						
Commonwealth of Northern Mariana I	yes	yes	yes	yes	unknown	yes
Compacts of Free Association						
Republic of the Marshall I	yes	yes	yes	yes	yes	yes
Federated States of Micronesia	yes	yes	yes	yes	yes	yes
Republic of Palau	yes	yes	yes	yes	yes	yes

Table 2. Summary of what demographic data has been collected for green and hawksbill turtles in US Pacific Flag Areas and Compacts of Free Association. Details regarding the source of these studies can be found in Appendix Tables 1&2.

	GREEN				HAWKSBILL			
US Possessions and Territories	*DNA sampled*	*DNA analyzed*	*Abund. estimate*	*Abund. trend*	*DNA sampled*	*DNA analyzed*	*Abund. estimate*	*Abund. trend*
Midway Atoll	no	no	no	no	no	no	no	no
Johnston Atoll	no	no	no	no	no	no	no	no
Palmyra Atoll	no	no	no	no	no	no	no	no
Howland I	no	no	no	no	no	no	no	no
Baker I	no	no	no	no	no	no	no	no
Jarvis I	no	no	no	no	no	no	no	no
Wake I	no	no	no	no	no	no	no	no
American Samoa	yes	yes	yes	no	yes	no	yes	yes
Guam	yes	yes	no	no	no	no	no	no
Commonwealth in Political Union with USA								
Commonwealth of Northern Mariana I	yes	no	yes	yes	yes	no	no	no
Compacts of Free Association								
Republic of the Marshall I	yes	yes	yes	yes	yes	yes	no	no
Federated States of Micronesia	yes	yes	yes	yes	no	no	yes	yes
Republic of Palau	yes	yes	yes	yes	yes	yes	yes	yes

Appendix Table 1. Identification of studies or observations of green turtles (*Chelonia mydas*) in the Pacific. Each number refers to a reference, see below. Bolded numbers indicate citations from 2000 to present, regular font indicates studies from between 1990 and 1999 and italicized numbers indicate citations older than 1990.

	Occur	Nesting	Foraging	DNA sampled	DNA analyzed	Abundance estimate	Abundance trend	Threats Identified
US Possessions and Territories								
Midway Atoll	**110**,117, *134*	*134*	**110,143,144**					117
Johnston Atoll	119,*120*, *134, 136*		119,*120*,*136*					117,*120*
Palmyra Atoll	**107**,117,119	117	**107**,119,**145**					117
Howland Is.	119,117							117
Baker Is.	119,117							117
Jarvis Is.	117	117						117
Wake Is.	117,119, *134*		119					117
American Samoa	24,43,**109,** 117,**122, 137**	7,24,43,**109,** 117,**122**	117, **137**	**133, 137**	**133**	117,**122**		117,**122**
Guam	117,119,**123**,132, **139, 140**	117,119,**123**,132 **,133, 139, 140**	**140**	**133, 140**	**133**			117,119,132
Commonwealths in Political Union								
Commonwealth of Northern Mariana Is.	**111,112,** 117,**118,121, 141**	**111,112**,117, 119, **141**	**111,112**,117, **118,121,133, 141**	**133**		**111**,117,**121**	117	117,119
Compacts of Free Association								
Republic of the Marshall Is.	117,119, **128,129**,132	117,119,**128, 129**,132,**133**	117,**133**	**133**	**133**	117,**129**	119	117,119, **129**,132
Federated States of Micronesia	**113,114,** 117,132	**113,114,115,** 117,132,**133**	**114**,117	**113,133**	**113,133**	**114,115**,117	**114,115,** 117,132	**114,115,** 117,132
Republic of Palau	**68,98**,117, 119,132,**146**	117,119,132, **133,146**	117,**133**	**133**	**133**	117	**98**,117,119	**68,98**, 117, 132

Potential source stocks in the Pacific	**Occur**	**Nesting**	**Foraging**	**DNA sampled**	**DNA analyzed**	**Abundance estimate**	**Abundance trend**	**Threats Identified**
Japan	20,29,32,41, **93**,119	20,29,32,41,119				26,29	119	26,29,**93**,119
Malaysia	22,45,**59, 73,**119,**124**	7,22,45,**52,59.67 83,115,**119,**124**	**113**	**113**	**113**	**67,83,113, 115,**119,**124**	**59,115,**119,**124**	5,59,**73, 115,**119,**124**
Thailand	**78,**119	**78,**119					**78**	**78,**119
Taiwan	27,**64,88,**119	27,37,**64,88**		**133**	**133**	27,**88**		119
Philippines	23,**72,113,** 119,**125**	13,23,**52,72, 113,115,**119,**125**	**113**	**113**	**113**	23,**113,115,**119	**115,**119	13,23.25, **115,**119 ,**125**
Australia	21,**47,50,55, 91,115,127**	*4*,14,18,**46,56,61 70,71,115,127**	**16,53,86,113**	**56,65,77, 91,113**	**56,65, 95,113**	36,**71, 113,115,127**	**71,94,115,127**	**58,65,76,92, 94,100,101,127**
Indonesia	28,**80,90,105, 113,115,126**	28,**66,80,87 ,90,115,126**	**87,113**	**87,113**	**87,113**	**113,115**	**87,115,126**	10,28,**66,80, 90,99,105,126**
Papua New Guinea	*3*,8,**113**	**113**	**113**	**113**	**113**	**113**		*3*,8
Solomon Islands	35,*130*,131	131	*130*					35,131
Vanuatu	117							117
New Caledonia	19,**113**,131	131		**113**	**113**			
Fiji	24,43, **109,**131	131	**82,109,**131	**133**	**133**	**82**		**24,82**
French Polynesia	**11,**131,**133**	**11,**131		**133**	**133**			
Tonga	131	131	131					
Pelagic Pacific	38,**62, 84,106**			38,**62,89**	38,**62,89**			30,38,44,**62, 74,84,106**
Mexico	**57,63, 89,115**	**57,63,115**	**57,96**	**63,89**	**63,89**	**115**	**115**	9,**115**
Costa Rica	*1*,**51,115**	**51,115**						15,34
Ecuador, Galapagos Islands	12,31, 39,**54,133**	6,31,**79, 89,108,115**	31	**89,133**	**89,133**	**54.108,115**	**79,115**	25,31,**84, 108,115**
Peru	**69,75, 103,104**			**103**	**103**			**69,75,84, 103,104**

Appendix Table 2. Identification of studies or observations of hawksbill turtles (*Eretmochelys imbricata*) in the Pacific. Each number refers to a reference, see below. Bolded numbers indicate citations from 2000 to present, regular font indicates studies from between 1990 and 1999 and italicized numbers indicate citations older than 1990.

	Occur	Nesting	Foraging	DNA sampled	DNA analyzed	Abundance estimate	Abundance trend	Threats Identified
US Possessions and Territories								
Midway Atoll								
Johnston Atoll								
Palmyra Atoll	**107**		**107**					
Howland Is.								
Baker Is.								
Jarvis Is.								
Wake Is.								
American Samoa	116,**122, 137, 138**	116,**122, 138**	**137**	**137**		116,**122**	116	116,**122**
Guam	116,**123,**132, **140**	116,**123,**132	116, **140**					116,132
Commonwealths in Political Union								
Commonwealth of Northern Mariana Is.	**133, 141**		**133, 141**	**133**				
Compacts of Free Association								
Republic of the Marshall Is.	116,**128, 129,133**	116,**129,133**	116,**133**	**133**	**133**			116,**129**
Federated States of Micronesia	**114,**116,132	**114,**116,132	**114,**116			**114**	**114**	**114,**116,132
Republic of Palau	**98,**116, 132,**133,146**	116,132, **133,146**	116,**133**	**133**	**133**	116	**98,**116,132	**98,**116,132

Potential source stocks in the Pacific	**Occur**	**Nesting**	**Foraging**	**DNA sampled**	**DNA analyzed**	**Abundance estimate**	**Abundance trend**	**Threats Identified**
Japan	*2*,10,32,**102**	32	**102**					*2*,10
Malaysia	45,**124,** **81,78,**119	45,**52,124** **78,**119		**81**	**81**	**124**	**124**	5,**124,78,**119
Thailand	**78,**119	**78,**119						**78,**119
Taiwan	**88**	**88**						
Philippines	*2*,13,23,**52** **72,125**	13,23,**52** **72,125**						*2*,13,23,**125**
Australia	40,**48,97** **101,127**	33,**48,127**	40,**48,127**	42,**91**		40,**127**	**97,127**	**76,92** **101,127**
Indonesia	28,**48,60** **85,97,126**	28,**60** **85,97,126**		**126**			**85,126**	*2*,10,28,**60** **85,105,126**
Papua New Guinea	**48**							
Solomon Islands	*2*,8,35 **48,***130*,131	*130*,131					131	*2*,8,35,131
Vanuatu	**48**							
New Caledonia	131							
Fiji	*2*,8 **82,**131	**82,**131	**82**			**82**	**82**	*2*,8,**82**
French Polynesia	131							
Tonga	131	131	131				131	131
Pelagic Pacific	6,**84**							**84**
Mexico								9
Costa Rica	34,*134*	*134*						34,*134*
Ecuador, Galapagos Islands	17,**49** **79,84**	**49,79**					**79**	**84**
Peru	**69,84**							**69,84**

List of citations corresponding to Appendix Tables 1 and 2, full citations are given in the bibliography section

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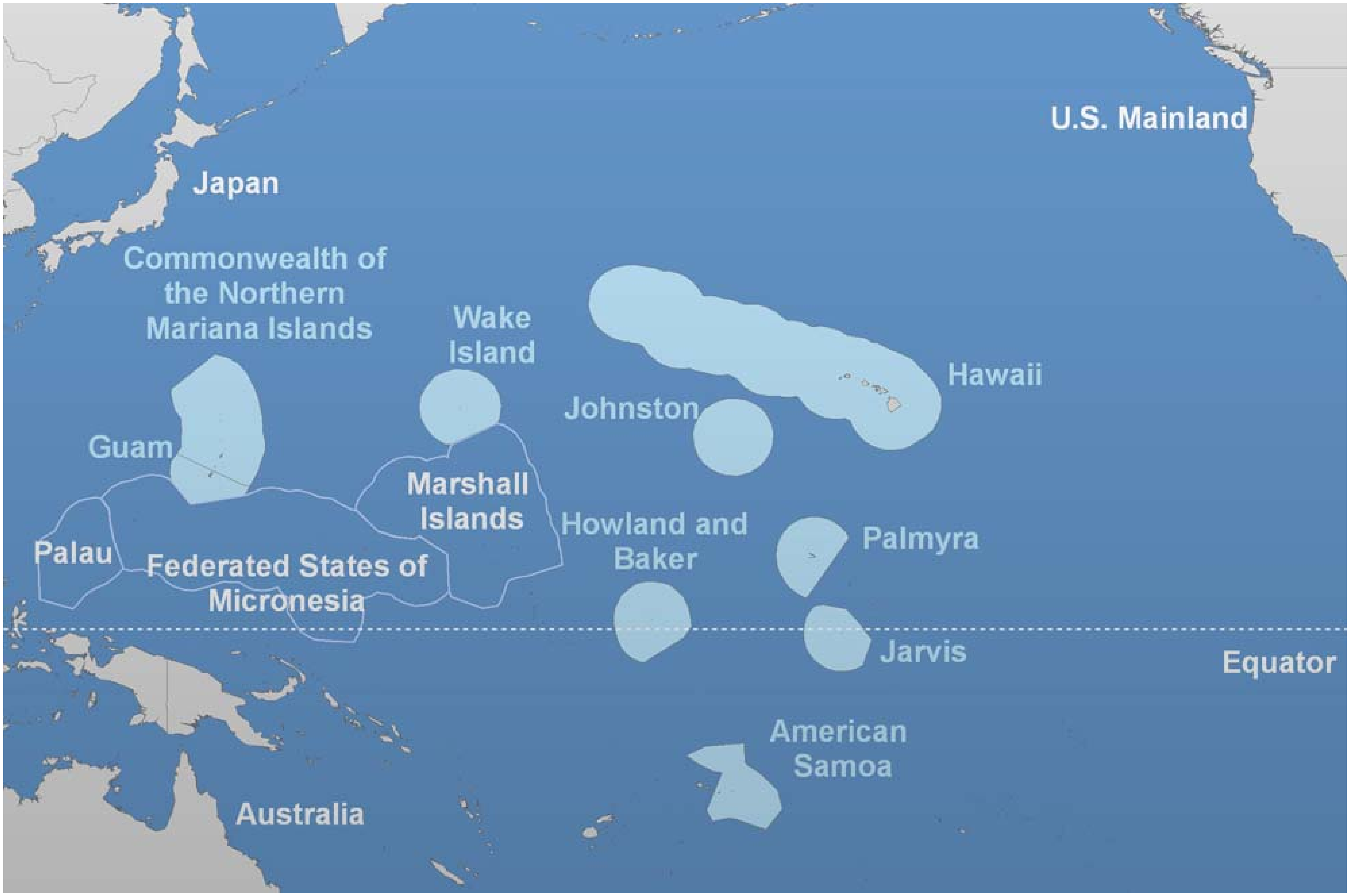

Figure 1. Map of the Pacific Ocean. Included in light blue test are the names of US Possessions, Territories and Commonwealth Areas. Areas shaded in light blue are US EEZ waters. Areas outlined in blue are EEZ's of nations with Compacts of Free Assosciation with the US. Map from http://www.fpir.noaa.gov/DIR/dir_index.html

Green (*Chelonia mydas*)

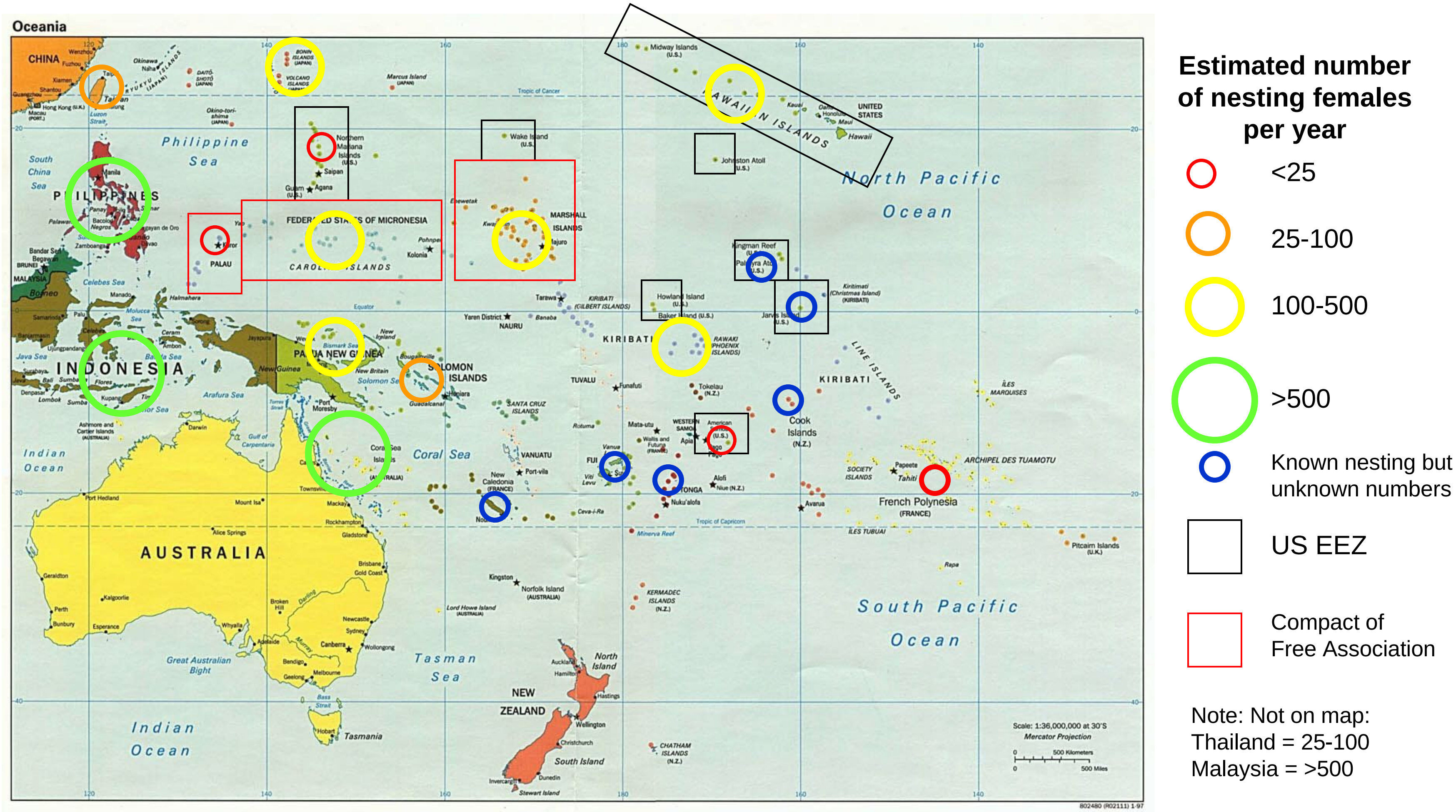

Figure 2. Political map of the Pacific Ocean (from www.pica-org.org). Black boxes highlight the US Flag and Commonwealth Areas. Circles indicate green turtle (*Chelonia mydas*) nesting with estimated abundances as per the legend. Malaysia, Thailand, Solomon, and Bonin Islands data are personal communication from C. Limpus as cited in Moritz et al. (2002). References for the remaining information can be found in the Appendix

Hawksbill (*Eretmochelys imbricata*)

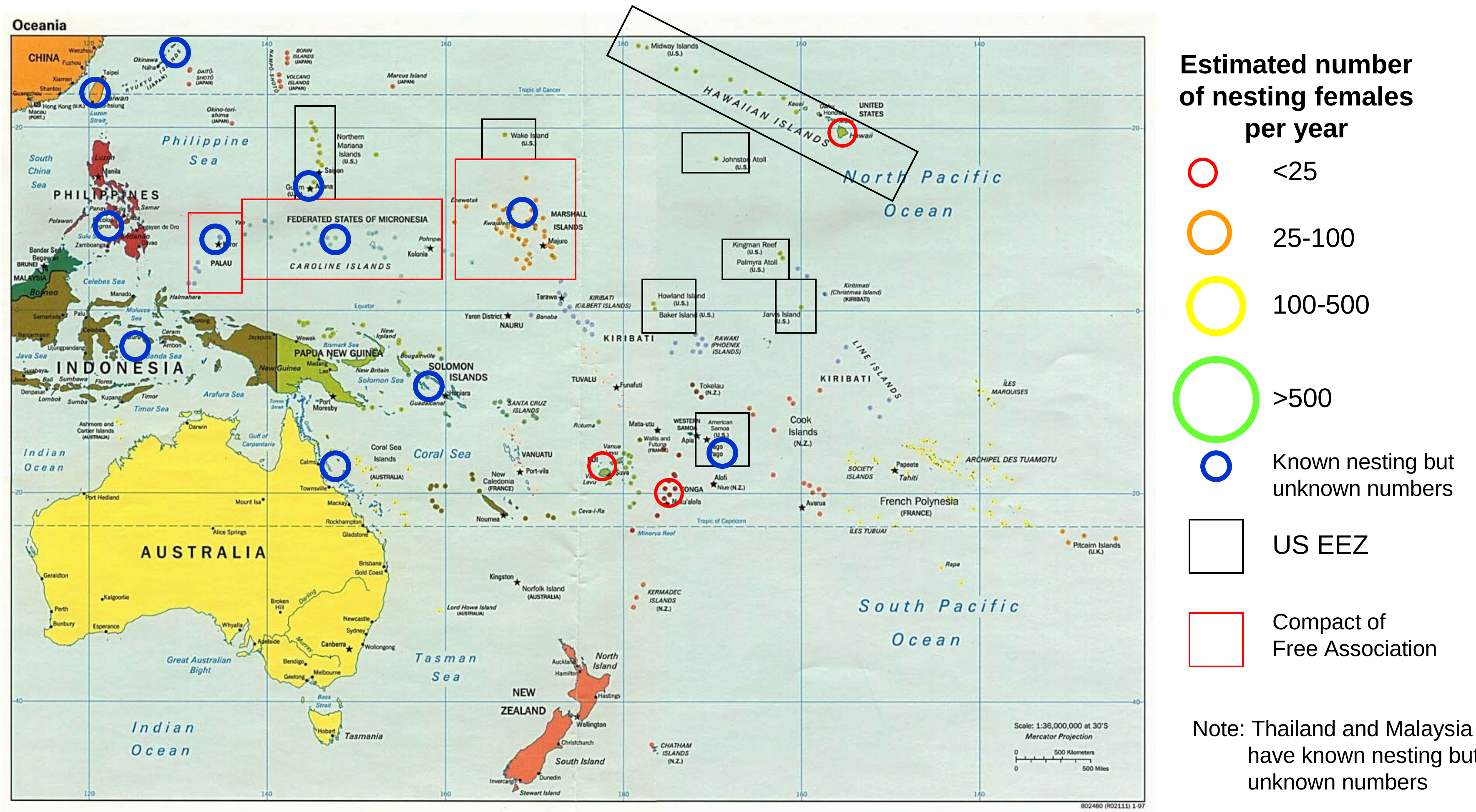

Figure 2. Political map of the Pacific Ocean (from www.pica-org.org). Black boxes highlight the US Flag and Commonwealth Areas. Circles indicate hawksbill turtle (*Eretmochelys imbricata*) nesting with estimated abundances as per the legend.