Sessions IV and V

Meeting Management Goals

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Determining Population Distribution and Status

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Introduction

To implement biodiversity conservation programs, necessary input to establish priorities includes information on the distribution of the species, its structure (how is it organized internally?), and its conservation status, both for the species as a whole and for the populations or stocks that comprise it. This information enables the development of an effective and direct strategy linking priority goals with local and regional actions. This chapter outlines the methods used in determining the distribution of marine turtles species and emphasizes the issues related to the study of population structure and the assessment of conservation status.

Determining Distribution

A species' distribution describes the entire geographic region with all known or inferred sites in which a species occurs (vagrants are excluded). For migratory species such as marine turtles, which utilize numerous habitats during their lifetimes, distribution encompasses vast areas, including all sites essential for the survival of every life stage. Marine turtles are present in many of the world's oceans and seas. They have complex life histories, and over a period of many years use continental shelves, bays, estuaries, and lagoons in temperate, subtropical and tropical waters. Determining the extent of their distribution has been difficult. Fortunately, once the major aspects of each species' life cycle became known, direct and indirect methods to identify the presence of individual species have permitted the collection of a great deal of information about their distribution.

The simplest direct method relies on the identification of species during the nesting season at *breeding sites.* The global nesting distribution is the sum of all sites found. In most cases, many sites are already known from recent and historical surveys (see individual species chapters in this volume). Aerial and boat surveys (Schroeder and Murphy, 1999) are useful to increase the coverage of large expanses of territory and extend scrutiny into regions less well studied or with difficult access. Identification of species using these survey methods can rely on direct observations of nesting turtles or on deductions from characteristic tracks.

Basic data derived from nesting beach surveys are essential to construct the inventory of the species' nesting sites and should include: (a) geographic coordinates and references to landmarks and/or the political entities where each nesting beach is located; (b) nesting period for each of the species using the beach; and (c) the relative importance (in terms of numbers of nests per season) of the nesting beach within the country or the region (Briseño-Dueñas and Abreu-Grobois, 1999).

Other essential habitats and areas include those used as *migratory* corridors, *developmental* sites and *foraging* areas. Identification of the location of these sites is much more difficult due to the fact that they are found at sea and they exist at localities often separated by many hundreds or thousands of kilometers from the nesting sites where the majority of research efforts take place. Species have distinct developmental and foraging sites that correspond to their ecological requirements. When more than one species of marine turtles utilizes an area, each species generally has different ecological requirements. For example, hawksbills forage on sponges in reef areas while green turtles utilize grass flats. However, at some sites, particularly in the coastal areas, a combination of species may be found during a portion of their life cycle even though the seasonality and locality of breeding may not coincide. In other cases, turtles of the same species but of different ages may be found at individual habitats.

The locations of migratory routes initially were derived from opportunistic sightings in the open sea by biologists or fishermen familiar with these species. Tagging programs for marine turtles in many regions have provided useful insights into the extent of the species' ranges. With time, the accumulated information gathered has allowed biologists to construct a more complete picture of nesting sites, migratory routes and developmental areas. The use of traditional mark-recapture techniques (Balazs, 1999) together with more sophisticated biotelemetry (Eckert, 1999) or genetic methods (FitzSimmons *et al.*, 1999) in conjunction with an understanding of oceanic currents has refined our knowledge of dispersal routes as well as the location of developmental and feeding sites of juvenile and mature organisms. The emerging picture now includes details of long distance movements, and the realization that turtles originating in many breeding colonies converge in developmental and feeding sites. This research has also confirmed the extensive migratory behavior of all marine turtles, crossing through and into territorial waters of more than one country during their lifetimes.

Indirect methods are also useful to detect the presence of marine turtles in coastal habitats that are less well studied or difficult to reach. Relevant data often can be derived from historical and anecdotal information from individuals acquainted with sea turtles, such as villagers, marketplace shoppers, or fishermen (Tambiah, 1999). Published accounts of the general biology of the species are very useful as general guides to potential locations. Surveys of potential nesting or feeding sites can be undertaken in areas which have the ecological, physical or biological characteristics known to correlate with sea turtle presence (e.g., coral and sponge reefs, seagrass beds for hawksbill and green turtle foraging grounds, respectively; Diez and Ottenwalder, 1999). On some beaches during the reproductive season, nesting can be confirmed through the presence of crawls, nesting pits, or egg shells and the species' identity can be deduced from characteristic markings left by nesting females (Pritchard and Mortimer, 1999).

Importance of identifying the basic demographic units

As in many other species with broad geographic distributions, marine turtle species are made up of discrete demographic subunits and these can, for the most part, be differentiated with modern genetic techniques. Isolation between these subunits (also known as "stocks", "populations" or "management units"), originates from relatively low levels of gene flow between breeding assemblages. In the case of marine turtles, a tendency for organisms to return to breed at or near the site of birth ("natal homing" or "philopatry"; see Frazier, this volume) promotes this kind of isolation between breeding assemblages, even though they still remain part of the same species. A practical consequence of this degree of isolation is that the populations will exhibit independent population dynamics that correlate with the degree of genetic differentiation. Thus, as individual populations may react independently to management actions, management practice can and should be tailored specifically to the conservation status of each individual population. In practice this means that each individual population will need to be identified, tracked and evaluated throughout the geographic range where it is distributed. This requirement imposed upon marine turtle management on a regional scale is not unlike fisheries management of species composed of multiple stocks (see Musick, this volume).

Identification of populations of marine turtles can rely on a combination of techniques, including mark-recapture with flipper tags and various forms of telemetry and molecular methodologies for the most precise results. However, because differences between breeding assemblages have a genetic basis, the most useful and time-efficient method takes advantage of assayable differences between the populations, either in the form of frequency shifts or presence or absence of distinct segments of the DNA, that serve as "markers" that can be used to track and identify populations or individuals.

In many cases, the use of DNA analysis allows for the unambiguous characterization of discrete breeding assemblages at their nesting grounds and their discrimination in distant feeding ground assemblages, in migratory corridors, or in harvests, where the actual composition of a mixture of stocks would be impossible without this technique

(Bowen, 1995; FitzSimmons *et al.*, 1999).

Although these studies are preliminary until more populations are researched, these types of genetic studies have been successfully applied to hawksbill populations in the Caribbean region. The significant differences in characteristics of the mitochondrial DNA among rookeries (Bass *et al.*, 1996; Díaz-Fernández *et al.*, 1999), besides demonstrating the existence of independent stocks, were employed to distinguish populations in sites where more than one stock would be present. At foraging sites located in Puerto Rico, Cuba and Mexico the presence of a mixture of populations was thus proven and the contribution by each stock at that time and season was derived by statistical analyses (Bowen *et al.*, 1996: Díaz-Fernández *et al.*, 1999). Further analysis of the genetic data also allows estimates of gene flow between rookeries, providing for a much clearer picture of the dynamics among populations.

Determining Status

The term "status" or "conservation status" refers to the condition or health of a species or population. Assessments of a species' status follow analogous procedures to those used by a physician when diagnosing a patient, requiring a comparison of his current condition against a standard of "health". Similarly, the status of a species can be derived by scrutinizing for "symptoms" that reflect its condition. These are based on an assessment of a species' population trends, distribution, and the state of critical habitat. On one end of the spectrum, threatened and stressed species exhibit marked declines in population size over time. This may be associated with direct threats to the organisms themselves or to loss or degradation of habitat. On the other end of the spectrum, if population stability or growth is observed over an acceptable period of time, the conclusion would be that the species is "healthy". When the latter is observable subsequent to a period of decline, the species could, at least, be considered "recovering". Condition of full recovery will require the elimination or control of external threatening factors, a measure of the species' health, as well as assuring that the species can perform its full ecological role.

Status in terms of risk of extinction

Rigorous methods for the evaluation of status of endangered species have been developed to focus attention on identification and measurements of extinction risk. Resulting evaluations have the additional value of providing means by which species can be compared across taxa on the basis of extinction risk. This information can be used in turn to prioritize conservation programs.

Extinction results from complex and not completely understood interactions between external threat factors and the species' intrinsic characteristics that, under extreme circumstances, lead to an ever increasing decline and, eventually, to an inability to survive altogether. In modern times, the major forces driving extinction are anthropogenic, such as a) habitat loss or degradation, b) overexploitation, c) introduction of exotic species or diseases, or d) a combination of all these factors. When these circumstances are present, they are symptoms that a species it at risk. Some natural history traits, because of the additional constraints they impose on population growth and general resilience, augment a species' vulnerability to extinction. Among these: a) narrow geographic range, b) only one or a few populations, c) population size is small, d) characteristic low population density, e) requirement for a large home range, f) low intrinsic rates of population increase, g) migratory behavior, h) scarce genetic variability, or i) highly specialized niche requirements. The more of these traits that a species exhibits, the more vulnerable it is to extinction.

Because of the biological complexities of species and their interactions with their environment, a thorough and objective analysis to gauge the precise risk of extinction for any species is extremely difficult. It requires in-depth knowledge of all factors involved and their effects on the survival capability of the species. In practice, however, identification of species at risk can be derived by employing measures of the symptoms that species under stress provide (habitat loss or degradation, population decline or highly reduced population sizes) and these can be used to classify species into threat categories. This can be seen as the initial decision a doctor takes when dealing with ill patients and will identify the cases that require most urgent action.

For example, if a population is characterized as having a small size and/or has a slow rate of population growth *and* is known to be drastically reduced in size, it is logical to deduce it is threatened. Likewise, if a significant proportion of a population's habitat has been lost or degraded, *and* the population has declined in size, this population is also vulnerable.

Measuring the extinction risk of species should ideally be objective and rely on the best available scientific data and incorporate measurements of indicators that correlate with extinction risk. Thus, the results of the assessment should be the same when performed by different assessors. Developing a single procedure for all organisms is a daunting task, particularly as species vary considerably in their life-histories and other ecological attributes that affect their vulnerability to extinction. Faced with devising dependable and rigorous guidelines for species status assessments, national and international authorities have developed procedures based on the ideas presented above. For example, for legislative and management policy purposes, some countries specify general guidelines defining endangered species as those showing some or a combination of the symptoms associated with extinction. In these cases, scientific or technical advisory committees review available information and the biological characteristics of species on a case-by-case basis to produce national lists of endangered species (e.g., Mexico's Diario Oficial de la Federación, 1994; The US Endangered Species Act 1973). Several international conservation treaties consider endangered species using general definitions (e.g., UNEP's SPAW Protocol, and the Convention on the Conservation of Migratory Species of Wild Animals-CMS).

Two major international organizations have specific pre-defined procedures to be applicable to all species under their respective evaluation processes: the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and, through its Red List Program, the World Conservation Union (IUCN).

CITES utilizes a suite of "Biological Criteria" to assess species that are, or are likely to be involved, in international trade in order to detect if they can be considered endangered species (Table I). These criteria detect endangerment on the basis of observations or inferences that reflect small population size and decline in the number of individuals or in the quality of their habitat; populations having a restricted area of distribution and exhibit declining population sizes, or fluctuations in size or are fragmented; or populations whose size has declined significantly over generations. Species meeting these criteria are listed in CITES Appendices I and II (see left column, Table I for CITES criteria; for further details, the interested reader should consult CITES Conf. 9.24 available in http://www.cites.org/CITES/eng/ index.shtml).

The IUCN has developed a more complex system (the Red List Categories) that relies on specific quantitative thresholds to assign one of eight categories of extinction risk. Of these categories, the three applicable to threatened species are relevant to marine turtles: *Vulnerable*, *Endangered* and *Critically Endangered* since each of the seven species of marine turtles are currently listed under one of them. The goal of the Red List Categories is to provide an explicit, objective framework (criteria) to classify species according to their risk of extinction. These have been developed to be applicable across all taxa and life histories, although some difficulties remain. The 1994 IUCN Red List categories and the corresponding thresholds are presented in a simplified form in Table I (right column). While species initially should be evaluated against all criteria, some of the criteria are not applicable to particular taxa. If a species meets one criterion, it is listed as threatened at that level (category) of risk. The Red List Categories employ quantitative criteria to distinguish amongst three categories of extinction risk, thus providing for greater resolution in the evaluation. Since a thorough description of the assessment procedure is beyond the scope of this chapter, the interested reader is encouraged to consult the complete documentation for further details and application guidelines (IUCN, 1994).

A number of important elements in the assessment procedure should be stressed. First, for adequate assessments, the time frame of the observations needs to be biologically relevant to the processes involved. Since population dynamics are scaled by generation lengths (see Congdon *et al.*, 1993), assessments need to be made over a period spanning several generations. Secondly, generation is defined as "the average age of parents". This value is greater than the age at which first reproduction is observable and less than the age of the oldest breeding individual. One problem with this definition is that this number will be lower than would occur naturally in a heavily exploited species because breeders will not have natural lifetimes. Third, although the assessments are usually applied to species at a global scale, they are also effective in evaluating the status of individual populations or stocks, particularly when they are isolated from other conspecific populations (as occurs for most marine turtle stocks). Fourth, since the results of either procedure rely on evaluating parameters such as "decline" or "reductions" in aspects of a species' habitat or its population size, the cut-off points need to be clearly defined for objective application. CITES, for example, provides a guideline (not a threshold) for defining a "decline" to be sufficiently large to warrant classifying a species in trade as "endangered": ≥50% reduction in number of individuals or in its area of distribution over a period of 5 years or 2 generations whichever is longer (≥20% in 10 yrs or 3 generations for small populations). The IUCN Red List Categories, on the other hand, specify that the observed or inferred changes occur over 3 generations or 10 years, whichever is the longer period (see Table I).

Using the IUCN Red List Categories to assess extinction risk of marine turtles

IUCN's procedures have been widely accepted by governmental agencies, academic and non-governmental organizations as a universal reference point for listing endangered species. All species of marine turtles have been assayed with these criteria and are provided in the IUCN Red List of Threatened Animals (Baillie and Groombridge, 1996; see species chapters in this volume).

Marine turtles are commonly analyzed for global assessments under Criterion A ("Declining population size", right column in Table I) which is the criterion most applicable to the taxon. For these species, assessments are generally based on direct observations (subcriterion a), an index of abundance appropriate to the taxon (subcriterion b), or actual or potential levels of exploitation (subcriterion d).

In most surveys, marine turtle population sizes are gauged on the basis of numbers of nests constructed annually as this information is the most accessible and abundant information which is amenable to analysis (Meylan, 1995). There is a very significant advantage in that these data are directly related to the true number of breeding females during each nesting season. To estimate population abundance, estimates of annual number of nests are commonly preferred over estimates of the number of individual nesting turtles as the index of abundance because (a) many (if not most) projects do not tag turtles, so it is not possible to distinguish between individual nesters leaving multiple clutches in the season and (b) there is no need to monitor individual tagged turtles between subsequent nestings (remigrations) to detect and account for variations amongst individuals and between geographic populations for frequency and length of remigration intervals (Alvarado and Murphy, 1999). Thus, information gathered by most surveys can be compiled and compared. If desired, numbers of nests can be converted to the number of females nesting annually by dividing the average number of nests per female (Alvarado and Murphy, 1999) when this information is available.

As mentioned above, evaluation of changes in population size for status assessment needs to be analyzed over a period of time compatible with the dynamics of population turnover. This scale would extend beyond the time frames required solely to achieve statistical robustness in trend estimates from demographic data (roughly in the region of 5-10 years; see Kerr, this volume) into a 2-3 generation period that is required by international procedures. Furthermore, employing multi-generation time series also facilitates the detection of true long-term trends.

Age at maturity for long-lived species, such as marine turtles, extends into decades (see Frazier, this volume). For the fastest developing species, such as Kemp's ridley (*Lepidochelys kempii*), maturity may be first reached in the range of 10-16 years (Márquez, 1994; Márquez, this volume; Zug et al. 1997). At the other end of the spectrum, green turtles may take as long as 50 years to reach maturity (Bjorndal and Zug, 1995). Although regional

Table 1. Simplified CITES and IUCN criteria and categories for assessing species threatened with extinction.

CITES Biological Criteria for inclusion in Appendix I

Species that meet, or are likely to meet, at least one of the following criteria (simplified)

A) A wild population is **small** *and* there is **decline** in the **population size or habitat size or quality**; *or* each sub-population is very small; *or* most of the individuals are concentrated in a single sub-population; *or* there are large fluctuations in population size; *or* there is high vulnerability due to the species' biology or behavior (e.g. migration), *OR*

B) A wild population has a **restricted area of distribution** *and* the distribution is fragmented; *or* there are large fluctuations in the area or number of sub-populations; *or* there is a decline in the population size or distribution or quality of habitat, *OR*

C) The **number of individuals** in the wild has declined, which has been observed or inferred as having occurred in the past; *or* inferred or projected on the basis of: decreased area or quality of habitat; *or* levels or patterns of exploitation; *or* threats from extrinsic factors (e.g., pathogens, parasites, introduced species, etc.); *or* there is a decreased reproductive potential, *OR*

D) The status of the species is such that if it isn't protected by inclusion in Appendix I, it is likely to satisfy one or more of the criteria within the following 5 years.

Definitions in CITES Criteria:

Decline — a guideline of 50% decrease in 5 years or 2 generations, whatever is longer; for small populations, a guideline of 20% in 10 years or 3 generations

Generation — average age of parents

Restricted area of distribution — guideline of 10,000 km^2 for smallest area essential for any life stage of the species

Criteria for the 1994 IUCN Red List Categories (simplified)
CR = critically endangered; EN = endangered; VU = vulnerable

A) Declining Population Size (past and/or projected), measured as changes in the numbers of mature individuals only
An observed, estimated, inferred or suspected reduction of at least X% over the last 10 years or three generations, whichever is the longer, based on either:

1) (a) direct observation; *or* (b) an index of abundance appropriate for the taxon; *or* (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat; *or* (d) actual or potential levels of exploitation; *or* (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites *OR*
2) A reduction of at least X%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on any of (b), (c), (d) *or* (e) above.
[values for: **X%- CR=80; EN=50; VU=20**]

B) **Small Geographic Distribution** *and* Decline, Fragmentation or Fluctuation. Population occurring in <X km^2 or occupying < Y km^2, *and* indications of any two of the following:

1) Severely fragmented or known to exist at only Z location(s).
Continuing decline, observed, inferred or projected, in any of the following: (a) extent of occurrence, or (b) area of occupancy, or (c) area, extent and/or quality of habitat, or (d) number of locations or subpopulations, or (e) number of mature individuals.
2) Extreme fluctuations in any of the following: (a) extent of occurrence, or (b) area of occupancy, or (c) number of locations or subpopulations, or (d) number of mature individuals.
[values for: **X km^2- CR=100; EN=5,000; VU=20,000 / Y km^2- CR=10; EN=500; VU=2,000 / Z loc.- CR=1; EN= ≤5; VU= ≤ 10**]

C) **Small Population Size** *and* Decline. Population estimated at < V mature individuals *and* either:

1) An estimated continuing decline of at least W% within X years or Y generation, whichever is longer *or*
2) A continuing decline in numbers of mature individuals and population structure in the form of either:
(a) severely fragmented (i.e. no subpopulation estimated to contain more than Z mature individuals),
or (b) all individuals are in a single subpopulation.
[values for: **V** individuals - **CR=250; EN=2,500; VU=10,000** / values for: **W%** - **CR=25; EN=20; VU=10** / values for: **X** years - **CR=3; EN=5; VU=10** / values for: **Y** generations – **CR=1; EN=2 ; VU=3** / values for: **Z** individuals - **CR=50; EN=250; VU= 1,000**]

D) **Very Small Population** or **Very Restricted Distribution**. Population estimated to number < X mature individuals.
[values for: **X** ind.- **CR=50; EN=250; VU=1,000 or with acutely restricted area of occupancy**]

E) **Quantitative Analysis** (e.g., Population Viability Analysis). Quantitative analysis showing the probability of extinction in the wild is at least **X**% within **Y** years or **Z** generations whichever is the longer
[values for: **X%- CR=50; EN=20; VU=10** / values for: **Y** years and **Z** generations- **CR= 10 years or 3 generations; EN= 20 years or 5 generations VU= 100 years**]

Species are assessed against all possible criteria considered applicable for the available quantity and quality of data as well as the species' life history characteristics that best fit Criteria A - D. However, it is only sufficient for one category to be applicable for listing under one of the three "threatened" categories. Identification of category of risk (level of extinction risk) will depend on which threshold values for parameters in bold text best corresponds to the available information on the species.

Note: At the time of writing, the 1994 Categories are under revision by IUCN. However, since marine turtles are normally assessed under Criteria A and there the only major change is in the threshold for VU (to 30%) , the information is adequate for the purposes of this chapter assessments of age at maturity have not yet been undertaken, differences in growth rates among populations of the same species found in different ocean basins may also need to be taken into account when making assessments.

An assessment of the extinction risk for *Lepidochelys kempii* using the IUCN Red List Categories can best illustrate their application since this is a case where a time series spanning many decades is available. The species is the most seriously endangered of the sea turtles, having declined precipitously from the 1940s to the 1980s (Figure 1) and it has a distribution concentrated in the Gulf of Mexico (in contrast to global distributions for five of the other six species). For this species, the assessment can be performed using Criterion A (decline criteria) for data on the number nests laid annually.

The remaining parameter required for the assessment is the generation length for the species. When undertaking assessments, the MTSG has concluded that the most appropriate measure of generation length in marine turtles is age at sexual maturity plus half of reproductive longevity (Pianka, 1974). Using approximations for maturity of 11-16 years for this species and an estimate of reproductive longevity of about 11-15 years (observed in conservation programs for olive ridleys, *L. olivacea* [D. Rios-Olmeda, pers. comm.] and which is probably equally applicable to Kemp's ridleys), 20 years is a reasonable estimate for one generation.

Observed trends in the estimated size of the annual breeding female population (Figure 1) can be compared to the Red List threshold decline rates. In spite of a dramatic 3-fold increase in nestings from 1986 to the present, the species has not yet recovered sufficiently to remove it from the Critically Endangered category.

Methodical monitoring of marine turtle nesting beaches did not begin until the 1950s in some areas, and not until the mid 1960s or even later is this information obtainable. In order to overcome limitations in the available scientific literature, historical accounts, trade data, and qualitative information need be considered to complement existing reports from modern nesting beach monitoring programs. This approach has been used for status assessments of hawksbills, green turtles, olive ridleys, and leatherbacks at a global level. In the case of the hawksbill, a species which has been scrutinized in recent years within the Wider Caribbean region, Meylan (1999) inferred the status of Caribbean hawksbill populations from a compilation of reports and various accounts, showing the species to be declining or depleted in the majority of areas for which some status and trend information was available (22 of the 26 countries or territories).

Measures of recovery

Though it is understandable that efforts at developing universally acceptable criteria have concentrated on extinction risk, it is no less important to have practical means with which to measure the success of conservation programs and ultimately "recovery". In general, population recovery has been defined in terms of: reversing, stabilizing and increasing a formerly declining population; abatement, control or elimination of known threats; and stabilizing and guaranteeing the long-term protection of critical habitats.

Nonetheless, as with measurements of extinction risk, there is great utility in being able to gauge the recovery process to provide wildlife management authorities with benchmarks against which to measure advances made in their management and conservation programs. In the absence of adequate, clearly stated criteria, conservation actions can remain open-ended, with no clear objectives. To date, few national conservation programs for any species have included a formal analysis to identify recovery criteria and goals. The need to define these will become more urgent in the not so distant future as marine turtle conservation programs start to bear fruit, at least for some populations (e.g., as probably is the case for both Kemp´s ridleys and hawksbills in the Gulf of Mexico, see Márquez *et al.*, 1999 and Garduño *et al.*, 1999, respectively).

While an analysis of the mechanisms and processes underlying recovery is beyond the scope of this paper, a listing of criteria comparable in scope to those utilized for measuring risk of extinction is presented (Table II), derived largely from the Recovery Plans that the US National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service (USFWS) have devised for marine turtle conservation programs in that country. Including

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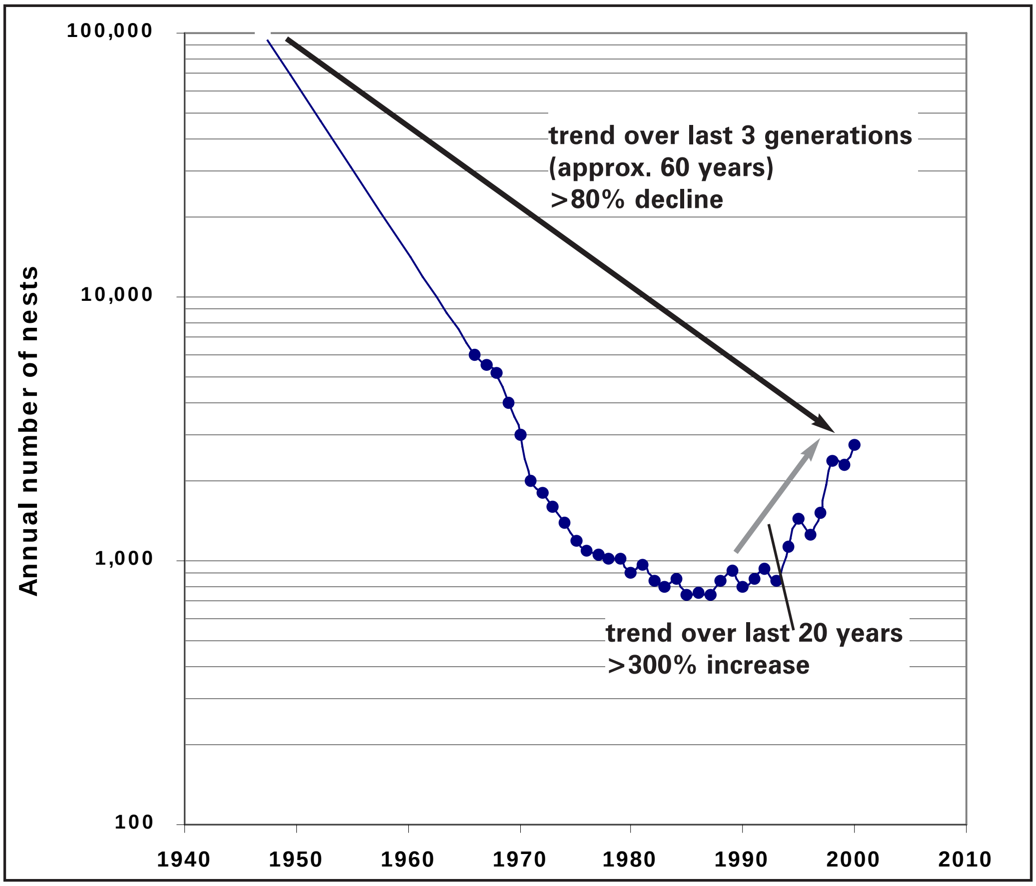

Figure 1. Long-term trends in the annual number of nests laid by *Lepidochelys kempii* 1947-2000. These records include information from 1947 of observed females (derived by Hildebrand (1963) from a 1947 film) and records from modern monitoring of annual numbers of nests (data from Márquez *et al.*, 1999). The 1947 record was converted to numbers of nests by multiplying the estimated number of nesting females by nesting frequency of 2.5 nests/female/season for the species (Turtle Expert Working Group, 1998). A three generation decline of >80% (equivalent to the IUCN *critically endangered* status) is not yet reversed by the very significant increases over the last 10 years.

this draft list should stimulate further discussions among sea turtle specialists, national and international resource managers, as well as NGO's, with the aim of developing them into a universally accepted set of criteria to define recovery, under a similar scheme to what is available for species' extinction risk assessments. It should be noted that besides including criteria for demographic parameters (population sizes, trends, etc.), considerations are also necessary that gauge improvements in management capabilities such as threat control and presence of national and international management schemes.

While goals for desirable population size should figure prominently in any recovery criteria, questions stemming from current debates on this issue need to be addressed. What level of recovery should be aimed for and can it be known which levels are necessary to restore full ecological functioning to depleted marine turtle populations? Is it desirable or practical to aim at recovering historical population sizes of marine turtles? Alternatively, if

Table 2. Some criteria useful in determining population recovery in marine turtles

(largely based on US Recovery Plans for marine turtles, e.g., NMFS and USFWS, 1998)

A species or population could be considered "recovered" if it meets the following criteria:

A) Knowledge

- Individual stocks and migratory routes of populations are known and the natal origin of each stock has been identified
- Natal origin of each stock has been identified
- Most important foraging sites have been identified

B) Habitat integrity and stock productivity

- Adequate protection is in place at key foraging areas
- Protection of size and quality of nesting habitat for at least **50%** of the known sites is guaranteed in perpetuity
- Hatching recruitment into the marine environment is stabilized at above **75%** of eggs laid in key nesting beaches

C) Size of Populations

- Numbers of annually nesting females at key source beaches for the identified stocks are either stable or increasing for at least **1 generation**
- Each stock reaches and maintains a sufficiently large average annual nesting female population size that it will be biologically reasonable that it can remain a stable population in perpetuity [e.g., **10,000** (*Lepidochelys kempii*)] over a period of at least **six** years
- Foraging populations show statistically significant increases (or stability) at key foraging grounds within each stock region for at least 5-10 years (time scale necessary to derive a robust estimate of trends; see Kerr, this volume)

D) Management capabilities

- A management plan based on mechanisms that guarantee sustained populations for turtles is in effect
- All sources of threat (including bycatch) have been identified, and their impacts controlled to levels not affecting the intrinsic rate of increase of the species
- International agreements are in place for adequate conservation and management of shared stocks

Author's note: terms in bold are guidelines for possible values, based on usage by NMFS/USFWS marine turtle recovery plans which would need to be adjusted to characteristics of specific marine turtle stocks, or will require further clarification. Periods of time for key parameters (e.g., for foraging populations) that have not been analyzed have been left as tentative values.

declines in populations can be arrested or stabilized, should population sizes below historical levels be acceptable, given the probably diminished carrying capacity of the present-day environments and/or the existence of limited harvests of marine turtles?

Answers to these questions by scientists and resource managers are becoming more urgent as demands upon the natural resources increase. These issues need to be debated widely to reach consensus before decisions on alternative conservation or management schemes can become accepted, particularly if these are to occur at a regional scale. Yet, whichever management policy is selected, adequate benchmarks and monitoring over time scales appropriate to the biological characteristics of marine turtles are also needed to obtain universally acceptable status assessments of individual populations that are shared among the countries in a region.

Conclusions

Since marine turtle populations form discrete demographic entities, genetically isolated from other populations, major research efforts on the species in the Wider Caribbean region should focus on identifying individual stocks, and determining their distribution and migratory behavior.

Once individual stocks are identified, extinction and recovery status assessments of each stock should be promoted, taking into account that because of migratory patterns, information and analysis will need to involve collaboration among many countries within the Wider Caribbean region.

Until long-term monitoring data accumulate for periods beyond a single generation, status assessments will continue to rely on direct and indirect evidence of past abundance of marine turtles.

Universally accepted criteria for assessing population recovery need to be developed, based on the best available knowledge of the recovery process in marine turtles. These criteria should become an essential guideline for national and international resource management policy-making with which to monitor improvements in the status of individual stocks, particularly those that are shared among many range states.

Although providing essential information, extinction risk and recovery assessments will not by themselves be sufficient to define conservation and management priorities. Other factors that will need to be incorporated into the resource management decision process include cultural and economic values, as well as international commitments.

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Monitoring Population Trends

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As resource managers, scientists and conservationists, a considerable portion of our professional effort relates to population monitoring and assessment. The reasons for population monitoring are readily obvious and include the need to increase general knowledge, provide baseline data for management intervention, evaluate the success of management action, and inform general decision-making. This presentation will suggest a framework for developing a successful marine turtle population monitoring program.

One fundamental aspect of the assessment and monitoring of wildlife populations is an assessment of population trends. It is useful to begin discussing this topic by revisiting a definition. The Oxford Dictionary defines "trend" as "a general direction and tendency, to bend or turn away in a specified direction, or to be chiefly directed." We are therefore seeking to determine directions and tendencies in the population of interest.

To be informed as to whether a population is "in recovery" or is "recovered" is a desired landmark for managers and policy-makers. In order to reach this landmark, it is necessary to establish recovery criteria. There is some relativity to this. We could, for example, define "recovery" in terms of restoration to pre-Colombian population sizes. That would be a valid benchmark, but not a realistic one from an ecological or socio-political standpoint.

Sea Turtle Recovery Plans developed by federal agencies in the USA provide examples of recovery criteria; for example, "The U.S. populations of hawksbill turtles can be considered for delisting if, over a period of 25 years, the following conditions are met: (i) the adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on at least five Index Beaches, including Mona Island and the Buck Island Reef National Monument; (ii) habitat for at least 50% of the nesting activity that occurs in the USVI and Puerto Rico is protected in perpetuity; (iii) numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, USVI, and Florida; and (iv) all Priority I tasks have been successfully implemented." (NMFS-FWS, 1993).

Other examples of recovery criteria are provided by the Wider Caribbean Sea Turtle Conservation Network (WIDECAST) in its Caribbean recovery action plan series. For example, our draft *WIDECAST Sea Turtle Recovery Action Plan for Jamaica* recommends a "…. statistically significant rising trend in nesting populations over one generation, for all three [locally occurring] species" (Sutton et al., in prep.). As we heard in the species assessments yesterday, maturation requires one to several decades, depending on the species.

We [in Jamaica] have not yet developed target criteria for our foraging assemblages, nor have we moved beyond measuring "population recovery" by a single demographic parameter, typically annual estimates of the number of nesting females. This is an important point, because criteria based solely on the abundance of reproductively active females inevitably results in less available information for adaptive management than if other life stages (e.g., foraging juveniles) had been included in the assessment.

If a population is to be manipulated, either for conservation purposes or for sustainable harvest, additional criteria must be met. Indeed, most population models require age or size-specific growth rates, age (size) structure for all life stages, and other complex inputs.

Given the challenges posed to researchers by the marine, migratory and long-lived nature of marine turtle life history, there is a corresponding lack of real-world data to feed into population models. For example, long-term monitoring of adult populations on their foraging grounds (for the purpose of estimating demographic parameters) is not feasible for most marine turtle programs. As a consequence, we recognize that many if not most management

Table 1.
Comparison of accessibility (for purposes of research and monitoring) of population segment or life history stage, by species. 1 = practically inaccessible to 5 = readily accessible. Cc = loggerhead turtle; Cm = green turtle; Dc = leatherback turtle; Ei = hawksbill turtle; Lk = Kemp's ridley turtle; and Lo = olive ridley turtle.

Population Segment	***Species***					
	Cc	*Cm*	*Dc*	*Ei*	*Lk*	*Lo*
Nesting females (terrestrial)	5	5	5	4	5	5
at sea						
Large juveniles and adults at sea	3	3	1	2	4	4
Small juveniles	5	5	1	5	5	5
Pelagic neonates	1	1	1	1	1	1
Eggs and/or hatchlings	5	5	5	5	5	5

decisions will continue to be made using less-than-complete-data and will mostly likely focus on estimating changes in population parameters.

In the design and implementation of surveys and monitoring programs, conservationists and managers are constrained by human and monetary resources, as well as by the need for timely results. Monitoring programs reflect a trade-off between the accessibility of the target species and the timeline required to determine a significant trend in the various demographic parameters (abundance, recruitment, and survival/mortality). Because of their accessibility, gravid females on nesting beaches have been the mainstay of research and monitoring programs worldwide. However, slow growth and delayed maturation combine with stochastic variation in the annual number of females coming ashore to create time frames for trend analysis (annual survival, recruitment) that extend into decades. The time frame for parameter estimation and trend analysis is, by definition, much shorter for earlier life stages. Table 1 compares life stage

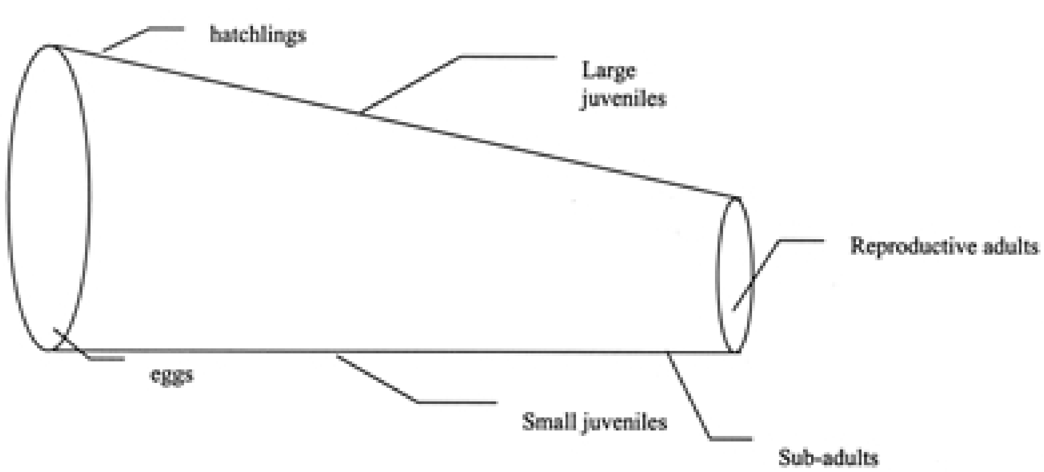

Figure 1. The Pipeline Concet

Table 2. For each "readily-accessible" life history stage (see Table 1), the minimum time frame required for parameter estimation is followed by the minimum time frame required for trend analysis in parentheses. These time frames are "floating" targets, as detecting a trend depends on abundance and the number of points (i.e., length of time), as well as the precision of the estimates. The time frames suggested here are loosely based on data from intense monitoring efforts emphasizing saturation tagging. An asterisk indicates that the "trend" for that parameter is at least 2 point-estimates that each cover the minimum suggested time frame or longer; i.e., an estimate based on 8-10 years of data will be one point in a linear regression. With fewer than five points, the power associated with any statistical tests may be low (see Gerrodette, 1987, 1993).

Parameter	*Nesting females*	*Juveniles*	*Eggs and Hatchlings*
Abundance	3-5 yr (1 generation)	1-3 yr (5 yr)	3-5 yr (3 yr)
Recruitment	4-5 yr (8-10 yr)*	3-5 yr (5-10 yr)	N/a (no prior stage to recruit from)
Annual survival	8-10 yr (8-10 yr)*	3-5 yr (5-10 yr)	N/a (hatchlings disperse to pelagic zones)

accessibility for the six Wider Caribbean species. Table 2 compares the time frame for parameter estimation and trend analysis for the various life stages. We can see from these tables that monitoring juveniles should receive increased priority from a management and policy-making standpoint.

If we visualize marine turtle life history as a pipeline (Figure 1) which "begins" with eggs laid on a nesting beach and "ends" with gravid females coming ashore to nest, the "lag" time in seeing credible results from nesting beach-based population monitoring programs is better appreciated. To expand on the pipeline concept, which is a modification of a concept first introduced by Mortimer (1995), consider the scenario of a newly protected nesting beach. Very soon we would expect to see a rising trend in successful hatchling production. Barring serious threats to neonates and small juveniles in early developmental habitats, increased hatchling production would lead, in a few years, to an increase in the number of juveniles recruited into coastal developmental habitats. Years and decades later we would anticipate an increase in larger juveniles and sub-adults. Finally, after as many as "10 to 50 or more years" (see Frazier, this volume), we might document an increase in gravid females emerging on to the nesting beach. To use nesting females as our recovery criteria is to use the life stage with the longest "turn-around time."

To improve (that is, to shorten) the timeline for obtaining quantifiable indices of recovery, we must place more emphasis on surveys and monitoring programs that extend beyond a single parameter (e.g., annual estimates of abundance) and a single life stage (e.g., mature females). In many Caribbean countries, monitoring small juveniles in neritic environments represents a positive trade-off between accessibility and a reasonable monitoring time frame (Table 3).

In summary, an *ideal* action plan for marine turtle population monitoring should logically include the following:

- estimate abundance (absolute or relative) of accessible life stages;
- estimate recruitment and survival rates for nesting females and small juveniles;

Table 3. Estimating key demographic parameters**.** An asterisk indicates that with populations of fewer than several hundred nesting females per year, saturation tagging may be required for accurate parameter estimations

	Nesting Females	*Small Juveniles*
Annual Survival	Tagging program 8 – 10 yr (*)	Tagging program 3-5 yr
Recruitment	Tagging program 4-5 yr (*)	Mark-recapture 3-5 yr
Reproductive Output	Nest counts 3-5 yr	X
Abundance	Tagging program with nest counts 3-5 yr	Tagging program 1-3yr

• estimate recruitment and survival rates for other accessible life stages, as practicable;

• estimate reproductive output (i.e., number of hatchlings per female per year);

• identify and quantify sources of mortality;

• identify the foraging grounds associated with local nesting stocks (such as by the use of satellite telemetry, tagging, genetic evaluation); and

• identify source beaches (natal beaches) for local foraging stocks.

The most successful monitoring programs will be those that are tailored to local circumstances and operate within local constraints of trained personnel, funding, infrastructure, and record-keeping capacity. Working to implement an action plan such as that described above will assist managers in the transition between the ideal and the real.

For additional information on this topic, please see Eckert et al. (1999), in particular the "Population and Habitat Assessment" chapters. In addition, Mortimer (1995), Conroy and Smith (1994) and Skalski (1990) are useful. Tim Gerrodette and John Brandon have made their software for power analysis of trends, TREND, available at http://mmdshare.ucsd.edu/trends/html

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Promoting Public Awareness and Community Involvement

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Marine turtles have been around for a very long time, much longer than we have. Given the rate at which we seem to be perpetrating the demise of our planet, and ultimately ourselves, one wonders how much longer these graceful creatures will survive. I do not wish to linger on this sobering thought, but rather I wish to deal with the issues of public awareness and participation. All of these aspects are connected because, while we seem so able to jeopardize the survival of marine turtles, we still have so much to learn about their biology and ecology. Many stakeholders remain ignorant of current information that, if they had it at their disposal, might encourage them to make a positive difference.

Many youngsters growing up in St. Lucia today have never seen a turtle, living or dead. They may have seen posters and videos and have read about marine turtles, but that is about all. As recently as the early 1980's, marine turtles were a fairly common sight at St. Lucia's fish landing sites and in the Central Market. This situation has since changed. Today marine turtle meat, eggs, and other products are illegal commodities in St. Lucia due to a moratorium on the capture of all species.

Recent reports, unconfirmed by empirical studies, indicate that St. Lucia's marine turtle stocks are on the rise. Whether or not this is indeed the case, it cannot be concluded that the environment for the survival of marine turtles is ideal or improving. There is still illegal and accidental capture of marine turtles, and managers have no idea what our standing stocks are. Thus our efforts to establish sustainable levels of take are fruitless. Moreover, many nesting beaches have been degraded or destroyed by sand mining and foraging grounds have also been affected by human activity. Further, the fact that marine turtles are migratory means that they may be prone to capture in other countries.

The St. Lucia scenario is not unique in the Caribbean context. Despite cultural and other situational differences, we all grapple with many of the same problems. Where the status of marine turtles is concerned, all of us here today have some grasp of the problems as well as some ideas on how such problems should be resolved. If I identify one of the fundamental problems as a lack of awareness, I suspect, and hope, that most of you will agree with me. If my assertion is correct, then how can we address the issue?

I believe that we need to recognise first of all that people do not always feel compelled to learn about things which do not seem to affect their day-to-day existence. The young farmer in the hills, for example, who has never seen a turtle and has no expectation of eating turtle meat in her lifetime, will not necessarily be concerned about the status of marine turtles even though soil from her farm is destroying their foraging grounds. The turtle fisher, on the other hand, might be concerned as his livelihood is directly related to the sustained existence of the resource.

One of the primary objectives of any public awareness exercise, therefore, must be to create or to reinforce in the minds of people, the link between their existence and the issue(s) at hand. While this might appear to be obvious, many public awareness campaigns fail because they do not find the right means of creating the "link".

Another fundamental point to be remembered is that the target of the public awareness campaign is not necessarily a homogenous mass of people; indeed, there may be a number of target groups including policy-makers, resource users, management officials, educators (and pupils), and civic groups. Accordingly, the message and the mechanism(s) for delivery may both have to be fine-tuned to suit the respective groups. Booklets with useful biological information will not work for fishers who cannot read. Television will reach only those with access to television. Sometimes meetings with resource user groups or one-on-one interface with influential persons will succeed where other means fail. In some situations, popular theatre or the involvement of Church has been used to great effect.

We could embark on a lengthy discourse about the ins and outs of public awareness, but that is not the objective of this presentation. I will note, however, that while public awareness in and of itself is fine, ideally it should serve as a component of an education process which will result, where possible and necessary, in action or change in behaviour which will, in turn, help to address a specific problem. On the other hand, access to proper information in a timely manner is essential for effective participation. Therefore it can be concluded that public participation is dependent upon and reinforced by the availability of and access to adequate and appropriate information.

Who then, in our context, provides information? Who receives it? What systems exist for transmission? How can it be used to generate public participation? What are the opportunities for and constraints to public participation?

In many Caribbean territories, Government, through the Department of Fisheries or other agencies, is assigned the responsibility for marine turtle research and management. Consequently, much of the information on marine turtles, as well as relevant expertise, resides within these agencies. Over the years, however, many Caribbean territories have seen the growth of non-governmental organisations (NGOs); these bring additional expertise and resources to the issues. Many NGOs, whether working independently or in collaboration with Government, have been able to collect useful information. In St. Lucia, for example, the St. Lucia Naturalists' Society and the Department of Fisheries have collaborated on leatherback turtle research at Grande Anse Beach for many years.

Based on the above, the various government and non-government organisations are usually best placed to undertake public awareness activities due to the information and, hopefully, the resources at their disposal. In some instances, community-based organisations (CBOs) are also involved in a meaningful way in research and information gathering and they, too, can participate in public awareness activities. Further, the traditional knowledge of respective user groups must not be ignored but put to the best possible use when designing and implementing public awareness campaigns. Turtle fishermen, as an example, can be very influential in a classroom, or in sensitising their peers.

In the ideal situation, information flows dialectically between entities at all levels; that is, within and among Government, NGOs and CBOs. There should be a willingness to accept new information and not to become dogmatic, particularly at the Government level. If, as stated earlier, we seek to sensitise people in order to bring about change(s) in behaviour, we must endeavour to find out where change is most needed or feasible and focus on the agents most able to effect that change. Many argue that children should be the focus of environmental awareness efforts, as they will be tomorrow's resource custodians. This is a logical conclusion in most instances. Yet in a situation where an endangered species is being over-exploited, children may not have the chance to become custodians. Does one focus then, on the children, the hunters, the policy-makers, or all?

With respect to conservation issues in general and to marine turtles in particular, I can, using the St. Lucian context, provide some insight into the target audiences for public awareness, sensitisation and education.

1. **Policy-makers** at various levels decide, *inter alia*, what position the country takes on marine turtle conservation issues;
2. **Fishers** capture turtles and play a direct role in affecting the status of the resource;
3. The **media** plays a vital role, but in many cases needs to be further sensitised to environmental issues; to inform, they first must be informed;
4. **Teachers** teach others, especially children, and therefore they have an ongoing need for accurate information;
5. **NGOs** can often take on conservation issues which governments cannot or will not address. They are often a powerful force for advocacy, and their actions must, therefore, be guided by accurate information.
6. **CBOs** are usually more active at a local (community) level. They may have significant influence on community behaviour, but can

also stimulate action at the national level.

7. **Students** are the custodians of our future … and they also have a stake in the present!
8. The **general public** as a whole should be addressed, as well, and this calls for time and effort devoted to relatively generic public awareness strategies.

How do we reach our target audiences? There are a number of approaches that can be adopted, depending on the particular community or society.

While the mass media will continue to play a role in creating and maintaining awareness, nothing equals the effect of direct contact with the resource. For example, while slick videos and slide presentations can help to sensitise the general public about the status of marine turtles, participating in a successful turtle watch and seeing one's first leatherback turtle lays its eggs will have a more enduring impact. The same applies when one re-visits an important nesting beach and witnesses first hand the destructive efficiency of sand miners in reducing the beach to a pathetic shadow of its former magnificence.

The potential impact of direct contact is heightened if the experience is presented as part of a comprehensive and ongoing process of awareness building and education. In this regard, I wish to list just a few approaches that could prove useful in many Caribbean countries where marine turtle conservation is concerned.

Training of teachers to impart relevant information through the school curriculum. Anyone who has had any teaching experience knows how difficult it is to introduce a new subject into the already packed school curriculum, whether it be Family Life Education, Drug Awareness, or Environmental Education. The most realistic option, then, is to infuse issues into existing subjects such as Math, Social Studies and so on. Teachers should be formally trained and provided with relevant background information. In this way they become equipped to pass on knowledge to a continuous stream of students. This has been tried in St. Lucia through the Learning for Environmental Action Project (LEAP). There has been some success, but there is need for continued support and follow-up.

Training of relevant Government and NGO personnel in public awareness and environmental education. This approach will assist those in our community who have the technical expertise (for natural resource management) in selecting the right "tools" for reaching their target audiences.

Collaboration and co-ordination on public awareness and education between agencies and organizations. Many organizations may be involved in such activities, but may be working independently and even duplicating effort. Wherever feasible, avenues for effective collaboration should be explored. In St. Lucia, a number of agencies are discussing the possibility of forming a national environmental education network. A coalition approach suggests a more efficient use of human and monetary resources, and the opportunity to reach a larger audience.

Establishment of accessible information databases. Consideration can be given to establishing "Sea Turtle Information" sections in school and public libraries, as well as in the offices of relevant government and non-governmental organizations. The public availability of such information should be widely advertised.

Utilising the Internet for information gathering and networking. The Internet is becoming available to more and more schools, agencies and private individuals every day and it can serve as a useful tool for information gathering and for networking at the local, regional and international levels.

I must stress, again, that the foregoing list is by no means exhaustive and a little thought and imagination can generate many more useful approaches.

Now let us assume for a moment that our public awareness and education strategies are beginning to bear fruit. People want to make a change. What can they do? Who are the agents of action?

Many of the entities and audiences mentioned above can become directly involved in conservation and resource management. Throughout the Caribbean, NGOs, CBOs, school clubs and similar bodies participate in (and often instigate and organise) turtle watches, beach patrols and related activities.

Increasingly, we hear tell of former poachers turned wardens and stewards.

In some instances, community-based monitoring is the only feasible option because the resources of the "official" state entities are unable to service these areas. In other instances there is a healthy collaboration between Government and NGO or CBO partners. In St. Lucia, the St. Lucia Naturalists' Society (SLNS), the Department of Fisheries, and the Forest and Lands Department work together to monitor leatherback turtle nesting at Grande Anse Beach. Fisheries and Forestry offices provide transportation and logistical support, while the SLNS provides manpower and equipment. The effort is presently expanding in an attempt to involve neighbouring communities, and more work needs to be done in this regard. This is especially important as the poaching which takes place at Grande Anse is mainly the work of illegal sand miners residing in the wider area.

In terms of getting wider public support, one approach that worked well in St. Lucia in the 1980s was to ask members of the public to report turtle sightings at sea or onshore. Persons from all walks of life called the Department of Fisheries, and the data compiled eventually contributed substantively to what is now the Sea Turtle Recovery Action Plan for St. Lucia (d'Auvergne and Eckert, 1993).

In closing, I believe that meaningful public participation depends on the following:

1. Interest groups have to be made to feel some sense of stewardship and responsibility for the resource;
2. Government agencies, where feasible, must encourage involvement by soliciting the participation of user and other interest groups; and
3. Relevant information must be exchanged freely among collaborating entities.

Of course, in all of this, it is helpful if there is some agreement on how the resource should be managed … or at least some degree of consensus that it should be managed at all. I am sure that we all would be happy to live in a world where we were managing our resources perfectly. However, we live in a complex world and we know that life is not that simple. We need all the help we can get to manage our marine turtles, indeed our planet. Awareness building will continue to be an essential tool in our effort.

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Reducing Threats at Nesting Beaches

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Introduction

Despite the comparatively brief periods of time that marine turtles spend on land, these periods constitute critical stages of their life history. The threats that marine turtles face on their nesting beaches are many and varied. Given the enormous challenges in the marine environment that face scientists and managers, why should we be concerned about threats on nesting beaches? There are several reasons, such as (i) the vulnerability of marine turtles (nesting females, eggs, hatchlings) is extremely high on nesting beaches, (ii) human actions on nesting beaches, whether direct or indirect, can have catastrophic implications for marine turtle populations, and (iii) the long-term reproductive survival of marine turtles hinges on a thin strand of sandy beach. Without suitable, sufficient and "safe" nesting habitat, marine turtle populations are destined for collapse. A key ingredient in any program to recover and conserve marine turtles must include a strong nesting beach component of protection. In addition, conservation efforts on nesting beaches must go hand-in-hand with protection efforts in the marine environment.

Concern for protecting and conserving nesting beach habitat is not new. More than forty years ago, Dr. Archie Carr (1956), in his eloquent book "The Windward Road", wrote: "*There were hundreds of islands and keys and mainland beaches where nobody lived and where you could comfortably imagine thousands of safe nests erupting yearly multitudes of little turtles. But... the wild beaches are shrinking. The drain on nesting grounds is increasing by jumps. It is this drain that is hard to control, and it is this that will finish Chelonia*."

While Dr. Carr was speaking specifically about the green turtle, his words and concerns are all the more applicable today, to all species of marine turtles that inhabit the Wider Caribbean Region and to all nations that have the good fortune to harbor nesting sites. This paper will provide a review of the principal threats that face marine turtles at Caribbean nesting grounds. For additional information on this topic, interested readers should consult Witherington (1999) and Lutcavage et al. (1996). The recently published "Research and Management Techniques for the Conservation of Sea Turtles" (Eckert et al., 1999) explains standard protocols for beach assessment and monitoring and is a "must-have" for the development of assessment, monitoring, and management programs for marine turtles.

The key to solving problems on nesting beaches is to identify the threat(s) facing a particular population, assess the magnitude of these threat(s), and prioritize actions to ensure that effort and resources are focused in the most effective manner. Expending inordinate amounts of time, personnel, and/or funds addressing threats that have low impact on a population, while more serious threats go unchecked, hinders population recovery, depletes program funds, and frustrates personnel. Understanding the threats operating on nesting beaches requires careful survey and monitoring efforts during the nesting and hatching seasons; thus, an assessment of threats is the first step. Follow-up monitoring efforts are equally important in that they are required to evaluate the success of management action taken to reduce priority threats.

Witherington (1999) suggested four general approaches to minimizing threats on nesting beaches: (i) eliminate the threat, (ii) manage the threat, (iii) relocate eggs, or (iv) do nothing (some threats, such as chronic erosion, either cannot be eliminated or threaten too few nests to justify costly intervention). The preferred approach will vary depending on the specific situation and local conditions, but in general the least manipulative approach is preferred. Management actions that allow the nesting cycle (from egg-laying to hatchling emergence) to occur without direct human intervention should be the goal. Measures that require some level of manipulation (e.g., beach hatcheries) should be considered interim measures while efforts continue to solve underlying threats. Manipulative management measures are often costly, time consuming, and require high effort; thus, eliminating the source of the threat can be the most cost- and labor-effective in the long run.

Threats to marine turtles on their nesting beaches may generally be divided into two sources: natural and anthropogenic (human-induced). Anthropogenic threats may be direct (e.g., egg poaching) or indirect (e.g., artificial beachfront lighting). The following discussion will review the principal threats.

Managing Natural Threats

Depredation: Depredation of nesting females, eggs, and/or hatchlings, while generally considered a "natural threat", is often linked indirectly to human activity and the consequences of coastal development. For example, small mammals are a significant egg predator on some nesting beaches, largely because their populations are unnaturally high as a result of the creation of new and favorable habitat, access to human garbage, or the removal of top predators in the ecosystem. In a normally functioning ecosystem, natural predators are an integral part of the system; however, on some nesting beaches, depredation of nests can be so significant that steps must be taken to reduce this source of mortality. Highly successful techniques and programs have been implemented that reduce nest depredation, including the use of nest cages and screens that keep predators out while allowing egg clutches to incubate *in situ* and hatchlings to emerge unimpeded.

Storm Events: Episodic storm events that occur during the incubation period can expose and destroy incubating clutches or cover them with so much additional sand that hatchlings are prevented from emerging successfully. Storms can also alter beach profiles and deposit extensive debris, leaving the beach unsuitable for successful nesting. These naturally occurring events are unpredictable and little can be done to prevent ensuing damage. Some managers have suggested that relocating nests to a safer (more stable) beach site provides assurance that storms will not affect nest success, but manipulative intervention can introduce unacceptable risks (e.g., high cost and maintenance, lowered hatch success), especially when the probability of a catastrophic event is comparatively low.

Beach Erosion and Accretion: Nesting beaches are dynamic and undergo physical changes on a regular basis, irrespective of major storm events. Over time some nesting beaches may naturally erode, while others accrete. Marine turtles have evolved to successfully adjust to these changes, provided the changes are not exacerbated or accelerated as a result of human alterations to the beach dune system (see discussion to follow). When human intervention is deemed necessary, under certain local conditions, to safeguard nests from erosion or accretion, the least manipulative option is generally preferred.

Managing Anthropogenic Threats (Direct)

Poaching: Illegal poaching of nesting females and/or eggs can devastate a local marine turtle population and contribute to range-wide depletion. Important strides have been made in addressing this threat in some range states, but poaching remains a serious problem in many places throughout the Wider Caribbean Region. Public outreach and education, community participation in management and recovery programs, and effective law enforcement all contribute to a successful strategy to reduce and eliminate this serious and ubiquitous threat.

Managing Anthropogenic Threats (Indirect)

Virtually all indirect, human-induced threats to turtles on their nesting beaches are intricately related to coastal development. Not only do the vast majority of Caribbean people live on or near the coast, but tourism especially targets coastal areas. The potentially negative impacts to marine turtles of coastal development must be taken seriously and should be addressed in any comprehensive plan for species conservation and recovery.

Beach Erosion: As discussed above, beach erosion is a natural process and part of the dynamic coastal system. As part of a naturally functioning system, beach erosion does not pose significant long-term negative effects to turtles. However, human alterations of the landscape can alter the coastline such that beach erosion is exacerbated and nesting beach habitat is degraded or destroyed. The dredging of natural inlets and the creation and maintenance of man-made inlets to allow deep water vessel access, for example, can significantly alter normal littoral sand transport processes and result in serious erosion at nesting beaches (Kaufman and Pilkey, 1983; Pilkey and Dixon, 1996). Placement of structures on, or in close proximity to, beach frontage can destroy the ability of the beach to respond to normal erosion/accretion cycles and storm events, and ultimately degrades and destroys nesting habitat as well as sandy beach habitat enjoyed by humans.

Coastal zoning that carefully considers the full range of impacts resulting from coastal development is urgently needed throughout the Wider Caribbean Region (and the world). Important lessons can be learned from poorly planned coastal development, and a policy of retreat from the shoreline (often referred to as construction setbacks) should be among those options most seriously considered to repair damage to coastal areas.

Beach Armoring: Armoring consists of a wide variety of hard or semi-hard structures (e.g., concrete or wood seawalls, rock revetments, steel sheet pile walls, sandbags) that are designed to protect upland property from wave force and water damage. In many areas, especially heavily developed areas, armoring is proliferating unchecked and the results are devastating for nesting turtles. Armoring structures block access to suitable nesting habitat, prevent the beach system from functioning properly and, under the most serious conditions, destroy all dry sandy beach. The impacts of coastal armoring structures on marine turtle nesting behavior are serious and include decreased nesting attempts and decreased nesting success (e.g., Mosier, 1999). From a long-term perspective, coastal armoring may be the most grave indirect threat facing marine turtles on nesting beaches. More thoughtful coastal planning that takes into account all users of the beach system, not simply those who own beachfront property, is urgently needed.

Artificial Beach Nourishment: A common practice in highly developed areas, beach nourishment consists of the placement of sand, through mechanical means, on eroded beaches. Sand sources may be from upland sites, dredged inlet material, or offshore "borrow" sites. Sand characteristics are critically important to successful marine turtle nesting, and subtle alterations of the natural nest environment can result in decreased nesting success (i.e., a decline in the number of nests laid), decreased nest success (i.e., a decline in the number of successfully emerging hatchlings), skewed hatchling sex ratios, and decreased hatchling fitness (see Ackerman, 1996; Foley, 1998). In addition to the environmental costs, beach nourishment projects are expensive and must be repeated regularly to maintain the artificially created shoreline. Conducting beach nourishment projects during nesting and hatching seasons is especially harmful to local populations. Despite nest relocation efforts in advance of nourishment projects, some nests are invariably missed and the risks (e.g., decreased hatch success) associated with egg relocation must be taken into consideration.

It should also be noted that the removal of nearshore and/or upland sand is not without broader ecological consequences. As more readily accessible sand sources are depleted, the search for sand widens, making projects more costly and widening the sphere of ecological concerns. Thoughtful, long-term coastal planning that obviates the need for perpetual beach nourishment should be among the goals of an integrated plan for species conservation and recovery.

Sand Mining: Sand mining is the opposite of beach nourishment and involves the deliberate mining of beach sand for use in construction (e.g., concrete production). According to UNEP (1989), "Sand mining is a predominant cause of beach and dune destruction throughout much of the insular Caribbean." The removal of beach sand destroys the functioning beach-dune ecosystem, exacerbates erosion, and can directly destroy incubating egg clutches. Sand mining can alter beach profiles which may lead to the intrusion of saltwater into incubating nests and result in escarpments that prevent nesting turtles from accessing suitable nesting sites. Sand mining on marine turtle nesting beaches is a chronic problem at many sites in the Wider

Caribbean Region and has degraded or destroyed once valuable nesting areas (see Eckert, 1995). Beach sand mining is incompatible with successful marine turtle nesting.

Artificial Beachfront Lighting: As coastal areas are developed, structures are lighted. Once remote areas now have ready access to electrical power. The negative effects of artificial lighting on nesting females and their emergent hatchlings have been well documented to include reduced nesting success and, most seriously, modifications to the sea-finding behavior of hatchlings (Witherington, 1992; Witherington and Bjorndal, 1991). Lighted beaches have catastrophic consequences for tens of thousands of hatchlings each year, and can significantly reduce hatchling productivity across large stretches of suitable nesting habitat. Fortunately, among anthropogenic threats, artificial lighting is one of the most easily solved. Witherington and Martin (2000) provide a comprehensive review of the problem and provide a wide-range of solutions. These solutions have been used with excellent success at many nesting beaches. Sky-glow caused by the cumulative effects of thousands of inland light sources not directly visible from the nesting beach is a more complex problem and one that has yet to be adequately addressed.

Beach Cleaning and Vehicle Use on Beaches: Beach cleaning often involves the use of mechanized machinery to remove both human garbage and natural materials from the beach. The use of mechanized beach cleaning vehicles, as well as driving on beaches for other purposes, can directly damage incubating egg clutches or pre-emergent hatchlings, create tire ruts that impede the movement of hatchlings from nest to ocean, and/or directly kill emergent hatchlings traversing the beach (Hosier et al., 1981; Cox et al., 1994). The removal of human-generated garbage from nesting beaches should be done by hand whenever practicable. Removal of natural materials from the beach (e.g., seaweed) should not be a matter of routine practice, as these materials serve important roles in the beach ecosystem and provide food and cover for other species that share the beach, such as shorebirds and invertebrates. Driving on nesting beaches should be limited to emergency situations only, and should be confined to the lowest portions of the beach, away from incubating nests.

Increased Human Presence: The development of coastal areas brings human activity to the beach and can both negatively and positively affect marine turtles. Uncontrolled human activity can deter nesting females, cause aborted nesting attempts, and the use of lights can lead hatchlings astray. Recreational beach equipment (e.g., beach chairs) can block access to nesting sites, impede hatchlings, and trap nesting females. On the other hand, increased human presence may deter poaching and may provide for more accurate monitoring and protection. Organized, ecotourism-oriented "turtle watches" can bring heightened awareness of marine turtles to coastal communities and serve as a source of income, underscoring the value of live turtles and the value of protecting nesting beaches. It is important that this aspect of ecotourism be carefully planned to ensure that it does not interfere with nesting activity. Local communities should strive to develop measures that protect turtles while at the same time educate, inform, and galvanize public support for their long-term conservation.

Oil Spills: Nesting females, incubating eggs, and emergent hatchlings can all be exposed to oil that reaches nesting beaches. Lutcavage et al. (1995) provide a review of the effects of oil on loggerhead turtles (*Caretta caretta*). While some nations have developed oil spill response plans, an integrated response plan is needed throughout the Wider Caribbean Region. The catastrophic effects of a large-scale oil spill may be unthinkable, yet the probability that such an event may occur cannot be ruled out. We must be prepared to rapidly mobilize, act, and provide whatever assistance is necessary when the time comes. Most Wider Caribbean governments are Contracting Parties to UNEP's "Protocol Concerning Co-operation in Combating Oil Spills" to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region ('Cartagena Convention') (see Andrade, this volume).

Summary

It should be clear from this overview, as well as that provided by Horrocks (this volume), that the challenges facing managers concerned with marine turtle recovery and conservation are numerous and complex. Ensuring the survival of marine turtles in the Wider Caribbean Region will require genuine cooperation within and among nations. I would like to suggest the following reasons why it is important to have a shared vision and a plan of action for protecting marine turtle nesting beaches:

- Nesting females exhibit strong nest site fidelity; a short-term ability on the part of nesting females to shift nesting sites as their natal beaches are degraded or destroyed should not be assumed.
- Each nesting beach produces turtles that are eventually shared (in non-breeding habitats) by many other nations. Hatchlings produced in one nation become immature and adult turtles that inhabit the waters of one or more other nations, and they form an integral part of the regional ecosystem.
- Nesting habitat, once destroyed, can oftentimes be impossible to restore, and with its destruction may come dire consequences to the human economy.
- Catastrophic events on a subregional scale may affect nesting habitat and reduce nesting success for one or many years, thus emphasizing the value of a mosaic of healthy, intact nesting habitats.

While significant progress has been made in addressing some of the identified threats on nesting beaches, more work is clearly ahead of us to ensure the recovery and long-term survival of marine turtles in areas where they have been seriously depleted. We must work both regionally and domestically to ensure that sufficient nesting habitat remains intact and protected for the long-term future. A unified strategy and range-wide attention to reducing nesting beach threats must occur in order to recover the depleted populations of marine turtles in the Wider Caribbean Region.

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Reducing Threats on Foraging Grounds

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Introduction

Reducing threats to marine turtles, eggs and hatchlings at nesting beaches and protecting beach habitat is only part of the process required to ensure the long-term survival of threatened and endangered marine turtle populations. Threats to marine turtles on their foraging grounds, as well as threats to foraging habitat, must also be identified and addressed.

Following an epipelagic post-hatchling dispersal phase, most Caribbean marine turtles (with the exception of the leatherback) settle into relatively shallow nearshore foraging habitats where they will spend the vast majority of their lives (Meylan and Meylan, 1999). Two particularly important foraging and refuge habitats for marine turtles in the Caribbean region are coral reefs and seagrass beds. Coral reef-associated algae, sponges and other invertebrates are grazed and preyed upon by hawksbills (Meylan, 1988), and coral reefs are widely used as refuge areas by hawksbill and green turtles. seagrasses are grazed by herbivorous green turtles, while olive ridleys and loggerheads prey on crustaceans and other invertebrates within the beds (Bjorndal, 1997).

As juveniles, turtles may reside for relatively short periods on a particular reef or in a particular seagrass bed; individuals may move extensively among nations during the decades prior to sexual maturity. Upon reaching adulthood, turtles apparently engage in more predictable movements between established breeding and foraging grounds. Studies of the migratory behaviour of post-nesting hawksbills in Barbados, for example, suggest that these animals may only be in Barbadian waters for a few months every few years, and that immediately following their last nest they leave Barbados and return to resident foraging grounds in other countries, taking advantage of prevailing currents and moving quickly over areas of deep water (Horrocks et al., submitted). Minimising threats to turtles on foraging grounds, particularly threats to adults, and minimising threats to the foraging grounds themselves are clearly critical to the effective management of marine turtle populations (Eckert, 1995; IUCN, 1995).

The Importance of the Coastal Zone

Most marine turtles spend the majority of their lives in nearshore marine habitats within 2 km of the coast, and 40% of the human population of the Wider Caribbean Region resides within 2 km of the coast. Many threats to the marine environment emanate from the land ... and the nearshore coastal zone is disproportionately affected.

Coral reefs and seagrass beds are among the most important coastal resources in the Wider Caribbean Region. Reefs are formed by the secretion of calcium carbonate skeletons by tiny colonial animals (Cnidaria). seagrasses are submerged flowering plants. Both ecosystems are slow to develop and slow to recover from disturbance. The fastest growing corals (e.g., finger corals, staghorn corals) grow at rates of 2.5-26.6 cm/yr, while the massive brain corals only 0.81-2.5 cm/yr (Davies, 1983). Similarly, mature seagrass beds (defined as 95% substratum cover) dominated by the climax species *Thalassia,* (commonly known as turtle grass) require some 15-50 years to develop (Patriquin, 1975, Duarte, 1995).

Coral reefs and seagrass beds are both highly productive ecosystems, and aside from their value to marine turtles, they provide substrate, food, shelter and nursery areas for many commercially important fish and crustaceans. Coral reefs are the basic habitat for all of the reef-associated fish that support trap fisheries throughout the Caribbean. seagrass beds serve as juvenile and adult habitat for many commercially harvested species (e.g., shrimp, lobsters, conch, sea urchins, mullets) in addition to be used as nursery habitat by commercially important reef fish (e.g., groupers, parrotfish, surgeonfish) and as foraging habitat to which adult reef fish routinely migrate (e.g., grunts, snappers, parrotfish, squirrelfish). Studies have shown that coral reefs near to seagrass beds have larger and more diverse reef fish populations than reefs without nearby beds (e.g., Ogden, 1972; Salm and Clark, 1984).

Much of the sand on Caribbean beaches is produced as a result of the erosion of reef structure and reef-associated calcareous algae, and reefs physically protect the coastal zone during storm and hurricane events. seagrass beds are also important in physically stabilising the coastal zone. Their dense leaf canopy reduces current velocity near the sediment surface and promotes settling, and the roots and rhizomes bind sediments and limit erosion (Ogden, 1983). seagrass meadows often develop in the protected waters landward of reefs, and they play an important role in reducing sedimentation of reefs from land-based sources. Coral reefs and seagrass beds therefore have a high level of ecological interdependence and a change in one ecosystem as a result of man's activities often has repercussions in the adjacent ecosystem, emphasizing the need for a holistic approach to their management and conservation.

Managing Threats to Foraging Habitat

Declining Water Quality: Declining water quality is perhaps the most important factor affecting shallow marine habitats. Fringing reefs are in the immediate vicinity of the land, and this results in them being maximally exposed to land-based sediments, high levels of nutrients such as nitrates and phosphates from sewage and fertilisers, and of industrial and agricultural pollutants. Between the years 1982 and 1992, percent substrate cover by living coral on the fringing reefs of Barbados declined by between 30-50% and species numbers by between 25-45% (Hunte et al., 1998). The principal cause was algal overgrowth resulting from reduced grazing pressure and eutrophication.

Increased sediment loads reduce the amount the light needed by seagrasses and the algal symbionts of corals for photosynthesis. Turbidity is increased by sediment runoff from land-based sources as a result of poor land clearing practices for agriculture, deforestation of watersheds, reclamation of mangroves, mining, road construction, and development activities for tourism such as marina construction and golf courses (Gibson and Smith, 1999). Similarly, dredging for navigational purposes or shoreline reclamation can significantly increase nearshore turbidity in localized areas. Upon settling, sediments reduce available substrate for larval settlement by corals and other reef-associated organisms, reduce oxygen levels, or in severe cases physically smother corals and seagrasses. Pesticides and herbicides that are toxic to marine organisms can also be bound to sediment particles.

Nutrient enrichment of nearshore waters is of increasing concern in the Wider Caribbean Region. On Barbados' south coast, for example, there was a 3-10 fold increase in nitrate contamination of ground water discharging into the coastal zone between 1977 and 1994 (Delcan International Ltd., 1995). A primary source of the nitrate contamination is sewage, reflecting increased tourist and resident densities in the coastal zone over this 15-year period. Nutrient enrichment of the water promotes the growth of microscopic phytoplankton, benthic or bottom-living macro-algae and of epiphytic algae.

Microscopic algae suspended in the water column contribute to turbidity and further reduce light penetration to seagrass beds and reefs. The increased BOD (biological oxygen demand) caused by algal respiration can reduce oxygen levels sufficiently to contribute to fish kills. Increased abundance of benthic turf and macroalgae can result in overgrowth of the slower growing corals leading to increased mortality, particularly among juveniles (Wittenberg and Hunte, 1992). Dense cover by turf algae also decreases successful coral larval settlement on reefs. The problem of increased turf algal abundance on reefs has been aggravated by reduced herbivory on reefs. Over-fishing of herbivorous reef fish, and the 1983 mass mortality of the black spiny sea urchin (*Diadema antillarum*) throughout the Caribbean, have both contributed to reduced herbivory on Caribbean reefs (Hunte et al., 1996). Epiphytes growing over seagrass blades may reduce light availability and hence the growth rates of seagrasses.

With respect to the use of seagrass beds as foraging habitat by green turtles, it is important to note that nutrient enrichment of nearshore sediments may increase the abundance of narrow-bladed seagrass species, such as *Syringodium*, relative to the broad-bladed *Thalassia* (Vermeer, in prep). *Thalassia* is the seagrass species most often seen in gut analyses of Caribbean green turtles (Mortimer, 1981) and may be preferred over other species because it can be grazed more efficiently. *Thalassia* can fix nitrogen in its roots (Patriquin and Knowles, 1972) and therefore in more pristine, nutrient-poor waters, it has a competitive edge over *Syringodium*.

Anchor Damage: As tourism and pleasure boating intensifies in the Caribbean, indiscriminate anchoring can result in significant physical damage to both coral reefs and seagrass. Anchors uproot seagrasses and break the rhizome system; once the roots are disturbed, recovery is slow. Repetitive anchoring in many coastal bays of the U.S. Virgin Islands has so reduced seagrass cover that pastures once extending to 18.5 m depths now rarely persist below 4 m. With disturbance rates higher than recovery rates in many areas, the capacity of seagrass beds to support foraging green turtles is declining (Williams, 1988). Local physical damage to coral colonies through indiscriminate anchoring can be extreme and in addition to the direct mortality caused, holes and channels in the reef can alter current patterns and result in atypical sediment movement, thus causing further damage.

Oil Pollution and Marine Debris: The Wider Caribbean Region is one of the largest oil producing areas in the world. Most of the oil produced in the region is shipped to destinations within the region, and on an average day, more than 700,000 tons of oil are being transported by sea (Gibson and Smith, 1999). The result is an intricate network of distribution routes, some of which run through restricted channels close to islands, and which increase the vulnerability of the region to accidents. In spite of regulations established in Annex I of MARPOL 73/78 (Convention for the Prevention of Pollution from Ships), tankers do not always use port facilities for the disposal of bilge and tank washings. The deliberate release of washings at sea far exceeds the amount of oil entering the sea from accidental spills. Offshore oil and gas exploitation are also potential sources of pollution, either in the form of accidental oil spills or from the release of "produced water" from the oil-bearing strata during drilling operations.

Oil pollution and tar fouling are hazardous to coral reefs and seagrass beds, as well as to marine turtles and their young (Lutcavage et al., 1995). Aside from the toxic effects of oil constituents, an oil slick decreases gas exchange between the water and the atmosphere, and can cause oxygen depletion in enclosed bays. Following a spill on the Caribbean coast of Panama in 1986, seagrasses declined in biomass and infauna was severely affected, intertidal reefs declined, and sub-tidal reefs suffered significant mortality and sub-lethal effects (Keller and Jackson, 1993).

Marine debris (i.e., garbage disposed at sea, or finding its way to the sea from land-based sources) is a serious global threat to the coastal zone. Death to marine turtles as a result of ingestion or entanglement in marine debris is widespread and well publicized (e.g., Balazs, 1985), but perhaps less widely known is the threat that debris poses to the environment. For example, plastic bags can wrap around corals and suffocate underlying tissues. Debris also smothers seagrass, and can leak noxious elements and pose other threats to important foraging habitats.

Damaging Fishing Techniques: The use of dynamite, chemicals and coral smashing techniques to capture fish causes irreparable harm to the sea bed, and especially to coral reefs. Bottom trawling, and the dropping of fish traps or anchoring blocks indiscriminately on living reef is similarly destructive. In the case of dynamite, many non-target fish are killed. Many of the target fish do not float to the surface and therefore are not collected. The physical damage effected by methods such as these destroys the very foundation of the reef, reducing or eliminating its capacity to support commercial fishes and invertebrates, as well as marine turtles (Gibson and Smith, 1999). Chlorine and a wide variety of other chemicals are extremely toxic to corals.

The application of chlorine bleach or other noxious substances to a reef for the purpose of catching lobsters or obtaining fish (including tropical specimens for the pet trade) kills corals, poisons important nursery areas for commercial fishes, and degrades marine turtle foraging habitat.

Tourism Impacts: These stressors are particularly serious in countries where there is significant tourism development. Negative impacts include careless snorkeling and diving, collection of corals and reef-associated organisms for sale to tourists, and physical removal of reef rubble and seagrass to improve areas for sea-bathing.

Global Warming: The impacts discussed above are, in a sense, local but widespread stressors of reef and seagrass systems. However, there are other more global factors that contribute significantly to seagrass and coral reef disease and deterioration. These are increases in sea temperature, severe storm events, and sea level rise, all of which have been exacerbated by human-induced global warming resulting largely from excessive CO_2 emissions in the developed world. These stressors cannot easily be mitigated by individual countries in the region and require mitigation at a regional or global level.

Managing Threats to Marine Turtles on Foraging Grounds

The major threats to marine turtles on their foraging habitats arise as a consequence of directed catch, whether legal or illegal, and incidental catch. This becomes particularly problematic when turtles are protected on the nesting beaches in one country but exploited on the foraging grounds of another. For example, adult female hawksbills nesting in Barbados where they are legally protected, spend the majority of their lives in the waters of countries that have legal turtle fisheries. These countries may have closed seasons, but their closed seasons generally coincide with the breeding season in order to protect their own breeding populations. The "Barbados females" return to their foraging habitats in these countries as the closed seasons end there, and they are, therefore, fully exposed to the harvest.

Incidental catch can sometimes be more damaging to marine turtle populations than directed catch (Oravetz, 1999). The annual mortality of loggerheads and Kemp's ridley turtles due to drowning in shrimp trawls in U.S. waters, for example, was estimated at 5,500-55,000 per year in 1990 and has been a significant factor constraining the recovery of the "Critically Endangered" Kemp's ridley turtle. Likewise, incidental capture of leatherback turtles in the swordfish gill net fisheries of Chile and Peru has been implicated in the recent collapse of the largest nesting assemblage of leatherbacks in the world (in Pacific Mexico: Eckert and Sarti, 1997).

Aside from catch, turtle mortality on the foraging grounds due to oil ingestion and smothering, ingestion of and entanglement in debris, and as a result of boat strikes is widespread. We have all seen examples of this in our own countries.

Summary

All of the factors discussed above (see "Managing Threats to Foraging Habitat") are known to pose threats to coral reefs and seagrass beds, critically important foraging habitats for the long-term survival of marine turtles. But the diversity and vitality of these ecosystems may also have been adversely affected by the demise of the turtle populations themselves (Bjorndal, 1999). Both hawksbills and green turtles fill unusual marine feeding niches. Green turtles have specially modified guts that can digest the cellulose found in seagrasses, and the hawksbill gut is modified to subsist on a diet consisting almost entirely of sponges. We do not know what the impacts of historically high levels of turtle harvest have been on these ecosystems. Currently, only about 10-20% of seagrass biomass in the Caribbean is grazed by herbivores, the remainder either decays *in situ* and forms the base of detrital food chains, or floats out to sea to form the base of pelagic food chains (Thayer et al., 1984).

Before European colonisation and increased levels of turtle harvesting, a much larger percentage of the primary production in these beds would have been grazed by green turtles, and nutrients moved from the seagrass beds to contribute to the energy budgets of adjacent reefs. Furthermore, green turtles are known to maintain grazing plots, i.e. to consistently re-graze specific areas (Bjorndal, 1980). The re-growth provides a higher quality diet for the turtles because the new blades are higher in nitrogen and lower in indigestible lignin. It is very likely that this conditioning of the environment by green turtles was also to the benefit of other formerly important grass bed herbivores. In short, the absence of green turtle grazing has probably significantly altered the productivity and nutrient content of seagrasses, and through this, the biodiversity and community structure of the grass bed ecosystem. It has also been recently suggested that spongivorous hawksbills play a critical role in controlling overgrowth of corals by sponges on coral reefs (Hill, 1998). Consideration needs to be given to what the repercussions have been for the health of coral reefs from the widespread decline in numbers of hawksbills over the last few decades.

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Strengthening the Regulatory Framework

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Introduction

This paper is about the regulatory framework for the protection and management of the natural environment and, in particular, the marine turtles of the Wider Caribbean Region. The words 'regulatory framework' imply a body of rules and regulations that constitute a national framework for environmental protection, including marine turtles. Before exploring these rules and regulations it is necessary to put the framework in its proper setting, and that is the national level. Earlier today, Mr. Andrade (UNEP) provided an excellent review of international treaties and conventions applicable to the protection and management of marine turtles. These (international) legal instruments are, in principle, only binding between parties; that is, between countries. To be effective at the national level, treaties need either to be transformed into national law or at least must be directly applicable to nationals in their local legal setting.

We must keep in mind the structure of the political, economic and socio-cultural system of a country. If we consider the Caribbean Region, for example, there are big and small states and island nations. There are four major language groups (English, Spanish, French, Dutch) and hundreds of dialects. Caribbean states have different historical backgrounds, and this heritage is reflected in the national regulatory framework. Within this context we find the basis for the existing structure of legislation, organization, implementation, control and enforcement of rules and regulations in every Caribbean state necessary to protect and manage the environment and, in this case, marine turtles.

Despite the differences, there is a common logic among regulatory mechanisms, and it is this logic which forms the basis of my presentation.

Legislation and Legal Structures

The first area to consider is the legal structure of the state. One needs to examine the body of environmental laws and derivatives, including decrees, ordinances, rules, regulations, legal guidelines, and rulings, to have an impression about the type of regulatory framework that exists to protect the environment. In general, there are two types. The first category is comprised of laws that protect and manage marine turtles directly. These laws protect specific species (flora and fauna) and their habitat. Fisheries legislation can be placed in this category, although fisheries rules tend to have a strong economic tendency and value. The second category is comprised of laws that protect and manage marine turtles indirectly by prohibiting activities that are harmful to the environment, and are generally considered harmful to people as well. Examples include laws against pollution of the marine environment, or spatial planning legislation on land.

It is important to understand the different kinds of regulations in place at the national level. Very often there are strict norms, such as rules that prohibit or rules that are mandatory, and these are referred to as "hard laws". There are also rules that demand installing various types of policy and management plans, which are referred to as "soft laws". Regulations of all types can be constrained by insufficient and/or outdated legislation, and this is certainly true of marine turtles where, for example, many fisheries laws protect young turtles but allow the seasonal harvest of breeding-age adults. We also find conflicting regulations, which makes it even more difficult to know what is applicable and what is not. Moreover, we find that countries are party to international or regional treaties, such as CITES, SPAW or CMS, but have failed to implement treaty commitments by adopting the necessary implementing legislation at the national level. As a result, multilateral agreements are significantly weakened.

Organizational Structures

Part of the regulatory framework is the legal organization of the Government, be it on a national level and/or vested in local municipalities. Most Governments are divided into departments or (sub)departments that operate independently of one another and all have their specific legal tasks to perform. Some of them protect or manage nature, including marine turtles (e.g., National Park Service, Department of Environment), or have related tasks (e.g., Fisheries Department) or combined tasks (e.g., Department of Public Health and Environment).

Besides governmental offices or departments we sometimes find subsidized private organizations that are given a mandate by the government to protect and manage nature. As private corporations or foundations, these organizations perform governmental tasks. Nowadays there is a trend to increasingly "privatize" former government offices and make them semi-governmental or independent private organizations with governmental tasks. In these cases, the government withdraws from an executive role and focuses more on policy development and control. These private organizations are then subsidized for their task of managing the environment.

In the organizational field we find also the non-government organizations (NGO's), which are a strong force nowadays in the environmental framework. The first and oldest role they play is that of a "watchdog organization", observing and often criticizing bureaucratic and inefficient action by government in environmental protection and management. They form an effective advocacy for all kinds of specific environmental topics, including the protection of biodiversity. More recently we see the role of NGO's changing, becoming partners of government. By acknowledging that governing structures can be ill-equipped to perform specialized executive tasks, resource agencies form alliances with NGO's with the intent of allowing the NGO to perform a task originally done by the government. The government may subsidize the NGO, and in return the NGO uses these funds more efficiently (than could government) and with maximal output.

Even in countries where there is no strong NGO presence, individual non-organized activities can make a difference. For example, public outcry as a result of media coverage of the pointless slaughter of a giant leatherback turtle may result in changes in public attitudes and public policy.

As a final note on organizational structure, we find that, as a general rule, there is institutional overlap and redundancy within the governmental organizational structure in Caribbean countries. There are also gaps in jurisdiction among departments which lead to non-productive competition and duplicative programming or, alternatively, inaction as one department is confident that "the other will do it". We see similar patterns among NGOs. In countries with energetic and enthusiastic NGO's, we sometimes find several groups working with almost the same statutory goals . . . and in this case there is redundancy and wasted effort. On the other hand, other critical areas with the same need for input and energy are neglected.

Implementation

With regard to the implementation of plans and programs within a legal framework for environmental protection, we see within the Government organization the following constraints. First, there is a pervasive lack of sufficient funds for all the necessary tasks required to protect and manage the environment properly. Government income from taxes is decreasing, while the scope of tasks is increasing. Environment is an area that was some years ago a primary sector for fund allocation. Today we see interests changing to combating crime, poverty, health and drug abuse, and other social issues. What funds are given to the environmental departments are often and necessarily allocated to wages and infrastructure, such as vehicles, offices and utilities. For every dollar budgeted, the major part is not used for direct environmental projects in the field. Second, we face a lack of technical personnel trained to oversee all the necessary tasks required to protect and manage the environment properly. A related problem is that what government lacks in quality, it makes up in quantity; that is, more people are employed than reasonably necessary. Finally, with respect to plans and programs on which budgets are appointed, many such plans lack realistic goals and time-frames; for this reason, progress is difficult to evaluate. Bureaucratic rules and regulations make the project "input-oriented" rather than "output-oriented". It is critical that information is shared among departments (indeed, among countries) to ensure that the lessons of the past are learned and that best practices are strongly integrated into policy making and planning.

NGOs have fewer bureaucratic problems, but often struggle mightily to acquire the necessary funds for their scheduled environmental programs and goals. It seems that the government subsidy is always given to the other NGO, and not yours! Competition amongst NGOs, especially for limited funding, is common. Too often the subsidy is insufficient to ensure a proper job, or funds are specifically earmarked for relatively low priority projects. A lot of energy is put into fund-raising, and thus diverted from the real work of environmental protection. On the other hand, strong competition (in biological terms, the struggle for life) makes the surviving NGOs strong, efficient, and not to be underestimated players in the national environmental framework.

Control and Enforcement

Despite common shortcomings, there is, of course, always some legal structure and most governments have a more-or-less functional organizational structure when it comes to the environment. Government also has the obligation to use its power to enforce the laws protecting the environment, including public health, land use, biodiversity, etc., and to ensure the continuation of necessary projects and action plans. When violations or breaches of the law are identified, action must be taken. Control and enforcement are usually seen as a governmental, especially police, task and area of responsibility.

Typically there are three areas in which we can think of control and enforcement. The first is the use of administrative powers. Many departments of government have special supervisory powers to control and inspect people's, and especially corporation's, activities. If these activities are not done in agreement with the relevant laws or regulations, actions can be taken that include withdrawal of subsidy or permits, or prohibiting the person or corporation to continue the task. Government can take many actions without the use of judicial steps. The second area is the judicial route, or what I call the use of penal powers. Many laws have penal articles as methods for enforcement. Police and special enforcement agencies (generally answering to the office of a public prosecutor) have the power to perform investigations into activities that are suspected of being illegal. With enough evidence, offenders or wrongdoers are prosecuted by a judge or court of justice and allotted a fine or even imprisonment. The third area which can be used to combat environment unfriendly behavior is the use of civil law powers. Individuals, NGOs, and even government can use torts or unlawful behavior lawsuits against offenders and claim damages. Nowadays a trend is visible where NGOs are suing the government in civil court for non-compliance or negligence with regard to laws they (government) made themselves. This is surely a part of the watchdog role of NGOs.

Once again, constraints in the area of law enforcement include funding shortages and a lack of basic tools (e.g., patrol boats, vehicles, radios). Enforcement and other skills training for rangers are, too often, minimal. And penalties, if given, are not commensurate with product value or the ethical standards of the community. The majority of environmental fines, and this includes marine turtle violations, are far too low to act as effective deterrents. Public prosecutors tend to focus on common criminality, rather than environmental offences. Support from government for its enforcement agencies is typically low and sometimes internal corruption ensures that the enforcement effort is not made.

Conclusions

To summarize and to conclude, there are four areas to consider when talking about the regulatory framework for environmental protection and management. These are: (i) legislation, (ii) organization, (iii) implementation, and (iv) control and enforcement.

Every one of these areas has its own specifics to recognize. After recognition, it is necessary to identify the setbacks and constraints of each area. Only then will it be possible to find solutions and to make recommendations for improvement in each area. I have almost not touched on this last aspect; that is, how can we improve and strengthen the regulatory framework so that the environment, including our marine turtles, will meaningfully benefit from it? I did this intentionally, because I want the Working Group, using this presentation as a starting point, to discuss means and mechanisms for strengthening the regulatory framework. By doing so, the outcome of that Working Group will be the final section of this presentation.

May I suggest that the Working Group focus on the following aspects? First, legislation – is there direct or indirect environmental legislation, is it sufficient, and is it outdated? Second, organization — is there an adequate governmental and non-governmental environmental organization, is there overlap (or are there gaps) in tasks, what role do NGO's play, and are NGOs partners or watchdogs? Third, implementation — are there enough funds available (both for government and NGOs), are the available tools adequate, is there enough quality available for high standard performance, and are there enough (or too many) people involved? And, finally, control and enforcement — what kinds of control and enforcement are in place, are all legal possibilities used, what problems contribute to a poor performance in the areas of control and enforcement, and how can these problems be resolved?

Open Forum: Meeting Management Goals

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A. Abreu (Moderator) suggested that the discussion focus on questions asked by participants, as well as on the identification of elements for the Working Groups.

S. Tijerino (Nicaragua) asked how the Presenters would consider the threat of climatic change on nesting beaches, and how might it affect populations over time?

B. Schroeder (USA) responded that this was an excellent question, and that climatic change will result in rising sea levels that will influence coastal geography in the future. She felt that the complexity of the topic was beyond our capacity to discuss in this forum, but that one influence on sea turtle populations may be skewed sex ratios in hatchlings as incubation temperature regimes shift.

S. Tijerino (Nicaragua) emphasized the need to take anthropogenic effects on these species into account in the policy and management process. She asked for feedback from the Presenters regarding the vulnerability of seagrasses and coral reefs, which serve as important sea turtle foraging habitats.

J. Horrocks (UWI) responded that coral reefs and seagrasses are indeed critical foraging habitats for sea turtles throughout the Caribbean. Global warming and sea level rise threaten shorelines, but also coastal marine ecosystems such as coral and seagrass. Perhaps of more immediate concern, however, are threats to these important ecosystems that result from coastal development. These threats include erosion, sedimentation, beach armoring, and destruction of the seabed. These threats have a direct effect on sea turtle populations, as well.

N. Frazer (UFL) added that we need to protect habitat in order to protect sea turtles, and he noted that sea turtles themselves often act in ways that "engineer" the habitat to their advantage.

M. Donnelly (IUCN MTSG) agreed, adding that we cannot take habitat for granted or allow good habitat to be degraded. We should be diligent in safeguarding habitats, especially unspoiled habitats, that are successfully exploited by sea turtles for nesting or foraging. Habitat monitoring programs are critical to the success of any long-term conservation or management program.

J. Frazier (Smithsonian) agreed with S. Tijerino and recommended that we protect habitat because without it, we have no sea turtles.

C. d'Auvergne (St. Lucia [1]) expressed the view that climate change would surely have a profound effect on sea turtles, and that we must also take into account the reactions of people to climate change...reactions that include building sea walls, for instance. He expressed his concern, as well, about the transport of hazardous nuclear waste through the Caribbean Sea, and the fact that oil spills are always a possibility. He reminded the meeting that one of every eight barrels of the world's oil passes through the Caribbean. In St. Lucia there has been a loss of seagrass and living coral as a result of dredging, as well as some fishing practices.

C. Parker (Barbados) observed that "everything we have discussed in this session is part of integrated coastal management", and that integrated coastal management should be a priority for every nation in the region. He noted that the threats we and our environment face are complex, and the answers will not be found in fragmentary and isolated programs. We must strive to assimilate best practices in the management of marine turtles and their habitats.

A. Abreu (Moderator) closed the session with instructions about convening the Working Groups after the lunch break. He thanked the translators for their diligent and professional assistance.

[1] Mr. C. d'Auvergne participated as an Invited Expert, and not as a delegate from St. Lucia.