Recommendations and best management practices for the conservation of green turtles

1) Predator control – objective is to have <10% of nests in a season have any indication of non-native species predation (Appendix A).

- Regular, year-round monitoring of nesting beaches and nests (when present) for predators and predation.
- If predation is documented, mongoose are present, or predator detection rates exceed the percentages in Appendix A, then implement predator control measures as described in approved Beach Predator Removal Management Plan. Each agency/location must develop a Beach Predator Removal Management Plan that describes procedures that can be implemented to reduce predation on sea turtles. Plans must be approved by the USFWS.
- If predator control fails to reduce predation to an acceptable level, then nest protection measures may need to be implemented (e.g., nest screening, increased active surveys), which should be discussed with USFWS.

2) Sea turtle monitoring – objective is to collect species data that can contribute to sea turtle status and recovery goals and, ultimately, delisting of the species (Appendix B). Survey methods and intensity will be determined based on human usage and nesting use during the sea turtle nesting season.

- Determine whether beach is a high human use area (e.g., any beaches used for recreation, training operations, or have ORV or other vehicle use) or known high turtle nesting area (average of ≥3 nests per year).
    - *Low human use or low nesting beaches* – weekly or biweekly monitoring for nests; weekly or biweekly monitoring of all documented nests until hatchings leave.
    - *High human use or high nesting beaches* - daily morning monitoring for nests; daily monitoring of all documented nests until hatchings leave.
- Information collected during monitoring includes: survey date, survey start time/end time, spatial coordinates of interaction, nests, turtle activity (e.g., nests, false crawl, non-nesting excavation, observation of adults), gender, size, other observations (e.g., tumors, tag, tag #) for adults, hatching date, excavation information, and success for nests.
- If appropriate, cordon off nests to prevent disturbances.
- Conduct nest excavations to determine nest success. Contact USFWS before undertaking this activity as proper training and a recovery permit is needed.

3) Wildlife-friendly lighting – objectives are to provide appropriate dark beach areas for female sea turtle nesting and prevent mortality of hatchlings and adults (e.g., female directional disorientation after nesting, hatchling sea turtle directional disorientation after nest emergence; Appendix C).

- Develop and implement a wildlife-friendly light management plan approved by USFWS.

- Topics include: appropriate types of lighting, light shielding or off hours, training for leadership and staff involved in lighting decisions and design (e.g., public works, construction, recreation departments).
- Provide wildlife-friendly light management plan to relevant facilities and construction personnel.
- If the location already has appropriate animal-friendly lighting, then light management plan should focus on guidelines for future lighting.

4) Reduce impacts on sea turtles by implementing Best Management Practices (BMP) – objective is to reduce negative impacts on sea turtles and habitats and areas used by sea turtles (Appendix D).

5) Develop and implement beach management/shoreline protection plan – objective is to maintain and/or improve beaches for sea turtle habitat.

- Topics include: habitat/shoreline protection activities, vegetation management near/on beaches, invasive plant control, acceptable/unacceptable beach activities (e.g., vehicle and/or ORV use, horseback riding).

6) Develop and utilize USFWS-approved outreach, educational materials, and signage – objective is to educate and provide information to recreational users, visitors, volunteers, and staff about proper procedures and acceptable activities within sea turtle habitat and how to act when coming in contact with sea turtles.

- Topics include: pet management (dogs on leashes, keep cats indoors), light management during nesting season, "do's and don'ts" on beaches at night and during the day, acceptable behavior around sea turtles (e.g., keep a certain distance away, do not touch them, use barbless hooks for fishing, no flash photography at night).
- Outreach materials should be placed in kiosks, access points, provided to visitors upon housing check-in, equipment rental, and other appropriate venues.
- Signage placement includes: beaches, appropriate parking lots, visitor/recreational check-in locations, cabins/hotels/housing.

7) Incidental monitoring of basking turtles (Central North Pacific Ocean DPS) – objective is to document basking locations and have information on high and low-use basking areas.

- Provide training and field forms to staff/volunteers to identify and record incidental encounters with sea turtles.
- Information needed includes: location description, spatial coordinates (as close as possible to the location without disturbing the sea turtles), time of day for encounter, number of sea turtles, activity, notes on sea turtles (e.g., whether tagged, tag numbers if visible, gender, approximate size of sea turtles, symptoms of diseases, e.g., fibropapillomatosis, any visible injuries and potential causes).

Appendix A - Predator Control Approaches and Methods

Objective: <10% of nests have any indication of non-native species predation

In sea turtle nesting areas, general guidelines for non-native predator detection rates are:

- <35-40% for rats
- <15-20% for mongoose
- <10-15% for cats
- <10-15% for all other non-native predators

Predator controls should be implemented when detection rates are greater than the above levels, as determined through regular predator monitoring.
If predation by *native* species is having a significant impact on sea turtle nests, discuss options with USFWS.

Examples of predator monitoring methods (both for predator levels and to determine efficacy of predator control measures) include:

- live trapping (e.g., tomahawk, Sherman, coral traps)
- chew block (mongoose and rodents)
- camera traps, image and/or video (often medium-large sized mammals, e.g., cats and dogs)
- hair traps (medium-sized mammals)
- tunnel traps (small mammals; see *Example 1*)
- field surveys (mammals, reptiles)

Examples of predator control measures include:

- kill traps (e.g., body grip traps, A-24, snares)
- bait stations (toxicants)
- hand broadcast or aerial rodenticide (toxicant) application
- live trapping (e.g., tomahawk, coral traps) and removal
- hunting

In cases when predator control measures are inadequate to prevent sea turtle predation, protective measures may need to be taken (e.g., *Example 2*). Potential protective measures should be discussed with USFWS before implementation.

Example 1 - Monitoring method for small/medium mammals:

Using tracking tunnels to monitor rodents and mustelids.

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1 Background

Conservation managers and researchers at mainland sites throughout New Zealand now commonly use tracking tunnels as a method of indexing rodent and mustelid abundance. In 1997 we wrote a protocol (DOC Tracking tunnel guide version 1) as a direct response to repeated requests by DOC staff for some basic guidelines on how to use tracking tunnels. However, there were several important issues that needed to be resolved with the technique, particularly for monitoring mustelids. These issues were investigated as part of DOC Science and Research Unit investigation 3275, the fieldwork for that project was completed in June 2002. This protocol was written as an update for the original version based upon what we learned during the course of that investigation. This protocol describes a technique for monitoring rodent and mustelid activity. If you have set up tracking tunnels to monitor rodents using version one of the protocol (i.e. 4 x tunnel lines each of 25 tunnels spaced at 50m) then there is no need to change what you are doing (see section 3.3).

2 Introduction.

Using tracking tunnels as a method for monitoring small mammal abundance in New Zealand was first described by King and Edgar (1977). The technique uses a "run through" tunnel containing two pieces of paper either side of a sponge soaked with a tracking medium (food colouring). As an animal passes through the tunnel it picks up the tracking medium on its feet, then as it departs from the tunnel it leaves a set of footprints on the papers. There are several reasons why tracking tunnels are now a commonly used way of indexing small mammals instead of kill-trapping. Information can be gained on a variety of animals from large insects to whatever can fit through the tunnels. It is a non-destructive sampling technique so it does not impact the target population or for that matter any non-target species. Tracking tunnels are perceived as being more sensitive than snap traps for detecting the presence of rodents at low abundance, the method is also less labour intensive than trapping because the tunnels remain permanently in place between monitoring sessions.

3 Methods.

3.1 Some things to consider before setting up a tracking tunnel operation.

For monitoring rodents and mustelids, tracking tunnels only provide a coarse index of relative abundance; they are not a direct measure of population density, but a measure of activity. The technique is best suited for providing simultaneous comparisons of the relative abundance of rodents (particularly rats) or mustelids between similar habitat areas (e.g. treatment and non-treatment) or gross changes in relative abundance over time at a single site. We suspect that the technique can become "saturated" when rodents or mustelids occur at high densities, so you should be cautious how you interpret the results in those situations.

Tracking tunnels can be reasonably sensitive to the presence of rodents (particularly rats) when they are present at low densities. Therefore, the technique can be a useful management indicator for determining the results of rodent control operations. We recommend that tracking tunnels are used for monitoring the effects on rodents of ongoing (over a season or longer) pest control operations but if you wish only to monitor the effects of a one off poison operation on rodents, or survey to identify what rodent species present in an area you may want to consider using snap traps and follow the guidelines produced by Cunningham & Moors (1996).

If you are planning to use tracking tunnels for monitoring mustelids, or you plan to use them to monitor mustelids at some time in the future, then we strongly suggest that you discuss this with your conservancy technical support staff or predator specialists within DOC before setting up any monitoring operation. Tracking tunnels are not always sensitive to the presence of mustelids when they are present in very low numbers so we recommend that if you plan to use these as a management result indicator you treat a "not detected" result with caution. We currently do not know if the tracking tunnels can be used to provide a useful relative index of abundance for monitoring hedgehogs. Hedgehogs are certainly detected in tracking tunnels at some sites, but we have not determined whether or not the technique is sensitive to the presence of these animals.

3.2 Choosing line locations for monitoring rodents and/or mustelids.

For most study sites (~300 to ~10,000 ha), six to twenty tunnel lines in the treatment area (and a similar number set in the non-treatment area if applicable) should be sufficient for surveying rodents and anywhere between four to fifteen lines should be sufficient for surveying mustelids. We have suggested some guidelines (based upon our experience) for the number of tunnel lines for different sizes of survey area (Table 1), obviously some areas will be easier to survey than others, but the more lines you can set up the better. If you are planning only to survey for mustelids in areas ≤ 300ha, you should discuss the limitations of using this technique with your technical support staff or predator specialists within DOC prior to setting up any monitoring operation. Each tunnel line consists of 10 tunnels set at 50m spacing for rodents or if you only intend to use the tracking tunnels to monitor mustelids then each tunnel line consists of 5 tunnels set at 100m spacings. Any lines you intend to use to monitor mustelids should be an absolute minimum of 1000m from the nearest adjacent mustelid line at the closest point (the greater the distance between lines the better). Those lines that you intend to use exclusively to monitor rodents need only be a minimum of 200m from the nearest adjacent rodent line at the closest point.

Table 1. Suggested number of tracking tunnel lines to use for surveying both mustelids and rodents.

Approximate area to be surveyed	*≤300ha*	*300-600ha*	*600-900ha*	*900-1,200ha*	*1,200-10,000ha*	*>10,000ha*
Suggested number of tracking tunnel lines for rodents	6-8	8-10	10-12	12-15	15-20	20 (or more if logistically feasible)
Suggested number of tracking tunnel lines for mustelids	4-5	6-7	7-8	9-10	10-15 lines	15 (or more if logistically feasible)

When setting out tracking tunnel lines it is very important to ensure that representative environments are sampled within the areas you are interested in (e.g. a rodent control block). The easiest way to do this is to consider the gross environment types that make up your study site or management block and what proportion of that area they make up. So for example, if fifty percent of your study area is red beech forest, then fifty percent of your sampling effort should include that environment. Generally speaking, the start points for each line should be determined by environment type, access, logistics (all lines need to be serviced on the same day) and the distance away from the next nearest tunnel line.

When determining the direction the tunnel line runs avoid biasing the sample by running lines entirely along geographic features (e.g. roads, ridgelines or streams) or other potential sources of bias such as along bait station lines. The best way to avoid any bias is to randomise the direction each tunnel line runs. A simple method we use is to roll a six-sided die and the number rolled determines the compass bearing from the start point along which the line is set out (Table 2). Run the line in the most practicable of the two bearings either Easterly or Westerly from the designated start point, if you can't decide which to choose, roll the dice again. If the result is an odd number pick the Westerly bearing and the Easterly if the die result is even.

Table 2. Suggested method for determining the direction (compass bearing) of each tracking tunnel line.

Die roll	*Angle of tunnel line (magnetic)*
1	285°W-105°E
2	315°W-135°E
3	345°W-165°E
4	15°E-195°W
5	45°E-225°W
6	75°E-255°W

3.3 How can I change from the tunnel layout used following the old version one protocol to follow this protocol?

If you have an existing rodent monitoring tracking tunnel network already in place that has been set up following the original "version 1" protocol, then there is no need to physically change anything you do. One line of 25 tunnels set for rodents can easily become two lines of ten tunnels with a space of 300m between them if you ignore the data collected from the 11th through to the 15th tunnels on each line. However, the only reason you would want to consider changing how you interpret the data is if for some reason you needed to compare your existing data with data collected from tracking tunnels set up following this updated protocol. You cannot use an existing tracking tunnel network set up under the "version 1" protocol to monitor the relative abundance of mustelids. If you wish to do this then you will have to install additional tunnels and lines to ensure there is a minimum 1000m spacing between lines.

3.4 Setting out the tunnels and lines for monitoring rodents and mustelids.

1. Set out the tunnels at least three weeks (ideally even longer if you plan to survey mustelids) prior to the first survey session to ensure any resident animals are conditioned to the presence of the tunnels.

2. Leave the tunnels in place between survey sessions.

3. Mark the tunnel locations with flagging tape (or if you have the funds use permanent plastic triangle track markers). Since the tunnels are left in situ between surveys (in some cases several years) the locations of the tunnels need to be well marked. When using flagging-tape to mark tracks it is a good idea to use one colour to mark the track and another to mark the tunnel.

4. Write each tunnel number on the flagging-tape or plastic triangle at the tunnel site with a permanent indelible ink marker pen.

5. Assemble the tunnels as you put them out in the field. It is a lot easier to carry the bases, trays and pre-cut corflute for 10 tunnels than it is to carry 10 fully assembled tunnels.

6. Site the tunnel at the most suitable spot within two meters of the 50m marker along the line (e.g. places that look like they would provide a good "run" for small mammals).

7. Place each tunnel on reasonably level ground as this will reduce the chances of the food colouring running from the middle sponge tray and blotting out the paper on the down hill side.

8. Ensure that the tunnel is firmly in place by pegging the tunnel down with two No.8 wire loops. This is particularly important in areas were disturbance by possums is likely to be a problem and especially important if you plan to use the tunnels to monitor mustelids.

9. Check that access to both ends of the tunnel is unobstructed.

3.5 Tunnel construction.

Each tunnel consists of a wooden base with a black plastic "coreflute" cover. Coreflute is the material used for real estate signs; it is cheap, light in weight and reasonably rigid. In the majority of cases these tunnels are quite resistant to interference and damage by other animals, however if kea, weka or possum interference is so bad that it is compromising the amount of data you are collecting from your surveys then we suggest you consider using the "Te Anau Area Office tunnel design" (see Appendix II). The tracking papers and sponge are placed in a separate tray that sits inside the tunnel on the wooden base. Jurgen Fiedler Plastics in Rotorua manufacture polycarbonate trays specifically for this purpose (see Appendix I). At around $8 each these trays are quite expensive but they should last for five to ten years.

Use red (Amaranth 123) food colouring as the tracking media on the sponge. It is cheap easy to use and prepare and is readily available if supplies run out.

3.5.1 Tunnel dimensions and materials.

- Wooden base, 100mm (W) x 535mm (L) plywood or 25mm thick rough sawn pine.

- Tunnel cover, black corflute, stapled or nailed to the base, 615mm (L) allows for 40mm overhang each end of timber, tunnel internal clearance height should be 100mm.

- Polycarbonate trays, 520mm (L) x 95mm (W), with each of the three partitions being 173mm (L).

- Papers, each paper should be pre-cut to 173mm x 95mm in size. We strongly suggest you source this pre-cut from a printer, as hand cutting can be very time consuming. The type of paper may be determined by local availability (and cost) but ensure it is sufficiently absorbent to retain the food colouring animal prints. Sponge, 173mm x 95mm in size and 3-5mm thick. Sponge, 173mm x 95mm in size and 3-5mm thick.

- Tracking media, use liquid red (Amaranth 123) food colouring at approximately 1:3 dilution in water. In extremely dry conditions or where you think freezing is likely to be an issue, mix the food colouring and water solution with polyethelene glycol (approximately 20%).

3.6 Using the tracking tunnels to monitor rodents.

Each rodent monitoring survey is conducted over one fine night.

Day One.

1. Place fresh papers in each tunnel.

2. Check that the sponge is in good condition, fits neatly into the tray, and contains adequate food colouring. An old "H_2Go" or similar type of plastic water bottle is an easy (and less messy) way of applying food colouring to the sponges in the field. You will need to carry spare sponges and scissors to ensure replacement sponge fit the trays.

3. Bait each tunnel with a generous ~ 3 - 4 cm sized blob of ("No Frills" crunchy) peanut butter. This is smeared on the vertical face of the wooden base at each end of the tunnel.

Day two.

1. Keep the papers in order when collecting them, write the tunnel number on each paper, on the end closest to the tunnel entrance. Writing the numbers on the outside edge of the paper will help you to sort the papers after the survey (it is often easier to identify footprints if the papers are arranged in the same direction as most of the tracks will be heading from the inside outwards). Keeping the papers in order will help you to identify any mistakes (i.e. if you miss a tunnel or make an error with the numbering).

2. Check the papers in the field (if you have mastered the identification process) and keep a running total of the results in a notebook. This may help to eliminate mistakes and problems with identifying faint tracks.

3. Make a note of any fresh scats found in a tunnel, and count that particular species being present, even if there are no tracks in the tunnel. So remember to remove any scats from the tray when setting up the tunnel with fresh papers and food colouring.

4. Note anything of interest or importance (e.g. possum disturbance, particularly if the papers and or trays have been pulled out these tunnels need to be accounted for when analyzing the data).

5. Record when the bait is taken from untracked tunnels.

6. Remove the bait from the ends of the tunnel bases.

Once you are back in the office.

7. Spread the papers out to dry (if needed) and double check your results.

8. Label the bundles of tracking papers with the survey area and the date, and store for later reference.

The frequency of sampling (number of surveys) should be determined by the desired outcomes and management objectives at your site, for example you may only want indices of rodent abundance at critical times, such as during bird breeding seasons or before and after control operations. The minimum number of surveys we recommend for ongoing studies is at least four times per year (February, May, August and November are the usual months). However, more frequent sampling (e.g. once a month or every two months) will give you a better picture of any gross fluctuations in relative abundance for the year.

3.7 Using the tracking tunnels to monitor mustelids.

Mustelid surveys should be conducted over three consecutive fine nights (or at least three nights where you can reasonably expect a period of weather with no heavy rainfall).

Use the same procedure as for rodent monitoring except;

1. Tunnels should be spaced at 100-meter intervals. This can be done by using every second tunnel on your rodent monitoring layout (use the odd numbered tunnels).

2. Bait the tunnels with a generous ~ 4 - 6 cm^3 sized chunk of skinned rabbit meat placed in the center of the sponge (on a 4 cm x 4 cm square of polythene or suitably sized leaf to keep maggots off the sponge). Ensure any uneaten peanut butter left over from any rodent surveys is flicked off the base.

3. Collect the papers after three nights.

There is no problem running this type of survey immediately following a rodent session. You can save yourself some time by re-papering and baiting (with rabbit meat) every second tunnel as you are removing the papers from the previous night's rodent session.

The minimum number of mustelid tracking surveys for ongoing studies should be at least once per season, but you should be aware that the summer peak in stoat abundance usually lasts only for a very brief time so if it is important you detect this at your site then you may need to consider two surveys in summer. As with rodent surveys, the desired management outcomes at your site should determine when you conduct these surveys. For example, you may only want indices of mustelid relative abundance at critical times, such as during bird breeding seasons or before and after control operations.

3.8 Identifying small mammal tracks.

This can often be one of the more difficult aspects of the technique. However, after some practice it becomes relatively easy to quickly identify the tracks of different small mammals at a glance. We have included a brief description of the various small mammal prints with associated pictures in a document saved on the Department of Conservation DME system (Click here for "*DOC tracking tunnel prints*" dme://HAMRO-20234/). If you are having difficulty identifying tracks, fax copies to your Conservancy technical support staff who should be able to assist you or put you in touch with people who can.

3.9 General tips

We strongly recommend you get a copy of the paper by Hiltrun Ratz (1997) on identification of footprints of some small mammals and read it before you start. If the tracks appear extremely faint, check to see if they have not been transferred from another paper. This is most likely to happen if the papers were wet when they were collected. When we were trialing this technique we found that placing each paper separately between the pages of an old paperback novel whilst we were collecting them stopped this from happening, plus it helped absorb any excess moisture from the papers. If you see faint tracks when collecting the papers and are concerned that they may be overlooked later, note the species and highlight the tracks by circling them in pencil, while in the field. This is also a good reason for handling the papers carefully when you are collecting them and keeping a running total of the results in a notebook as you check each tunnel. Partial tracks or footprints can often occur if the sponge has dried out, the food colouring was too dilute, or if the animal has backed out after placing only one foot on the sponge. If a set of prints is too obscure to identify, don't take a guess, mark it down as unidentified.

3.10 Counting the tracks, calculating the activity/tracking index.

The tracking index of relative abundance for rodents is expressed as the mean percentage of tunnels tracked by rodents per line. This will enable some statistical comparison between treatment and non-treatment sites and/or between surveys over time at the same site. The information you record is the presence or absence, of a particular species in a tunnel, so it is not important how many tracks are on each paper and it does not matter if only one paper is tracked.

1. Total the number of tunnels on each line that have tracks present (or fresh scats that indicate the animal had been present). Do this separately for each species.

2. Total the number of tunnels on each line that were badly disturbed (e.g. by possums) with papers that do not show rodent tracks then multiply this number by 0.5. Subtract this number from the total number of available tunnels on each line (10). We define a tunnel as being badly disturbed when both papers are removed from the tunnel and it is obvious that the target animals would not have been able to leave tracks on the papers.

3. Divide the number of tunnels tracked on each line by the number of available tunnels in each line and multiply this figure by 100. This gives the percent-tracking rate (for each line). Do this separately for each species.

4. Calculate the mean (average) percent-tracking rate over all the lines. To do this add the percent tracking rates from each line and divide the total by the number of lines. Do this separately for each species.

5. Calculate the standard error of the mean. The standard error (SE) is simply a measure of the precision of the mean. It is often very useful to express the mean percent tracking rate plus or minus SE (e.g. The mean rat-tracking rate was 35% ± 6%). If you use a calculator with statistics functions you can calculate the standard deviation (δn-1 button) of your sample (of percent tracking rates from each of your survey lines). The standard error can then be calculated from the standard deviation. The standard error is equal to the standard deviation divided by the square root of the sample size, which for these surveys is the square root of the number of lines. Do this separately for each species.

6. For mustelids we suggest you also express the total number of tunnels tracked by mustelids as a percentage of all the tunnels (minus 0.5 times the number of badly disturbed tunnels not tracked by mustelids) baited for mustelids. We also suggest that you also express the results as the percentage of tunnel lines tracked by mustelids (as opposed to individual tunnels).

If you are comfortable using MS Excel we have a copy of the spread sheet we use for calculating the mean tracking rate per line for rodent surveys, we have also included sheets for calculating the overall proportion of tunnels tracked by mustelids (plus mean tracking rate per line with standard errors and proportions of lines tracked by mustelids) saved on the Department of Conservation DME system (Click here for "*DOC tracking tunnel calc*" dme://HAMRO-53370/).

4 References and recommended reading.

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5 Appendix I. Suggested suppliers for tunnel materials.

- Polycarbonate trays. Jurgen Fielder Plastics (P.O. Box 6071 Rotorua). ph (07) 343 5542 or Fax (07) 348-0952.

- Black corflute sheets. Mico Wakefield (Mico *Pipelines* Division), www.mico.co.nz, contact nearest branch. Sometimes they will also cut these to size if you can afford the additional cost.

- Sponges. Para Rubber, www.pararubber.co.nz, contact nearest branch. A 1350mm x 1500mm sheet should make around 180 pads.

- Food colouring. Hansells (NZ) Ltd., www.hansells.co.nz, Opaki Rd, Private Bag 410 Masterton, (ph: 0800-733-663, Fax: 06-377-3114, e-mail orders@hansells.co.nz) will bulk supply food colouring. Please specify that you require the red colour code Amaranth 123.

- Papers. EC Attwoods Ltd., www.attwoods.co.nz, Head Office, PO Box 37-568, Parnell, (ph 0800 722548, Fax 0800 377758). This company will supply pre-cut papers for tracking tunnels. Other printing firms will often supply pre-cut papers at relatively low cost too.

6 Appendix II. The "Te Anau Area Office tunnel design", courtesy of Megan Willans.

- Tunnel cover, one sheet of black polypropylene plastic - 350mm (W) x 900mm (L) x 1.5mm thick.
- Wooden base, H4 treated rough sawn timber - 100mm(W) x 535mm (L) x 25mm thick
- Nails: 30mm Anualer S/S lumberlock flatheads - 10 nails for each tunnel.
- No 8 wire brackets (fashioned to shape at local engineering shop). The wire not only helps prevent possums, kea and weka from reaching in, but also keeps the plastic tray from sliding out. The wire may not be suitable for a lot of areas where you want larger animals using the tunnels.
- Click here (dme://HAMRO-105493/).to see a picture (courtesy of Megan Willans) of the tunnel.

Example 2 – Predation protective measure: nest caging (based on Hawaii Volcanoes National Park: Hawksbill Turtle Recovery Project, Nest Caging Protocol: (REVISED 4-07-10))

I. ACTIVITY PURPOSE

Nests may need to be caged to protect the eggs and hatchlings from being predated by mammals (i.e., cattle, mongooses, rats, feral cats and feral pigs. In addition to caging the nest, we implement a predator trapping program. This program significantly reduces the number of predators and the threats to the turtle nest). Nest cages protect the eggs and hatchlings from vehicular traffic and human foot traffic. Although exact construction varies, all cages are to provide adequate space for all hatchlings to completely emerge from the sand. Because the cages may become partially dislodged during the incubation period, they are to be checked and maintained regularly.

II. TOOLS AND MATERIALS NEEDED:

- Sledge hammer
- 15ft X 3ft fencing material (1" X 2" mesh size)
- 5 sq ft of chicken wire
- 4 anchors or pegs
- Slip-Joint Pliers
- Wire cutters
- 4ft of thin stainless steel straight gauge wire
- "Turtle Nest….Please Do Not Disturb" 6"x12" sign

Personal Protective Equipment:

- 1 pair leather gloves per person
- Safety glasses
- Boots

III. PROCEDURES FOR NEST CAGE CONSTRUCTION

*****NEST CAGES SHOULD BE CONSTRUCTED AS SOON AS POSSIBLE FOR NEST PROTECTION*

Step 1: Define outer edge of egg chamber in a circle (error on the side of caution). Extend four points 18 inches from the center of the nest to assure fencing wire does not impact the nest.

Step 2: Prepare wire fencing in four pieces 3 feet long. Connect (twist) the end pieces of the fence to make a circle or connect with straight gauge wire using pliers.

Step 3: Dig a trench 12 inches deep. Place fence circle in trench and backfill with sand.

Step 4: Place 4 anchors tied with straight gauge wire on the sides of fence. Drive anchors into the sand away from the egg chamber and tie wire to the fence cage.

Step 5: Use poultry wire to make a "roof" for the cage. Be sure the piece is big enough to cover the entire cage top. Attach chicken wire by wrapping the ends around the cage. This will prevent predators from climbing over the top and also to prevent people from throwing rubbish into the cage.

Step 6: To discourage predators from digging under the cage and tunneling into the nest, place sections of fencing outward or horizontally along the sand. Cut rectangular pieces of fencing (3ft by 1.5ft) and attach these pieces near the bottom of the nest cage with stainless steel straight gauge wire. Cover the horizontal sections of wire with sand.

Step 7: Attach "Turtle Nest….Please Do Not Disturb" sign on the cage using straight gauge wire. Make sure that no wire is "sticking out" anywhere on the cage so people will not get cut if they touch it. All wire ends need to be twisted downward with pliers.

Step 8: Mark the nest cage by tying orange flagging to the top of cage with nest information written on it (date, nest #, turtle tag #'s, observer's initials).

IV. MONITORING

a. The bottom edge along the entire seaward face of the cage is to be opened on day 45 of incubation to insure hatchlings can safely emerge from nest to the ocean. The opening should be at least 2" above the sand's surface.
b. Project personnel shall monitor caged nests daily and/or nightly for any signs of emergence pit, hatchling tracks, etc.
c. Continue daily trapping of predators.

Protocols adopted from the following:

Eckert, K.L, K.A. Bjorndal, F.A. Abreu-Grobois and M. Donnelly (Editors). 1999 *Research and Management Techniques for the Conservation of Sea Turtles*. IUCN/SSC Marine Turtle Specialist Group Publication No. 4

Florida Fish and Wildlife Commission; Marine Turtle Conservation Guidelines, Nov. 2007

Appendix B – Sea Turtle Monitoring Information and Example

Objective: collect species data that can contribute to sea turtle status and recovery goals

Data to be collected during each survey (see *Example data sheet*):

- Survey date.
- Survey start time/end time.
- Spatial coordinates of interaction, nests.
- Turtle activity (e.g., nests, false crawl, non-nesting excavation, observation of adults) for each activity observation.
- Adults – gender, size, other observations (e.g., tumors, tag, tag #).
- Nest information – nest hatching date, nest excavation information, nest success.

Surveys with no encounters still need to be documented and recorded as negative data and for level of effort.

Recommendations for marking nests to prevent accidental disturbance (these measures may not be needed for beaches that have low use or activities):

- Posts with signs installed in a 10ft X 10ft square around the nest site.
- Orange construction cones at the corners of the protected nest area.
- For nests that are located in areas where training activities or pedestrian use may cause disturbance, additional measures include:
    - Informational signage.
    - Wider buffer around nest area.
    - Temporary closures of beach accesses or sections of beach.
    - Additional protection measures may be implemented in coordination with USFWS.
- Prior to day 50 of incubation (50 days from the morning the nest was laid), Natural Resources personnel responsible for managing the beach will assess lighting impacts to nests and determine if any light sources may impact the orientation of emerging hatchlings. Identified light sources should be turned off and/or shielded during the nest's hatch window (beginning on day 50 of incubation through day 75) until hatchling emergence or nest excavation.

Example data sheet (from James Campbell NWR):

Turtle Monitoring Datasheet

	Time	Height
Last high tide		
Next high tide		
Last low tide		
Next low tide		

_____ Obs. Initials
_____ Survey type WK = Weekly MO =Monthly
_____ Monitoring Date (MMDDYY)
_____ Start Time _____ End Time
_____ % Cloud cover
_____ Rain (0) no (1) Mist (2) Drizzle (3) Light (4) Moderate (5) Heavy
Wind Beaufort (0) None (1) 1-3 mph (2) 4-6 mph (3) 7-10mph (4) 11-16 mph (5) 17-21 mph (6) 22-27 mph

Start time	Segment	Coord	SP	Nest	Pic	False Crawl	Pic	Basking	Pic	Notes
		Y / N	EI CM DC U?	C / U /ID	# Range	Y / N / U?	# Range	Y	# Range	(i.e., tag #, Nest characteristics)

CODES:
Coord Y = GPS Point taken
Coord N = NO GPS point taken
Segment A = Golf Course
Segment B = Ki'i Unit
Segment C = Airport
Segment D = TB (?)

EI = Hawksbill Sea Turtle, Honu 'ea, *Eretmochelys imbricata*
CM = Green Sea Turtle, Honu, *Chelonia mydas*
DC = Leatherback Turtle, *Dermochelys coriacea*
LO = Olive Ridley Turtle, *Lepidochelys olivacea*
U? = Unknown
Nest C = Confirmed
Nest U = Unconfirmed

Nest ID = Write ID for previously documented Nest C or U
Pic Range = First and last pic number
False Crawl Y = Positive ID of a false crawl
False Crawl N = Negative ID of a False Crawl
False Crawl U? = Unknown
Basking Y = Turtle Basking

TURTLE NEST DATASHEET **NEST #:** _____

SPECIES: EI CM DC LO
DATE NEST FOUND:_____ **PICTURES TAKEN:** _____
LATITUDE: _____ **LONGITUDE:** _____
DESCRIPTION OF NEST LOCATION: _____
PROXIMITY TO HIGH (HIGH) TIDE LINE: _____

HATCHLING EMERGENCE / NEST INVENTORY
Date of First Hatchling Emergence *(if seen at night before midnight, record NEXT day's date)*: _____
Any evidence of disturbance or water inundation during incubation? Yes No

NEST INVENTORY DATE: _____ **EXCAVATED BY:**_____

Total Eggshells (ES) = _____
Total Unhatched Eggs (UN) = _____
Early Develop = _____
Mid Develop = _____
Late Develop = _____
Pipped = _____
Unknown = _____
Total Dead Hatchlings (DH) = _____

Total Live Hatchlings (LH) = _____

Total clutch size: **(ES + UN) =** _____
Emergence Success: **((ES – (LH + DH)) / TCS) * 100 =** _____
Hatchling Success: **((ES – DH) / TCS) * 100 =** _____

ADDITIONAL NOTES (include any evidence of water inundation during incubation, predation, compaction, or root invasion in nest):

_____
_____
_____
_____

Appendix C – Wildlife-Friendly Lighting Recommendations

- "Keep it low, keep it long, keep it shielded"
    - Use only amount of lighting needed for particular purpose (illuminating walkways, security, etc.) = reduce lumens.
    - Keep lighting low to reduce light pollution/glow, e.g. close to ground and low lumens.
    - Use bulbs that are long wavelength, >560 nm (yellow, amber, red LED), low pressure sodium vapor.
    - Light fixtures that direct light downward and/or away from nesting beaches are recessed, filtered, or shielded so that all light emitted is <90°.
    - Use native dune plant vegetation or manage dunes as light screens to shield lights.
- Conduct a lighting assessment to determine if light is needed in an area.
    - If light is needed, determine the purpose of the light, intensity of light needed, and ways to minimize light trespass and spill.
- Reduce lighting of areas that require no security, vacant, no foot traffic (don't light unnecessary areas).
- Use of sensors, timers, etc. to limit the amount of time that an area is lit and increase darkness when area is not in use.
- Eliminate or minimize outdoor decorative lighting.
- Eliminate or limit fires, flashlights, flash photography on beaches during nesting season.
- For indoor lights, have tinted glass, window treatments, etc. on buildings in order to reduce light trespass to beaches; reposition lights away from windows to decrease light intensity.
- Temporary light needs (e.g., special events, road construction, security) need to also follow wildlife-friendly light recommendations.

Appendix D – Best Management Practices (BMP) for sea turtles

- Implement training on sea turtle BMPs and procedures for relevant staff, volunteers, or contractors (e.g., housing and recreation staff, visitor information staff, security personnel, facilities management).
- Limit use of recreational equipment/items to below mean high water on beaches (specifically, minimize or no use of such items between mean high water line to vegetation line).
- Daily removal of recreational equipment/items on nesting beaches, particularly above mean high water.
- Remove marine debris including derelict fishing gear, nets, or other entanglement hazards from the beach.
- When pets are allowed on beaches, they must be leashed at all times.
- Restrict nighttime use of beaches (e.g., trampling, light pollution, presence of people/pets, driving, training), particularly during nesting season.
- Encourage native plant growth on beach areas to reduce erosion by stabilizing the beach.
- Remove and/or avoid using plant species, particularly non-native species, that can inhibit turtle hatchling movement.
- During nesting and hatchling emergence periods for the local area:
    - Prevent driving of any vehicles on the ocean-ward side of active nests.
    - Tire ruts must be raked out to ensure that emerging hatchlings have a clear path between the nest and water.
- If nest excavations will be conducted:
    - Coordinate with the local government and USFWS a minimum of 72 hours after the first observed emergence, or according to the terms and conditions on an authorized Sec 10(a)(1)(a), endangered species permit.
- Signage:
    - Post informational signage and/or mark off areas to prevent entry or disturbance of basking hotspots.
    - Include phone numbers to report dead or injured turtles (i.e., turtle stranding line, other local emergency notification phone numbers).
- Encourage fishers to use barbless hooks and disentangle turtles if safe for them to do so.