TAGS II

Recovery of juvenile green turtles marked as hatchlings in the Hawaiian Islands

254-3

Growth

- KBAY GRAFT RECORDS: This is what Bowman letter says, is it correct?

- CARAPACE MARKING

- LIVING TAG

(7.) Position of grafted turtle at Mauna Lani + position on carapace I took to South Carolina?

Need

(1.) — graft sites at FFS - 1982 (aug)? Tern seam 1-2nd left lateral + 1st plastral scute, after gular scute, on the anterior left side

- KBAY Graft CAPTURE -

Bowman "84" 5,000 → (2.) Number ~~tagged~~ grafted in 1982 and released? 1100 8/82

(3.) 1,132 titanium tagged in 1... released at ... + 200 double tagged and returned to Honolulu + grafted

AT what SITE?

Donna "p. 75 gray book "2nd lat left against seam of 1st lat left." "Block stock left 2nd plastral scute after epiplastron". ventral

~~But~~ See photos — (4.) Position of graft? KBay capture **2nd Lat. Left seam**

see 1984 books + folder Kewalo (5.) FATE of 200 grafted in 1984 in Honolulu

(6.) DATE & Graft position of 16 cm release at Kailua ... Titanium no.

NOT Likely / Highly unlikely

8 years

Question: Is the ca 11.5cm SL grafted turtle from 8/82 "control" FFS, released Kailua Boat Ramp 2/4/83 the same one I captured in KBay 8/13/90 SL=53.3, or is it one of the 1,100 hatchlings grafted and released as hatchlings 8/82 at FF.

But note - This turtle had 3 size #1 tags
N711
N846
N847

No sign of small tags on KBay turtle.

Single tagged

TITANIUM SIZE #1
STOCK BRANDS =

July - Aug 84

Tag no. used -

H005 - H989 (985)

E004 - E990 (987)

K004 - K076 (73)

K641 - K989 (349)

K198 - K640 (443)

2837

CONCLUSION -
GAIL'S NO. of
"2542 tagged & released"
MOST Likely correct

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A BOORUM & PEASE PRODUCT LINE

died at the Olinda Captive Propogation Facility in 1987. Most were prepared as study skins, some as skeletons, some as both skins and skeletons, and a few as whole carcasses in alcohol. Sixteen eggs of Nene, Hawaiian Stilt and Hawaiian Crow were also received.

Reptile and mammal specimens from Hawaii accessioned in 1988 included a Hawksbill Sea Turtle, 12 small terrestrial reptiles, 3 whales and whole term whale fetus, a Monk Seal, 3 Hawaiian Bats, and a cow.

A few specimens went to the Museum's Education Department, but most went to the Vertebrate Zoology research collection for scientific and informative use.

Suggestions Wanted for Shell Marking Technique

December 1988
George H. Balazs, 943-1221
National Marine Fisheries Service, NOAA

A simple marking system that provides easy visual recognition of individual sea turtles on the nesting beach, with minimal disturbance, can be a useful research tool for recording significant events such as within season renestings. Several workers, including myself, have spray painted numbers on the carapace for convenient, short-term identification in conjunction with long lasting metal flipper tags.

Unfortunately, all too often the paint wears off much sooner than is desirable. To find a more tenacious yet simple-to-apply marking technique, experiments are currently under way in Hawaii, using captive adult green turtles at Sea Life Park. The goal is to find a paint, adhesive, or other substance that will stick for 8-12 weeks and is easy to use under field conditions. Drilling or other mutilation of the shell to meet this objective is not deemed acceptable.

Sea Life Park offers an ideal setting to conduct such experiments, since there is weekly access to the turtles when their display pool is drained and cleaned. I would welcome, and will fully test, any practical suggestions for marking that are offered by readers of the newsletter. An account of the results of this experimental work will be provided upon completion.

Hawaii Forest Birds Flycatching Iiwis

March 19-26, 1988
Lenny Freed, 948-8617
University of Hawaii

During a research trip to Hakalau Forest National Wildlife Refuge, my graduate seminar class and I (8 people total) noticed that iiwis were catching insects in the air after sallying from perches. To our knowledge, this is the first time that this fly-catching behavior has been documented in any Hawaiian honeycreeper, even though iiwis and other nectarivores have been extensively studied. The behavior is unexpected, especially in iiwis, because these birds have a most inappropriate bill for this mode of foraging. Both adult and juveniles flycatched from perches ranging from fence posts, fence wire, fallen logs, and trees in the Pua Akala gear or inside dredging equipment and deliberate injury by humans also are being looked at. Turtles can easily become trapped and drown inside the funnel-shaped nets of shrimp boats. None of the turtles found on the beaches was still alive, Thompson reported, and only a few showed any sign of external injury. Most had begun to deteriorate.

In addition to the Kemp's ridleys, two leatherbacks and 15 loggerhead turtles were recovered by scientists and concerned citizens, bringing the total number of stranded turtles to almost 80. One of the leatherback turtles was reportedly entangled in fish netting. (Excerpted from Federal Fisheries News Bulletin, December 20, 1988; to obtain further information, call Nancy B. Thompson at (305) 361-4487.)

SUGGESTIONS WANTED FOR SHELL MARKING TECHNIQUE

A simple marking system that provides easy visual recognition of individual turtles on the nesting beach, with minimal disturbance, can be a useful research tool for recording significant events such as within season renestings. Several workers, including myself, have spray-painted numbers on the carapace for convenient, short-term identification in conjunction with longer lasting metal flipper tags. Unfortunately, the paint often wears off much sooner than is desirable. To find a more tenacious yet simple-to-apply marking technique, experiments are currently underway in Hawaii using captive adult green sea turtles (Chelonia mydas) at Sea Life Park. The goal is to find a paint, adhesive, or other substance which (1) will be retained for 8-12 weeks and (2) is easy to use under field conditions. Drilling or other mutilation of the carapace to meet this objective is not deemed acceptable.

Sea Life Park offers an ideal setting to conduct such experiments, since there is weekly access to the turtles when their display pool is drained and cleaned. I would welcome, and will fully test, any practical suggestions for marking that are offered by readers of the Marine Turtle Newsletter. An account of the results of this experimental work will be provided upon completion.

GEORGE H. BALAZS, Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, 2570 Dole Street, Honolulu, Hawaii 96822-2396 USA.

JOBS AVAILABLE

Applicants are being sought to fill 3 or 4 field positions for the 1989 research season (April-August) with the U.S. Kemp's Ridley Team at Rancho Nuevo, Tamaulipas, Mexico. Applicants must be at least 18 years of age with one or more seasons of sea turtle

STEVEN H. LEWIS*
Departments of Obstetrics and Gynecology and Pathology
Indian River Memorial Hospital
Vero Beach, Florida 32960, USA

CHERYL RYDER
Department of Fish and Wildlife
Virginia Polytechnic Institute
Blacksburg, Virginia 24060, USA

and
KURT BENIRSCHKE
Department of Pathology
University of California School of Medicine
San Diego, California 92130, USA.

*Correspondence to: Steven H. Lewis, Doctors' Clinic, 2300 Fifth Avenue, Vero Beach, Florida 32960, USA.

Observations On The Defensive And Aggressive Behavior Of The Leatherback Turtle (*Dermochelys coriacea*) At Sea

We report an unusual encounter with an adult leatherback turtle (*Dermochelys coriacea*) off the coastal waters of the Republic of Palau in the western Pacific Ocean on 17 May 1991. We were plying the waters about 1 km south of Ncheangel (Kayangel) Atoll in the channel between the Atoll and Kossol Reef, approximately 8° 1' 30" N; 134° 44' E. The weather was sunny, the northerly wind light, and the ocean calm. Our boat was an open 7 m fiberglass runabout equipped with two 75-hp outboard engines.

At midday we noticed a large animal surfacing several times as we fished about 300 m away. After 5-10 min we motored toward the unidentified creature and found it to be a leatherback turtle interacting with a large (2 m) gray reef shark (*Carcharinus* sp.). The two animals were behaving aggressively, swimming rapidly about 5-10 min of this behavior, and after hitting our boat half a dozen times, the turtle appeared to lose interest and began to swim away.

At this point, two members of our crew (C. Cook and N. Idechong) donned masks and snorkels and entered the water, jumping in on opposite sides of the boat. When Cook was 3-4 m from the boat the turtle came immediately and aggressively toward him. The turtle approached with mouth agape, but veered away within the last few meters when Cook made a threatening gesture by spreading his arms. Cook climbed quickly back into the boat, whereupon the turtle shifted attention to Idechong, who had lost sight of Cook and was searching for him at the stern of the boat. As the turtle approached, Idechong swam between the propellers of the two outboard engines. The turtle came from below, mouth open, evidently intent on biting the swimmer. Idechong delivered several kicks to the turtle's head, and the turtle backed off. The turtle did not or was not able to bite the swimmer's foot, and at the first opportunity Idechong climbed back into the boat.

The turtle hit the boat several more times, and then appeared to lose interest, moving farther and farther from us. When the turtle was no longer in sight, we started our engines and motored away. The entire encounter lasted 15-20 min.

The turtle was an adult whose carapace length we estimated to be ca. 1.5 m or more. Leatherbacks with a carapace of this length would be expected to weigh about 450 kg (Anonymous 1975, Van Denburgh 1924). The tail was short and the turtle was probably a female. We took several photographs of the animal as it surfaced around our boat (photos on file at the U.S. Fish and Wildlife Service Honolulu Office). The leatherback is occasionally reported in Micronesia (Pritchard 1977) and is thought to be an uncommon or rare species in Palau and Micronesia. Noah Idechong, who grew up in Palau and spent much time on the water, had seen only one leatherback prior to this encounter.

NOT Likely / Highly unlikely

8 years

Question: Is the ca 11.5cm SL grafted turtle from 8/82 "control" FFS, released Kailua Boat Ramp 2/4/83 the same one I captured in KBay 8/13/90 SL=53.3, or is it one of the 1,100 hatchlings grafted and released as hatchlings 8/82 at FFS?

But ...e - This turtle (
#1 tags
711
846
847
...ign of
... tags
...n KBay turtle.

Recovery of juvenile green turtles ~~they~~ marked as hatchlings in the Hawaiian Islands

25 ...

Growth

...tion of grafted turtle

Mauratani ?

+ position on carapace

I took to South Carolina?

This is what Bowman's letters says, but is it correct?

Need -

(1.) —— graft sites at FFS - 1982 (Aug)?

Tern seam 1-2nd left lateral

+ 1st plastral scute, after gular scute, on the anterior left side.

(2.) Number ~~tagged~~ grafted in 1982 and released?

Bowman says 5,000 → 1,100 8/82

(3.) 1733 Titanium tagged in 1984 (July - Aug) released at FFS islets

+ 200 double tagged ~~and returned to Honolulu~~ + grafted

AT what SITE?

... gray book

2nd lat left against seam of 1st lat left "

"Black streak left 2nd plastral scute after epiplastron".

~~But~~ see photos

(4.) Position of graft? KBay capture

(5.) FATE of 200 grafted in 1984 in Honolulu?

see 1984 Books + folder Kewalo

(6.) DATE & Graft position of 16 cm release at Kailua ramp? Titanium no.?

Single Tagger

TITANIUM SIZE #1
STOCK BRANDS =

July - Aug 84

USA

Tag no. used -

H005 - H989 (985)

E004 - E990 (987)

K004 - K076 (73)

K641 - K989 (349)

K198 - K640 (443)

2837

... numerous broken ones

CONCLUSION -
GAIL'S NO. of
"2542 tagged & released"
MOST Likely correct

AMBERG
A BOORUM & PEASE PRODUCT LINE
MADE IN U.S.A.
57503

RESEARCH ACTIVITIES REPORT

EXPERIMENTAL CARAPACE MARKING OF GREEN TURTLES AT SEA LIFE PARK
APRIL 25, 1989

George H. Balazs and Barry K. Choy
Marine Turtle Research Task
Southwest Fisheries Center Honolulu Laboratory

This report presents the preliminary results of an ongoing study initiated in November 1988 to find a practical and durable marking method to use on green turtles, *Chelonia mydas*, nesting at French Frigate Shoals. After first encountering and applying a flipper tag to a nesting turtle, the same animal will usually be seen again on a number of occasions renesting or basking ashore later in the breeding season. The use of a carapace mark that is readable from a distance (>3 m), as opposed to rereading a small metal flipper tag, can significantly reduce the level of human disturbance to the turtle. Carapace marks used during past years at French Frigate Shoals have been made with Dupont Lucite and Zynolyte brands of spray paint. Numbers applied with Lucite usually remained readable for about 2 weeks. However, this product was discontinued by the manufacturer in 1985. Zynolyte has been used since that time, but has proven to be even less durable. There is now an increased need for a longer-lasting mark, ideally one that stays on for 2-3 months or more. This need arises from the fact that a greater timespan is currently being spent monitoring nesting turtles during the breeding season at French Frigate Shoals.

Testing to find an improved and practical marking substance has been carried out mainly using adult green turtles in captivity at Sea Life Park on Oahu. Turtles in the Park's large display lagoon were marked and examined weekly during routine draining and cleaning. However, several weeks after the study started it became apparent that constant physical contact among the 25 turtles, including nipping at the marks, made this setting inappropriate for comparison with turtles in the wild. To rectify the problem, Sea Life Park agreed to move one of the turtles to a separate tank where the study could continue. The turtle used was an adult female (tag 2051, 2495) measuring 81.9 cm in straight carapace length. Having a single turtle in a tank by itself worked out well in that draining and inspection could take place at any desired time. The only problem encountered was the growth of fleshy algae (i.e., Enteromorpha sp. and others) on the carapace. It became necessary to remove this growth on a weekly basis by gentle scrubbing with a plastic mesh pad. Algae on the turtles' backs in the display lagoon occur far less often, due apparently to constant rubbing and also basking that takes place on a cement ramp and adjacent artificial sand beach.

All experimental items were applied to the clean carapace after the turtle had been allowed to air dry for 10-15 minutes subsequent to draining the tank. The tank was refilled after only 15-25 minutes of allowing the mark to dry. This interval approximated the average minimum time a nesting turtle might stay ashore, taking into account false nestings and other short-term terrestrial emergences that occur at French Frigate Shoals.

The preliminary results of the study are for the most part straightward (Table 1). To date 60 items have been tested which include the use of paints, adhesive products, and other agents where durable bonding to the shell was considered a possibility. Two-part products were not included in the study due to the difficulties of working with them under field conditions at French Frigate Shoals. Surprisingly, many of the items tested lasted only a short time, frequently 1 week or less. Poor retention was shown by all of the peel-off back adhesive materials, except for the 3M Scotch Lite (item 25, Table 1) which lasted 5-6 weeks. To date, the longest remaining agent has been Ace quick drying enamel paint (item 56) applied with a brush. This mark became unreadable after 8-9 weeks. However, Deco-Rez Coating (item 59) which is still being tested, has shown almost no wearing, chipping or peeling after 4-5 weeks. At present, this brush-on paint product appears very promising for use as a long-lasting mark. An important element in the application of both Ace and Deco-Rez is adequate "working" of the paint onto the carapace using multiple brush strokes. A 3/4" wide inexpensive "throw-away" brush was used to apply the various paints and liquid products tested throughout the experiment.

Another agent worthy of mention is item 1, a polyurethane foam dispensed from an aerosol can. As of this writing, the foam has remained firmly on the shell for 6-7 weeks. The problem with this substance, as with several others tested in the study, is the difficulty of being able to easily write recognizable numbers or other individual identification marks. The foam product comes out of the can with the consistency of whipped-cream. It therefore needs to be rubbed onto the shell with a stick or other hard object to obtain adhesion. However, a possible practical use might involve imbedding a plastic, metal or wood plate with prestamped numbers into the foam when it is applied to the shell.

A final item (60) worthy of favorable comment at this point is the use of the Dremel brand 20,000 rpm battery powered "moto-tool." Numbers 1-2 mm deep were engraved into (but not through) the keratin scute of the carapace. This process proved to be relatively easy to accomplish with only minimal practice. The numbers were then filled in with paint to increase their readability from a distance. Unlike all of the other methods tested, except for item 21, this one involves the mild, but apparently harmless, scoring of the shell. No adverse response could be detected in the turtle's behavior while the engraving took place. This may be due to the very high rpm's involved. Numbers formed on adult turtles by this technique will likely be retained for many months, or possiby even years. Its use on nesting turtles may significantly surpass the original objective of this study, and result in other valuable applications for sea turtle research.

The optimum site to apply a mark to the carapace was determined in this study to be the third or fourth lateral scutes. These scutes of either the left or right side are much less prone to abrasion from the turtle rubbing its own front flippers over the carapace.

Table 1. **Experimental carapace marking of green turtles, *Chelonia mydas*, at Sea Life Park.**

No.	Application	Number of weeks retained and readable
1.	Everlast sealant foam (aerosol)	
2.	Permatex form-a-gasket sealant (2A pliable)	<1
3.	Permatex aviation form-a-gasket sealant (3D liquid)	<1
4.	Permatex heavy-duty rubberized automotive undercoating (aerosol)	<1
5.	Westley's rubberized automotive undercoating (aerosol)	<1
6.	Plumber's Goop sealant	2-3
7.	Seal-All cement	<1
8.	Evercoat muffler and tailpipe sealer	1-2
9.	Devcon steel repair	1-2
10.	3M polyurethane marine sealant	<1
11.	Macco Liquid Nails adhesive (LN602)	1-2
12.	Duro Extend Rust treatment	<1
13.	Lexel Sealant (white)	1-2
14.	Lexel Sealant (clear)	
15.	Henry 208 plastic roof cement	<1
16.	Cramer firm grip antislip paste	<1
17.	Lida topway fashion lipstick	<1
18.	Kiwi Elite white shoe polish	<1

19.	Turtle Wax (automotive)	<1
20.	MDR whip-end rope dip.	
21.	Pumie heavy-duty scouring stick	
22.	NAPA clear silicon sealant	1-2
23.	3M aluminium tape	1-2
24.	3M Controltac white adhesive reflective film (peel-off back)	
25.	3M Scotch Lite red adhesive reflective sheet (peel-off back)	5-6
26.	GSA 182-5041-X1-66 red adhesive reflective sheet (peel-off back)	1-2
27.	3M custom cut black, blue, and white adhesive vinyl numbers (peel-off front and back)	1-2
28.	Tuck Tape (green duct tape)	<1
29.	Ace Hardware white and black adhesive vinyl reflective house numbers (peel-off back)	<1
30.	Ace Hardware adhesive metal house numbers (peel-off back)	<1
31.	Jogalite adhesive orange reflective strip (peel-off back)	1-2
32.	Dyer adhesive vinyl boat numbers (peel-off back)	<1
33.	MDR Bootstripe boat tape	1-2
34.	Woolworth's silver adhesive reflective cloth tape (peel-off back)	<1
35.	Dymo Label (peel-off back)	<1
36.	C & P Hardware adhesive vinyl house numbers (peel-off back)	<1
37.	Thermacote Welco silver-streak marker	
38.	Non-skid grit impregnated adhesive strip (peel-off back)	2-3
39.	Crayola crayons no. 389 (blue, purple, red, orange, and green)	1-2

40.	Suction cups applied with silicon sealant	<1
41.	Liquid Paper (570-01 blue and 564-01 white)	
42.	Cutex finger nail polish (white and pink)	1-2
43.	Hard-As-Nails with Nylon pink finger nail polish	2-3
44.	Unipaint silver marker	1-2
45.	Unipaint gold marker	2-3
46.	Hi Impact black felt-tip marker	1-2
47.	Sanford's black felt-tip marker	1-2
48.	Polyurethane clear gloss spray	<1
49.	Dutch Boy fast drying spray paint (white)	1-2
50.	Fuller O'Brien epoxy spray paint (toast)	1-2
51.	Zynolyte spray paint (gray, olive, and flat white)	1-2
52.	Ameritone Mirrolac spray paint (white and gray)	2-3
53.	Super Stripe orange traffic paint (aerosol)	1-2
54.	Krylon spray paint (white)	1-2
55.	Fancy Finger instant finger nail glue used to affix pieces of scute cut from a dead turtle	1-2
56.	Ace Hardware flat white quick drying enamel (19A101)	8-9
57.	Ameritone interior/exterior acrylic enamel (olive)	<1
58.	Appliance touch-up paint epoxy fortified (harvest wheat)	3-4
59.	Deco-Rez Coating aluminium pigmented moisture cured urethane (ASP1 type 2 & 3)	
60.	Dremel 20,000 rpm cordless Freewheeler Moto-Tool used with #115 and #192 cutters to engrave scutes	

263-3611

.mt0
L:marking.ghb

S4. 81.9 cm female tag 2051, 2495

"work well with brush, shaked, stir well" 3 or 4th 1st Best

carapace

Number of weeks (length of time) retained and readable

Experimental Marking of Green Turtles at Sea Life Park

1. Great Stuff[TM] Insulating Foam Sealant (aerosol)
2. <1wk Permatex Form-a-Gasket Sealant (no. 2A pliable non-hardening)
3. <1wk Permatex heavy-duty rubberized automotive undercoating (aerosol)
4. 3/31 Plumber's Goop[TM] sealant 2-3 wks
5. 1-2wks 2/26 3M Aluminum tape
6. <1wk Permatex Aviation Form-a-gasket Sealant (no. 3D liquid)
7. 9 8+ 2/8/89 Ace Hardware Quick Drying Enamel (197A101 Flat White) (brush applicator applied with a brush)
8. <1wk Westley's Rubberized automotive undercoating (aerosol)
9. <1wk 3/31 Henry 208 Wet Surface Plastic Roof Cement
10. <1wk "Suregrip" atheletic pine pitch Cramers
11. 1-2wk 2/28 Fuller O'Brien Epoxy spray paint (Toast 616-77)
12. 3/31 Zynolyte spray paint (flat whites and gray) olive 1-2wks
13. 3/5 ~~Zynolyte spray paint (gray)~~ Evercoat sealant foam (aerosol)
14. 3/31 Ameritone Mirrolac spray paint (whites and gray)
15. <1wk ~~Ameritone Mirrolac spray paint (gray)~~ Ameritone Interior/exterior acrylic enamel (olive)
16. <1wk Seal-all cement
17. MDR Whip-end rope dip
18. 3/24 Unipaint Marker (gold ~~and silver~~) Silver - 1-2 Gold 2-3
19. 1-2wks 2/25 ~~Unipaint Marker (silver)~~ NAPA clear silicon sealant
20. 1-2wks 3/5 MDR Bootstripe boat tape
21. 1-2wks Hi Impact Intensive Color Marker (black) felt tip
22. 1-2wks Sanford's Marker (black) felt tip

Cramer Firm grip anti slip paste

23. Thermacote Welco Silver-Streak marker

1-2 wks 3/31 24. Crayola No. 389 (blue, purple, red, orange and green)

25. 3M Polyurethane Marine Sealant (No. 5200) adhesive

26. 3M Controltac Adhesive Film (white reflective) (peel-off back)

27. Super Stripe Traffic Paint (aerosol orange)

1-2wks 28. Evercoat Muffler and Tailpipe sealer

2/16 29. Heavy-duty Pumie Scouring stick

5-6wk 2/8/89 30. 3M Scotch lite sheeting (red reflective) (peel-off back) adhesive

1-2wks 31. Red Reflective Sheeting (GSA 182 5041 X1 66) (peel-off back)

32. Dymo Label (3/8" wide) applied with silicon ~~cement~~ adhesive

33. Vinyl House-address numbers (peel-off back ~~self-adhesive~~) adhesive

1-2wks 34. Devcon Steel Repair

1-2 wks 35. Macco "Liquid Nails" Construction Adhesive (LN602)

2-3wks 2/25 36. Non-skid (Black, grit impregnated) (peel-off back ~~self-adhesive~~)

37. Krylon spray paint (white)

38. Liquid Paper (570-01 blue and 564-01 white)

39. Cutex Finger Nail Polish (white and pink)

40. Silicon suction cups applied with silicon ~~cement~~ sealant

1-2wks 2/25 41. Jogalite Reflexite strip (peel-off back adhesive)

<1wk 42. Duro Extend Rust Treatment

2-3wks 2/25 43. Hard-As-Nails with Nylon (PINK Finger Nail Polish)

1-2wks 2/25 44. Lexel Sealant (white) adhesive

<1wk 2/25 45. Dyer vinyl boat numbers (peel-off back)

3-4wk 2/25 46. Appliance Touch-Up paint (epoxy fortified, harvest wheat) adhesive

adhesive

<1WK 2/25 47. Ace Hardware vinyl house numbers (white and black, peel-off back)

<1WK 2/25 48. Ace Hardware metal house numbers (peel-off back)

<1WK 2/25 49. Woolworths cloth refectant tape (silver) peel-off back

<1wk 50. Turtle (automotive) Wax

adhesive

<1wk 3/5 51. Polyurethane clear gloss spray

52. ~~Ameritone latex exterior house paint (brown)~~

1-2wk 3/16 53. 3M precut vinyl letters ~~(2 cm high)~~, (front and back peel-off)

3/16 54. Dutch Boy fast drying spray paint (white)

adhesive

Lida top way Fashion Lipstick <1wk

~~Shoe polish (white)~~

<1wk

~~3M~~ Duct tape (Tuck Tape brand ~~green~~ green) <1wk

3/16 Dremel engraving 3 - 2051's 2nd/at L&R #92 4th/at R #115 w/white

3/5 everlast foam (not feasible to form numbers)

~~Kory paint~~

<1wk Kiwi Elite White Shoe Polish

3/31 everlast foam (aerosol) w/plastic tag imbedded

3/24 Deco-Rez Coating ASP1 Type 2&3 Aluminum pigmented moisture cured urethane

3/31 (1-2 wks) Fancy Finger Instant Nail Glue - glue 4 scutes

4/21 Aquamend

4/21 Ropedipe

4/21 Boat bottom paint

Dry (late November) of 1988

NOTEBOOK

Suzie Geermans
South Pacific Regional
Environmental Programme
P.O. Box 155
Brisbane Albert Street
Qld. 4002 Australia.

Saint John the
Baptist.
Minevi village
Santa Cruz
Temotu Province

23rd August 199

Dear

Suzie thankyou very much indeed for writting to me regarding the turtle with tags X378 and X379 that I caught and released on December 9th 1992. My big thankyou also goes to George Balags for Informing you about that turtle. And at this Point in time I must Congradulate yourself and your hard working staff in this very big task in tagging and studing the movement of turtles in the South Pacific. And finally thankyou very much indeed for that lovely tshirt with that meaningful advertisement on it, however the tshirt was very Large that I could not wear it greatful if you could Kindly Send me a medium Sise Because I really like people to read the advertisement on the Shirt really meaningfull.
I now Come to what I'd like to tell you, and that is the Same turtle was Caught again by me On January 10th 1993 on the Same Island Nupa while diving for fish at night. The turtle was foun Sleeping under a huge Stone on shallow water, this time I could not Save its life anymore because the moment I saw it I shot it straight away through the head, the turtle died immidately. When I got hold of it I saw that it is the Same turtle with tags X378 and X379 the turtle was

very healthy it was eaten also there were small eggs inside its belly finally the tag numbs are with me now greatful if you could ifrom me of what to do with it. because somebody working in the fisheries department here in the Solomon Island came to me after he knew that I have the tag numbers saying he would pay me with the amount of five hundred dollars $500 Solomon Islands dollar if I give him the tag numbers. However I did not give him the tag numbers despite the big amount. greatful if you could inform me as soon as possible of what to do with tag numbers. Attached with this letter is a rough map of Nupani a ~~Par~~ Paradise home for turtles and birds fish trocus shell ~~[illegible]~~ and beach-de-mer. Once again thank you for taking up your time in ~~taking it up to~~ writing to me. I look forward to ~~[illegible]~~ hearing from you again.

Sincerely yours
Selwyn Sae SSae.

[illegible] REPORTS
1983
1984
1985
1986

Testing Sea Turtle Tags at Union Creek, Great Inagua, Bahamas

First Report to National Marine Fisheries Service

December 1983

Karen A. Bjorndal and Alan B. Bolten

Background

A project to compare sea turtle tags was initiated in November 1983 at Union Creek, Great Inagua, Bahamas. Union Creek is an impounded tidal bay (called a "creek" in the Bahamas) of approximately seven square miles. This natural feeding area for green turtles was enclosed in the early 1960's in a combined effort of the Caribbean Conservation Corporation (CCC) and the Bahamas National Trust (BNT). Union Creek is located in an area under the protection of the BNT.

In 1975-76, Karen Bjorndal lived at Union Creek where she conducted research on the nutrition of green turtles and began a long-term study of growth rates. Since that time, annual visits have been made to recapture turtles for growth rate data. Karen Bjorndal is Technical Director of the Union Creek Project of the CCC and serves on the Scientific Advisory Council of the BNT.

Two BNT wardens live on Inagua and regularly check on the fences and wall that impound the bay. They also catch small turtles that periodically swim along the ocean side of the fences and release them inside Union Creek. In this way, there is a steady supply of small turtles for growth rate studies, and, now, for testing tags. Although it is difficult to estimate the number of turtles in Union Creek because of its size and heterogeneous habitats, we believe there are at least 200 green turtles in the Creek. There are also hawksbills and loggerheads there.

Union Creek is an ideal area for recapture studies. The turtles feed under natural conditions, but, because the area is closed off, individual turtles can be followed over a period of years. There is also a wide size range of green turtles in the Creek, from 3 kg to sexually mature animals.

Turtles are caught by chasing them in motor boats and then diving on top of them. In this way, a boat-load of turtles is soon collected. The turtles are then put ashore, weighed, measured and tagged. Because we work with a relatively small number of turtles, on land, during daylight hours, we can easily ensure that each of the tags is perfectly applied and that the measurements are accurate.

Experimental Design

Four tag types are now being tested: National Band and Tag #681, #19 and #49 (all monel) and titanium tags produced in Australia and provided by Colin Limpus. Four tags of one type are applied to each turtle, one on each flipper. Tag types are not mixed on individuals in order to avoid possible metal-metal interactions. Tags are consistently applied to the same location, through a scale, as shown in Figs. 1 and 2. Previous experience with tagging turtles in Union Creek has shown that there is higher tag loss due to tissue necrosis when tags are not applied through a scale. The second scale on the trailing edge of the fore-flipper distal to the carapace is used rather than the first scale. Turtles previously double-tagged in Union Creek, with one tag in the first scale and one in the second scale (one on each fore-flipper), fairly consistently generated scar tissue around the tag in the first scale that resulted in a significant thickening of the tissue. This thickening put pressure on the tag and caused the tag to rotate, so that the length of the tag could accomodate the thickened tissue. This resulted in the side of the tag with the identification number being turned into the flesh; reading the tag was then difficult and in some cases the tag became badly tarnished. Because the #19 tag and the titanium tag cannot penetrate the scales, a leather punch is used to make a 2.2 mm hole, through which the tag is then applied.

Each tagged turtle is also given a coded sequence of drill holes in the rear marginals. If an experimental turtle that has lost all four tags is recaptured during later trips, the drill holes will enable us to identify when and what type of tags were applied. All tagged turtles are weighed, and straight-line measurements of carapace length and width and plastron length are recorded.

Results of the First Trip

In November 1983, we spent one week at Union Creek and caught 75 green turtles, ranging in size from 3.7 to 120 kg. Twenty-one of these turtles were already tagged (19 with two #681 tags, 2 with one #681 and one #49 tag). Style #681 tags were added to the rear fins in all of the previously tagged turtles. Of the 54 untagged turtles, 14 were tagged with #19 tags, 15 with #49 tags and 14 with titanium tags. Only those turtles (n=11) that weighed less than 14 kg and that were judged to be too small to carry the larger tags were tagged with #681 tags, because of the number of already-tagged turtles with that tag type. For turtles over 14 kg, size classes were divided equally among the tag types.

In order to compare the corrosion-resistance of the four tag types under Union Creek conditions, one of each tag type was fastened through holes drilled in each of four plexiglass plates. The tags were arranged on each plate so that they cannot touch each other, and the tag sequence was rotated so that each tag type was placed in each of the four positions. The four plates were fastened to rods underwater in the main area of the Creek.

Initial observations and preliminary suggestions for tag improvements can be made. In terms of tagging ease, we rated the tags as follows (easiest first): #681, #49, titanium, #19. The number of tags of each type destroyed during tagging attempts followed the same sequence. Some of our difficulty with applying titanium and #19 tags (particularly the latter) may have been due to a faulty tag batch or pliers. We had to adjust the angle of the tongue of the titanium and #19 tags with pliers so that the tongue would enter the receiving hole. This lack of alignment could have been caused by shipping stress or, in the case of the #19 tags, by faulty pliers. The poor alignment and the necessity of a pre-punched hole were our only complaints with the titanium tag. In other respects the titanium tag appears to be the best-designed tag of the four types. It has a very long tongue that has a long overlap on the opposing side of the tag when clenched, and it is easy to observe whether the tag has been applied successfully. The hood of metal above the opening in the tag acts as a guide to the tongue, so that if the tongue is not perfectly aligned with the hole, but hits the hood instead, the tongue is still guided into proper position and the tag clenches successfully.

The #19 tag not only required re-alignment and a pre-punched hole when tagging through a scale, but also varied significantly in the degree to which the tongue overlapped the opposing side of the tag when applied. This variation results in tags that appear to have clenched successfully but actually are held only by the very tip and are easily disengaged with slight pressure. These poorly-applied tags may pose a greater problem than tags that completely fail, because they can be mistaken for a successful tag application. In addition, since the #19 tag lacks the hood of the titanium tag, alignment must be perfect for the tag to clench successfully. There is little difference between the thickness of the metal tongue and the size of the hole through which it must fit.

Although the #49 tag was easier to apply than the #19 tag, it has serious drawbacks. The "tamperproof" cover over the tongue of the applied tag makes it very difficult to check whether the tag is successfully applied. Most taggers check this type of tag by pulling on the opposing sides of the tag. If the tag remains firm, it is assumed to be a successful application. However, in carefully checking our tags, we found instances in which the tongue had barely overlapped the bar, and thus passed the pulling test, but were clearly not well applied. Another negative feature of the #49 tag is the narrow bar which the tongue overlaps. This has long been recognized as a point of weakness. In several tagging projects, turtles have been found with tags hanging loose in the flesh, the bar having corroded away, releasing the tongue. It may well be that successfully applied #19 tags will last longer than successfully applied #49 tags, and that the #19 tags are worth the extra work involved in applying them.

The smaller tag, #681, was the easiest to apply. No re-alignment of tags or pre-punched holes were necessary. The amount of tongue overlap was consistent, although significantly less than the titanium tongue overlap. In addition, it was easy to check for success of application. Although this tag is smaller than that used on adult turtles by most investigators, George Balazs has successfully used this size of tag (same model, made of Inconel) on adult green turtles in Hawaii. We have also used this tag successfully on adult turtles in Union Creek. It may well be that smaller tags, because they produce less drag and move less with each flipper stroke, cause less tissue necrosis. Titanium, because is is lighter than monel, may have a similar advantage.

These are all, of course, preliminary observations. The real test of the relative values of these tags will be how long they stay on the turtles. Our next trip is planned for two weeks in May 1984. At that time, we will add plastic rototags and style #681 Inconel tags (if available from George

Balazs) to our study. All experimental turtles that have lost tags will be carefully examined for old tag scars, and attempts will be made to assign the cause of tag loss to either tissue necrosis or tag corrosion-failure. We will check the corrosion test plates and leave them in place for continued monitoring.

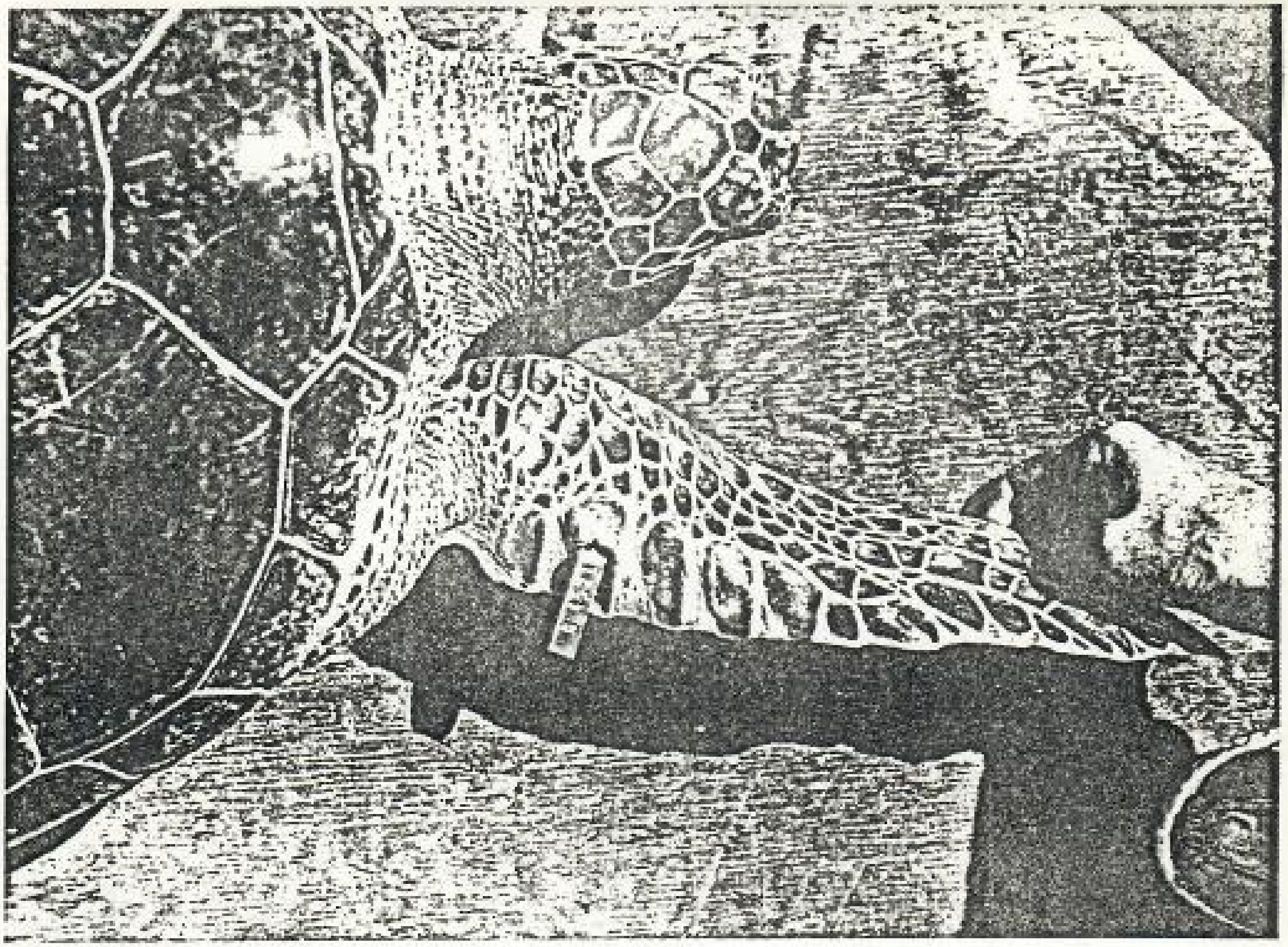

Figure 1. Placement of tag on front flipper.

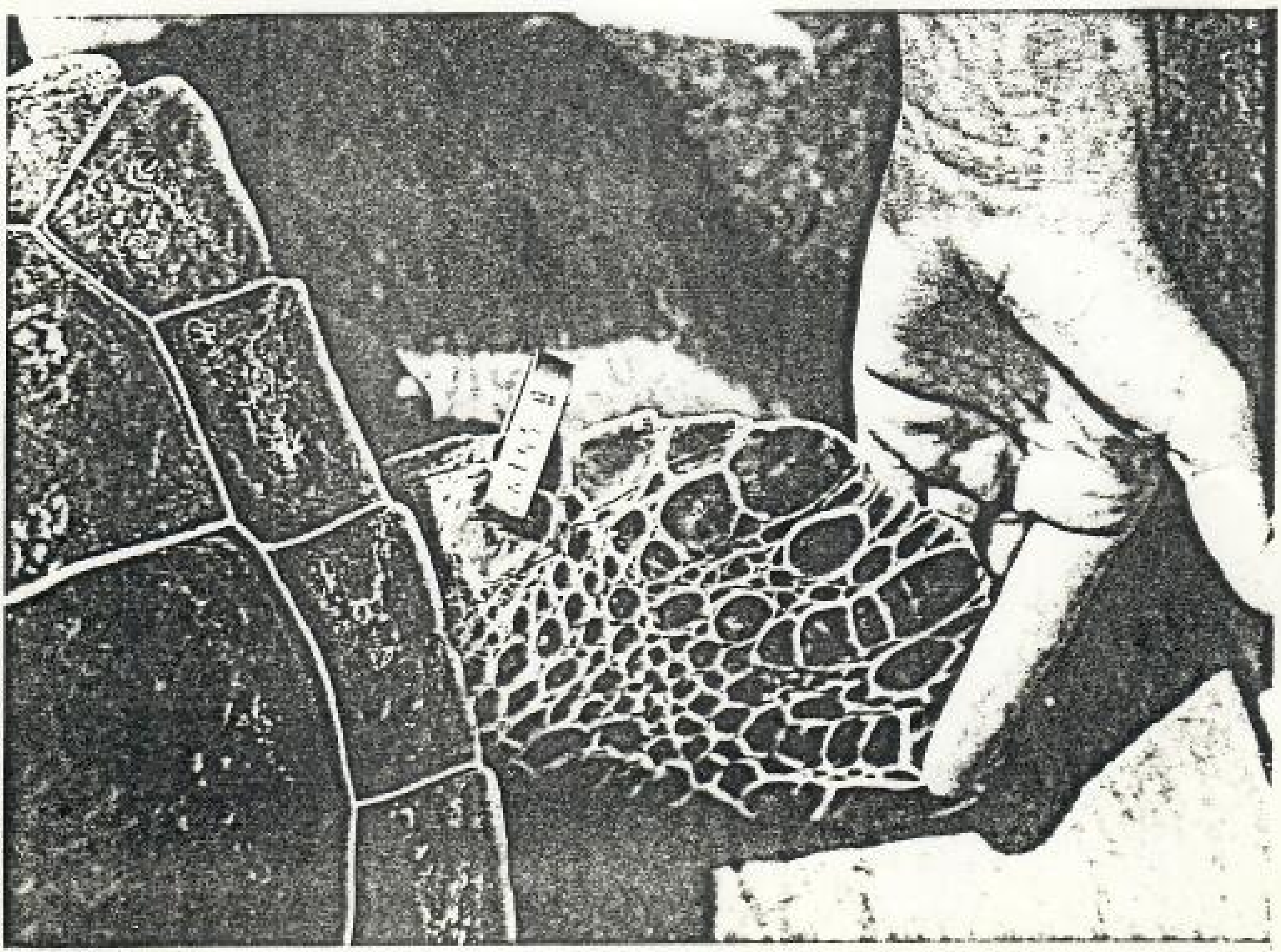

Figure 2. Placement of tag on rear flipper.

Testing Sea Turtle Tags at Union Creek, Great Inagua, Bahamas

Second Report to National Marine Fisheries Service

June 1984

Karen A. Bjorndal and Alan B. Bolten

Background

A project to compare sea turtle tags was initiated in November 1983 at Union Creek, Great Inagua, Bahamas. Union Creek is an impounded tidal bay (called a "creek" in the Bahamas) of approximately seven square miles. This natural feeding area for green turtles was enclosed in the early 1960's in a combined effort of the Caribbean Conservation Corporation (CCC) and the Bahamas National Trust (BNT). Union Creek is located in an area under the protection of the BNT.

In 1975-76, Karen Bjorndal lived at Union Creek where she conducted research on the nutrition of green turtles and began a long-term study of growth rates. Since that time, annual visits have been made to recapture turtles for growth rate data. Karen Bjorndal is Technical Director of the Union Creek Project of the CCC and serves on the Scientific Advisory Council of the BNT.

Two BNT wardens live on Inagua and regularly check on the fences and wall that impound the bay. They also catch small turtles that periodically swim along the ocean side of the fences and release them inside Union Creek. In this way, there is a steady supply of small turtles for growth rate studies, and, now, for testing tags. Although it is difficult to estimate the number of turtles in Union Creek because of its size and heterogeneous habitats, we believe that there are at least 200 green turtles in the Creek. There are also hawksbills and loggerheads there.

Union Creek is an ideal area for recapture studies. The turtles feed under natural conditions, but, because the area is closed off, individual turtles can be followed over a period of years. There is also a wide size range of green turtles in the Creek, from 3 kg to sexually mature animals.

Turtles are caught by chasing them in motor boats and then diving on top of them. In this way, a boat-load of turtles is soon collected. The turtles are then put ashore, weighed, measured and tagged. Because we work with a relatively small number of turtles, on land, during daylight hours, we can easily ensure that each of the tags is perfectly applied and that the measurements are accurate. In June 1984, a sample of turtles (N = 26, range = 3.4 - 73.5 kg) were measured twice in one day in order to test the precision of the measurements and to establish confidence limits for growth rate data.

Experimental Design

Six tag types are now being tested: National Band and Tag #681, #19 and #49 (all monel), titanium tags produced in Australia and provided by Colin Limpus, and two styles of plastic tags (Riese and Jumbo-Roto) from Dalton Supplies, Ltd. in Great Britain. These tag types include all of those commonly in use today, except for Inconel tags that have been used in Hawaii but are not now available for testing.

Four tags of one type are applied to each turtle, one on each flipper. Tag types are not mixed on individuals in order to avoid possible metal-metal interactions. Tags are consistently applied to the same location, through a scale, as shown in our last report. Because the #19, titanium and plastic tags cannot penetrate the scales, a leather punch is used to make a 2.2 mm hole for the #19 and titanium tags and a 6 mm hole for the plastic tags through which the tag is then applied.

Each tagged turtle is also given a coded sequence of drill holes in the rear marginals. If an experimental turtle that has lost all four tags is recaptured during later trips, the drill holes will enable us to identify when and what type of tags were applied and when the turtle was last seen with all four tags still attached. All tagged turtles are weighed, and straight-line measurements of carapace length and width and plastron length are recorded.

Results of the Second Trip

In June 1984, we spent two weeks at Union Creek and caught 145 green turtles, ranging in size from 2.5 to 73.5 kg. Forty-nine of these turtles were already tagged (23 with #681 tags, 9 with #19 tags, 11 with #49 tags and 6 with titanium tags). Of the 96 untagged turtles that weighed more than 14 kg (N = 51), 21 were tagged with Riese plastic tags, 21 with jumbo-roto plastic tags, 3 with #19 tags, 2 with #49 tags and 4 with titanium tags. Of those turtles that weighed less than 14 kg and thus were too small to carry the larger metal tags (N = 45), 37 were tagged with #681 tags, 4 with Riese plastic tags and 4 with jumbo-roto plastic tags.

The majority of untagged turtles were tagged with plastic tags in order to equalize the number of turtles tagged with each tag type. Combining the results of the first and second trips, the total numbers of turtles (weighing more than 14 kg) tagged with each tag type is as follows: 42 with #681, 17 with #19, 17 with #49, 18 with titanium, 21 with Riese and 21 with jumbo-roto. The number of turtles with #681 tags is high because of the number tagged before the tagging experiment began.

94 metal tags
41 plastic tags

We found the plastic tags to be easy to apply, although extra time is required for pre-punching a tag hole. Every attempted tag application was successful; there were no problems with tags being poorly applied. Because it is becoming apparent that much of the tag loss problem is due to original misapplication, the fact that the plastic tags are free from this potential problem is a strong factor in their favor.

Only two tags had been lost from turtles tagged in November 1983, the first tagging trip of this experiment, and recaptured in June 1984. One #19 tag was lost from the left rear fin of a turtle as a result of tag failure. It left no noticeable scar; only because we knew a tag had been there were we able to see a very slight line marking where the tag had been. The other tag was a #49 tag that dropped off the right rear fin of a turtle when it was thrashing in the boat. Although the activities involved in catching the turtle may have hastened its loss, we are considering this tag as one lost at six months.

One of the four tag corrosion test plates placed in Union Creek in November 1983 was recovered and examined. No corrosion was apparent in any of the tags. The tags were brought back to Gainesville for future examination under a scanning electron microscope.

The next trip to Union Creek will be in March 1985. At that time we will continue to tag all untagged turtles with the six experimental tag types. Turtles captured with tags will be examined for tag loss, and the cause of tag loss, either tag failure or tissue necrosis, will be noted.

Testing Sea Turtle Tags at Union Creek, Great Inagua, Bahamas

Third Report to National Marine Fisheries Service

June 1985

Karen A. Bjorndal and Alan B. Bolten

Background

A project to compare sea turtle tags was initiated in November 1983 at Union Creek, Great Inagua, Bahamas. Union Creek is an impounded tidal bay (called a "creek" in the Bahamas) of approximately seven square miles. This natural feeding area for green turtles was enclosed in the early 1960's in a combined effort of the Caribbean Conservation Corporation (CCC) and the Bahamas National Trust (BNT). Union Creek is located in an area under the protection of the BNT.

In 1975-76, Karen Bjorndal lived at Union Creek where she conducted research on the nutrition of green turtles and began a long-term study of growth rates. Since that time, annual visits have been made to recapture turtles for growth rate data. Karen Bjorndal is Technical Director of the Union Creek Project of the CCC and serves on the Scientific Advisory Council of the BNT.

Two BNT wardens live on Inagua and regularly check on the fences and wall that impound the bay. They also catch small turtles that periodically swim along the ocean side of the fences and release them inside Union Creek. In this way, there is a steady supply of small turtles for growth rate studies, and, now, for testing tags. Although it is difficult to estimate the number of turtles in Union Creek because of its size and heterogeneous habitats, we believe that there are at least 200 green turtles in the Creek. There are also hawksbills and loggerheads there.

Union Creek is an ideal area for recapture studies. The turtles feed under natural conditions, but, because the area is closed off, individual turtles can be followed over a period of years. There is also a wide size range of green turtles in the Creek, from 3 kg to sexually mature animals.

Turtles are caught by chasing them in motor boats and then diving on top of them. In this way, a boat-load of turtles is soon collected. The turtles are then put ashore, weighed, measured and tagged. Because we work with a relatively small number of turtles, on land, during daylight hours, we can easily ensure that each of the tags is perfectly applied and that the measurements are accurate. In June 1984, a sample of turtles (N = 26, range = 3.4 - 73.5 kg) were measured twice in one day in order to test the precision of the measurements and to establish confidence limits for growth rate data.

Experimental Design

Because the number and size distribution of untagged turtles could not be predicted with any certainty before the initiation of the tagging experiment, or before each of the tagging visits, experiments have had to be modified with each successive trip. The high rate of recruitment of small turtles (<10 kg) into Union Creek from the wild population present in surrounding waters has provided an unexpectedly high and continuous supply of small turtles for our tagging experiments. Also, observations made during each trip have suggested further variables that need to be tested.

We now have three experiments underway. In Experiment #1, six tag types are being tested on green turtles weighing more than 14 kg. These tags are: National Band and Tag #681, #19 and #49 (all monel), titanium tags produced in Australia and provided by Colin Limpus, and two styles of plastic tags (Riese and Jumbo-Roto) from Dalton Supplies, Ltd. in Great Britain.

Four tags are applied to each turtle, one on each fin. Tags are always applied in the same location, as shown in the first report, and always with the point of the tag entering from the dorsal surface of the fin. Tags of different metals are not mixed on individuals in order to avoid possible metal-metal interactions. Because the #19, titanium and plastic tags cannot penetrate the scales, a leather punch is used to make a 2.2 mm hole for the #19 and titanium tags and a 6 mm hole for the plastic tags through which the tag is then applied.

Very early it became clear that small turtles (<14 kg) could not be expected to carry the large tags (#19, #49, and titanium tags). Experiment #2 involves turtles in the weight range from 4 to 14 kg. These turtles are tagged with four tag types: monel #681, inconel #681 (provided by George Balazs), jumbo-roto and Riese tags. Because of the limited number of inconel tags available (50), and the small size of the rear fins in this size class, experimental tags are only placed on forelimbs in this study.

Observations from earlier trips have suggested that the direction of tag penetration, and the resulting orientation of the tag, may be important in tag retention. In order to test this, Experiment #3 was initiated during the 1985 trip. Turtles weighing less than 14 kg and monel #681 tags were used. Tags were applied from the dorsal surface of the fin on right fore and hind fins, and from the ventral surface on the left fore and hind fins.

In all three experiments, each tagged turtle is given a coded sequence of drill holes in the rear marginals. If an experimental turtle that has lost all four tags is recaptured during later trips, the drill holes will enable us to identify when and what type of tags were applied and when the turtle was last seen with all four tags still attached. All tagged turtles are weighed, and straight-line measurements of carapace length and width and plastron length are recorded.

Results of the Third Trip

In June 1985, we spent ten days at Union Creek and caught 154 green turtles, ranging in size from 2.6 to 50.0 kg. Seventy-four of these turtles were already tagged. Of the 29 tagged turtles weighing more than 14 kg, 10 were tagged with jumbo-roto plastic tags, 8 with Riese plastic tags, 5 with titanium tags, 4 with #19 tags and 2 with #49 tags. Thirty-five untagged turtles weighing more than 14 kg were caught and tagged as follows: 17 with #681 monel tags, 1 with #19, 1 with #49 and 1 with titanium. The majority of untagged turtles greater than 14 kg were tagged with #681 monel tags in order to equalize the number of turtles tagged with each tag type. To date, the total numbers of turtles tagged with each tag type in Experiment #1 are as follows: 17 with #681 monel, 18 with #19, 18 with #49, 19 with titanium, 21 with Riese and 21 with jumbo-roto.

Sixty untagged turtles weighing less than 14 kg were caught. First priority was to apply the inconel tags that we had just received from George Balazs. Twenty-four turtles were tagged with inconel tags in the forelimbs, exhausting the tag supply. Fourteen turtles were tagged with jumbo-roto tags, 10 with Riese tags and 2 with #681 monel tags. These turtles bring the total numbers of turtles tagged with each tag type in Experiment #2 to 49 with monel #681, 24 with inconel #681, 17 with jumbo-roto and 14 with Riese. Thirty-four turtles tagged in earlier years in Experiment #2 were caught this year. Twenty-six carried monel #681 tags, 4 had jumbo-roto tags, and 4 bore Riese tags.

Experiment #3, testing the effect of the direction of tag application on tag retention, was initiated this trip using turtles that fell below the weight cut-off of 4 kg for Experiment #2. Eleven turtles were tagged in this experiment.

A total of eight tags had been lost from Experiment #1 turtles. These tag losses are in addition to those reported in the last report. One #19 tag was lost from the left front fin of a turtle during the past 1.5 years. It was lost due to tag failure; it left an intact hole. Also, one #49 tag was lot from a left rear fin of a turtle during the past year. It also was lost due to tag failure.

The plastic Riese tags had the worst performance record. Six Riese tags had been lost from four turtles. All but one were from rear fins. In all cases, tag loss was due to tag failure, not to tissue necrosis. In several cases, tissue growth had filled in the tag holes, suggesting that tags had been lost fairly soon after application. All of these tags had been applied in June 1984. Examination of other Riese tags indicated that the point of fusion between the shaft and flange on the male part of the tag was the weak point. One tag, which remained attached by only 1 mm at this point, was removed and will be sent to Jim Richardson and to Dalton Supplies, Ltd. to determine whether this problem has been recorded previously. The 100 Riese tags applied in June 1984 were from one batch. The tags applied in June 1985 were from a separate order, placed a year later. Performance of the new set of tags will be compared with that of the first set to ascertain whether the problem is one of lack of quality control from batch to batch, or whether the problem is a consistent one with this tag.

Of the 26 turtles tagged with monel #681 tags in Experiment #2 that were caught in June 1985, three turtles had lost 5 tags from their forelimbs. Again, the problem was one of tag failure due to inadequate quality control. In one short series of tags, excessive corrosion and pitting of the metal occurred after 1.5 years. No sign of such corrosion has ever been seen in the hundreds of monel #681 tags applied to turtles in Union Creek. The distribution of pits and corrosion strongly suggests a separation of the component metals comprising the monel or contamination of the alloy with metals not resistant to corrosion.

One of the four tag corrosion test plates placed in Union Creek in November 1983 was recovered and examined. No corrosion was apparent in any of the tags. The tags were brought back to Gainesville for future examination under a scanning electron microscope.

The next trip to Union Creek will be in April 1986. At that time we will continue to tag all untagged turtles with the seven experimental tag types. Turtles captured with tags will be examined for tag loss, and the cause of tag loss, either tag failure or tissue necrosis, will be noted.

Testing Sea Turtle Tags at Union Creek, Great Inagua, Bahamas

Progress Report to National Marine Fisheries Service

September 1986

Karen A. Bjorndal and Alan B. Bolten

A project to compare the retention times of the commonly-used types of sea turtle tags was initiated in November 1983 at Union Creek, Great Inagua, Bahamas. Union Creek is an impounded tidal bay (called a "creek" in the Bahamas) of approximately seven square miles located in a Wildlife Sanctuary of the Bahamas National Trust. The Caribbean Conservation Corporation maintains the facilities. Union Creek is an ideal area for recapture studies. Approximately 300 green turtles feed under natural conditions, but, because the area is closed off, individual turtles can be followed over a period of years. Turtles are caught by diving on them from motor boats. The turtles are then put ashore, weighed, measured and tagged. Because we work with a relatively small number of turtles on land during daylight hours, we can ensure that each tag is correctly applied.

Synopsis of Experiments

Experiment 1: Seven tag types are being tested on green turtles weighing more than 14 kg. These tags are National Band and Tag #681, #19 and #49 (all monel); National Band and Tag #681 inconel tags; titanium tags produced in Australia and provided by Colin Limpus; and two styles of plastic tags (Riese and Jumbo-Roto) from Dalton Supplies, Ltd., in Great Britain.

Four tags are applied to each turtle, one on each fin. Tags are always applied in the same location, as shown in the first report, and always with the point of the tag entering from the dorsal surface of the fin. Tags of different metals are not mixed on individuals to avoid possible metal-metal interactions.

Experiment 2: Very early it became clear that small turtles (less than 14 kg) could not be expected to carry the large tags (#19, #49, and titanium tags). Turtles weighing less then 14 kg are tagged with four tag types: monel #681, inconel #681, Jumbo-Roto and Riese tags.

Turtles originally assigned to Experiment 2 (based on size) remain in this experimental category for tag retention analysis even though the turtles grow above 14 kg. The size of turtles when they are tagged may be important for evaluating tag retention for the different tag designs.

Experiment 3: Observations from earlier trips have suggested that the direction of tag penetration, and the resulting orientation of the tag, may be important in tag retention. To test this, Experiment #3 was initiated during the 1985 trip. Turtles weighing less than 14 kg and monel #681 tags were used. Tags were applied from the dorsal surface on the right fore and hind fins, and from the ventral surface on the left fore and hind fins. During the 1986 field trip, Experiment 3 was expanded not only to test direction of tag application (dorsal versus ventral), but also position of tag. In addition to using newly-captured turtles, recaptured turtles that have lost tags are being used to test tag application in different locations. Only recaptured turtles originally tagged with monel or plastic tags are used in order to avoid any metal-metal interactions.

EVEN THOUGH TAG FELL OFF ?

Table 1 summarizes the variables in the different experiments. In all three experiments, each turtle is given a coded sequence of drill holes in the rear marginals. If an experimental turtle that has lost all four tags is recaptured during later trips, the drill holes will enable us to identify when and what type of tags were applied and when the turtle was last seen with all four tags still attached.

Results of 1986 Field Work

DOMESTICATED !?

In September 1986 we spent 8 days at Union Creek and caught 149 green turtles ranging in size from 2.9 - 51.0 kg. (112 lbs.) Fifty-nine of these turtles were untagged, 83 were recaptures of experimental turtles tagged during previous field seasons and 7 were turtles tagged before the experiments were begun and thus not included in the summary here. Table 2 shows how the 59 untagged turtles were distributed in the three experiments. Table 3 summarizes how the 288 turtles tagged since the initiation of this project in 1983 have been distributed within the experiments.

The 83 recaptured experimental turtles in 1986 had a total of 102 tags lost (out of 320 tags applied), yielding an approximate 32% rate of tag loss. Tables 4 and 5 summarize the data for the 1986 recaptured turtles.

Conclusions

Causes for tag loss can generally be attributed to a) incorrect tag application; b) tag design, composition, or manufacturing defects;

c) animal response to the tag (tissue necrosis or tissue growth in the region of the tag); and d) tag position. To help evaluate causes for tag loss for the different tag types, the following three assumptions are made: a) no tag loss can be attributed to incorrect application because all tags were applied under ideal conditions and no turtles were included in the experiment if the tags were not applied correctly; b) tag loss associated with tag-holes are attributed to tag failure (tag design, composition, or manufacturing defects); and c) tag loss associated with notches where tags have torn through the tissue are attributed to adverse animal response to the tags or poor tag location.

BITING BY OTHER TURTLES ?

1. All tag loss for all tag types observed in Experiment 1 turtles recaptured during the 1986 field season left a tag hole suggesting tag failure. However, tag loss observed in Experiment 2 turtles was primarily due to animal tissue response (e.g., tissue necrosis) leaving a notch in the fin where the tag had been applied. Tag loss in Experiment 2 turtles was associated with notches significantly more frequently than with tag holes: for #681 monel tags in front fins $P<0.05$, $n = 14$; in hind fins $P<0.001$, $n = 38$; for #681 inconel tags in front fins $P<0.001$, $n = 16$ (Chi-square test). Small turtles frequently lose tags that tear out of their soft flesh leaving a notch.

2. There was a significantly greater tag loss from hind fins compared with front fins for #681 monel tags in Experiment 2 ($P<0.01$, $n = 140$, Chi-square test).

3. There was a significantly greater retention of plastic tags (Riese and Jumbo-Roto combined) in Experiment 2 than for either #681 monel tags (front fins $P<0.01$, n = 89; hind fins $P<0.001$, n = 107, Fisher exact probability test) or #681 inconel tags (front fins $P<0.001$, n = 56, Fisher exact probability test). There was a 98% retention for plastic tags (both Riese and Jumbo-Roto front and hind fins combined) compared with 70% for #681 monel tags on front fins and 46% on hind fins, and 33% for #681 inconel tags on front fins.

We postulate that the sharp edges in the #681 monel and inconel tags increase the likelihood for animal rejection compared with the smooth, round posts of the plastic tags. Also, the top and bottom flanges of the plastic tags can freely rotate and thereby reduce drag and stress on the tissue holding the tag compared with the "looped" end of the #681 tag style.

Applicator problem has been corrected (but better quality control for all pliers is needed).

4. The #681 inconel tag has a poor closure mechanism that required extra manipulation in order to achieve complete locking. This extra manipulation may be impractical when a large number of turtles need to be tagged (e.g., on a nesting beach) particularly at night. Therefore, further development in tag or applicator design is necessary to ensure complete closure of the #681 inconel following a single manipulation. Also, the third number stamped on the inconel tags was very shallow and may be difficult to read in the future.

5. There continues to be evidence of a lack of quality control in the manufacture of some of the tags. As discussed in earlier reports, we continue to see evidence of deterioration of the posts in some batches of

Riese plastic tags. Because a different batch of Riese plastic tags was used in Experiment 2 than in Experiment 1 (see Tables 4 and 5), evidence of lack of quality control by the manufacture can be demonstrated by comparing the number of tag failures in this year's recaptures of Experiment 1 and 2 turtles. After the 1985 field season we examined the Riese tags and found that the point of fusion between the shaft and flange on the male part of the tag was the weak point. However, this year we have observed failure not only at the point of fusion but along the entire shaft.

In addition to problems with plastic tags, some batches of #681 monel have shown irregular and sometimes extensive corrosion indicating lack of quality control during the production of the monel alloy for these tags. The distribution of pits and corrosion strongly suggests a separation of the component metals comprising the monel or contamination of the alloy with metals not resistant to corrosion.

6. There is not yet sufficient data from Experiment 3 to be able to comment at this time on the effect of either the direction of tag application or position of application.

The next trip to Union Creek will be in 1987. Based on the results from the 1986 field season, our emphasis will focus primarily on

1. increasing the sample size of #681 inconel tags in Experiment #1;
2. increasing the sample size of Riese and Jumbo-Roto tags in Experiment #2; and
3. comparing different tag positions.

Table 1. Summary of sizes of turtles, direction of tag application and types of tags used in each of the three experiments.

	Experiment #1	Experiment #2	Experiment #3
Turtle Size	> 14 kg	4 - 14 kg	< 14 kg
Direction of Tag Appication	from dorsal surface	from dorsal surface	from dorsal and ventral surfaces
Tag Type			
#681 Monel	Yes	Yes	Yes
#681 Inconel	Yes	Yes	No
Jumbo-Roto	Yes	Yes	No
Riese	Yes	Yes	No
Titanium	Yes	No	No
#49 Monel	Yes	No	No
#19 Monel	Yes	No	No

Table 2. Numbers of new turtles tagged in 1986, not including re-applications for tag losses.

Tag Type	Experiment #1	Experiment #2	Experiment #3
#681 Monel	0	1	10
#681 Inconel	9	32	--
Titanium	7	--	--

Table 3. Total number of turtles tagged with experimental tags from 1983 - 1986.

Tag Type	Experiment #1	Experiment #2	Experiment #3
#681 Monel	17	50	21
#681 Inconel	9	56	--
Jumbo-Roto	21	17	--
Riese	21	14	--
Titanium	26	--	--
#49 Monel	18	--	--
#19 Monel	18	--	--

Table 4. Summary of tag status in Experiment #1 for turtles recaptured in 1986. Minimum retention times (months) shown for all tags.

	Fore Fins							Hind Fins						
Months	0	6	12	15	18	27	33	0	6	12	15	18	27	33
#681 Monel														
Lost	2													
Remaining				10							12			
Jumbo-Roto														
Lost										3				
Remaining						14							11	
Riese														
Lost	4					2		4		1			1	
Remaining														
Titanium														
Lost									2					
Remaining				2		4	4				2		4	2
#49 Monel														
Lost								2	1			1		
Remaining				2			4				1			1
#19 Monel														
Lost														
Remaining						2							2	

Table 5. Summary of tag status in Experiment #2 for turtles recaptured in 1986. Minimum retention times (months) shown for all tags.

	Fore Fins							Hind Fins						
Months	0	6	12	15	18	27	33	0	6	12	15	18	27	33
#681 Monel														
Lost	15		1		1			41		4				
Remaining				5		29	6			1	18		13	6
#681 Inconel														
Lost	15			1										
Remaining				8										
Jumbo-Roto														
Lost														
Remaining				20							24			
Riese														
Lost	1													
Remaining				11										

MARINE TURTLE RESEARCH
AT THE UNION CREEK RESEARCH STATION
GREAT INAGUA, BAHAMAS

Report to National Marine Fisheries Service

July 1990

Karen A. Bjorndal and Alan B. Bolten

Archie Carr Center for Sea Turtle Research
Department of Zoology
University of Florida
Gainesville, FL 32611

INTRODUCTION

Union Creek (21°07'N, 73°34'W) is a bay (in the Bahamas, the word "creek" means a salt-water bay) of approximately 20 km² located on the north shore of Great Inagua, the southernmost island in the Bahamas (figures 1 and 2). The area is protected as a wildlife sanctuary by the Bahamas National Trust. Union Creek is a natural feeding area for all sizes of green turtles, hawksbills and loggerheads.

In 1964, Union Creek was fenced off to provide a protected area where marine turtles could be studied on their natural feeding grounds. At least 350 green turtles inhabit the study area; all of these turtles have entered from the ocean adjacent to Union Creek. Most turtles are from 25 to 35 cm straight carapace length when they enter the study area through gaps in the fences.

Four projects are currently under investigation at the Union Creek Marine Turtle Research Station: growth rates of juvenile green turtles (*Chelonia mydas*) and hawksbills (*Eretmochelys imbricata*), basic blood profiles (biochemical, morphological and physiological) of green turtles and hawksbills, nutritional ecology of green turtles, and a comparison of tag retention times and tag application procedures for seven types of sea turtle tags commonly used by researchers. Tag loss continues to be a critical problem in studies of individual growth and population biology in sea turtles.

Union Creek offers a good opportunity to study free-living, but protected, marine turtles in a natural feeding habitat. Turtles are caught by diving on them from motor boats after a brief chase. The turtles are put ashore, blood samples are collected for particular experiments, and then the turtles are weighed, measured, tagged and released.

PART ONE: 1990 TRIP ITINERARY AND TURTLE CAPTURES

We traveled to Nassau, Bahamas, on the morning of 22 June 1990. We spent the afternoon meeting with Gary Larson, the Director of the Bahamas National Trust. Because Union Creek is a wildlife refuge of the Trust, it is important that we remain in close communication concerning our work. That evening, we met with Mr. Michael Lightbourn. Michael is a member and past-president of the Bahamas National Trust, has had a long-term involvement in the Inagua turtle work and has given us tremendous support over the years.

We traveled to Great Inagua on 23 June 1990. The main purpose of our trip was to capture, tag and measure as many turtles as possible for additional growth and tag retention data and to collect blood samples to continue our hematology studies. It was also critical for us to check on the condition of the wall and fences. We worked with Trust wardens Jimmy and Henry Nixon, who, as always, had done an excellent job of maintaining the facilities during the year and worked very hard with us during our visit.

We caught 69 green turtles and 1 hawksbill in Union Creek. The green turtles ranged in size from 34.3 to 64.2 cm straight carapace length (figure 3). The median straight carapace length for untagged turtles was 45.0 cm and for recaptured turtles was 52.5 cm (figure 4). As can be seen in figure 4, the median sizes have remained fairly constant since 1984. The hawksbill had not been tagged previously and had a curved carapace length of 39.8 cm. All turtles appeared to be very healthy. Of the 69 green turtles caught during this trip, 53 (77%) had been captured in earlier years (figure 5) and thus yielded additional growth data. The recapture percentage was the highest it has been during our study (figure 5). We think this is a result of a low level of poaching for the past few years. In addition to the green turtles we caught in Union Creek, an adult male (straight carapace length 97.9 cm) was caught outside the Creek. We measured, tagged, and drew blood from the turtle before releasing it.

The facilities were in good condition. Extensive repairs had been made on the stone house since our last visit. The house is now in very good condition.

We returned to Nassau on 3 July 1990. We spoke with Colin Higgs of the Bahamas Department of Fisheries in the Ministry of Agriculture, Trade and Industry. We have worked with Colin for several years. His Department grants us the research and import/export permits that allow us to conduct our research in the Bahamas. Our discussions with Colin concerning sea turtle status and exploitation in the Bahamas continue to be productive. We met again with Gary Larson, Director of the Bahamas National Trust, to discuss the results of our trip.

We returned to Florida on 4 July 1990.

PART TWO: HEMATOLOGY

We collected blood samples from 70 green turtles and one hawksbill to make blood slides. The blood smears were fixed in methanol and will be analyzed for differential white cell morphology for differential white cell counts. Differential white cell counts can be a valuable indicator of the physiological status of animals. We will determine differential white cell counts for different size classes and will collect a similar series of samples during winter months to evaluate seasonal effect.

We are now completing a study (in collaboration with Dr. Elliott Jacobson, University of Florida, Gainesville) to establish a protocol for analyzing basic blood chemistry profiles. The variables evaluated are serum vs. plasma (using either lithium and sodium heparin), and two different commercial auto analyzers. Based on these results, we are now able to have the previously collected blood samples analyzed and evaluated. With this standardized protocol, comparisons of blood chemistry profiles between different geographic regions, seasons, and size classes can be evaluated.

The Union Creek population of green turtles are an important resource in order to establish baseline values for various blood parameters for healthy turtles in non-polluted waters. These values will provide an important database with which we can compare the parameters measured in sea turtles exposed to negative factors, such as disease or pollution, to assess the impact on sea turtles. For example, papillomas have recently been observed on green turtles around Crooked Island (central Bahamas). Comparisons of blood profiles, both chemical and morphological, between the Crooked Island population and the Union Creek population may help to elucidate factors predisposing a population to the disease.

PART THREE: GROWTH RATES

Growth rates for green turtles ranging in size from initial straight-line carapace length of 25 to 75 cm have been evaluated since 1979. This size range includes turtles that have recently arrived on the benthic feeding grounds from their early, pelagic habitat, to large, sub-adult turtles. Following the June/July 1990 field season, our sample size for growth increments in straight-line carapace length is 448.

From our study of growth rates of green turtles in Union Creek, we have established a solid baseline of growth rates for turtles between 25 and 75 cm straight-line carapace length. Three publications have resulted from the growth rate research (Bjorndal and Bolten 1988a, 1988b, 1989). During our study, we have found that there is considerable variation in growth rates, even within narrow size classes of turtles. Beginning in 1988, our efforts were directed towards analyzing the potential sources of this variation and identifying the controlling mechanisms of growth in green turtles. Variables we are considering are seasonal effect, annual variation, growth hormone titers, sex, diet selection, micro-habitat differences and genotype. Union Creek offers a unique opportunity to pursue these questions. It is the only feeding ground for which the nutritional quality of the habitat for green turtles and growth rates of green turtles have been established (Bjorndal 1980, 1982, 1985, in press).

The first two potential sources of variation that we are investigating are growth hormone titer and sex. In April 1988, we collected blood samples from 120 green turtles, ranging in straight-line carapace length from 25 to 70 cm and one hawksbill (45 cm straight-line carapace length). We have growth data for approximately three-quarters of the 120 green turtles, so we will be able to relate growth hormone titer and testosterone titer (sex) to rate of growth in green turtles to determine if either of these factors contributes significantly to the variation in growth rates that we have measured. Growth hormone titers have been analyzed in Dr. Paul Licht's laboratory (University of California at Berkeley), and a publication is in review (Denver et al., in review). Preliminary analysis indicates that there is no significant effect of growth hormone titer on growth rate, but that there is a significant inverse relationship between growth hormone titer and carapace length. Testosterone titer is presently being analyzed by Dr. David Owens and Dr. Janice Grumbles (Texas A & M University). When we have the results, we will test for the effect of sex and/or testosterone titer on growth rates in green turtles. In addition, we will co-author a paper with Drs. Owens and Grumbles on the sex ratio of the southern Bahamas juvenile green turtle population.

Preliminary analysis of our data suggests that there are individual turtles that, over a period of years and a number of recaptures, grow consistently either very much above or below the mean growth rate for a given size class. The research at Union Creek gives an excellent opportunity to follow individual turtles over long periods of time. By apportioning the variation in growth rates among as many potential sources of variation as possible (such as annual and seasonal variation, growth hormone titer and sex), we will be able to evaluate the extent of genetic variation in growth rates.

We need to assess the factors controlling growth in sea turtles to understand the limits of their productivity and their demography.

PART FOUR: TAG RETENTION STUDY

In 1990, we continued to monitor differential retention of commonly used types of sea turtle tags. We caught 69 green turtles, 53 of which were recaptures and 16 were added to the study. This study is composed of three experiments, as summarized in Table 1 and briefly described below.

EXPERIMENT 1: Seven tag types are being tested on green turtles weighing more than 14 kg. These tags are National Band and Tag #681, #19 and #49 (all monel); National Band and Tag #681 inconel tags; titanium tags produced in Australia and provided by Colin Limpus; and two styles of plastic tags (Riese and Jumbo-Roto) from Dalton Supplies, Ltd., in Great Britain.

Four tags are applied to each turtle, one on each fin. Tags are always applied in the same location, as shown in the first report, and always with the point of the tag entering from the dorsal surface of the fin. Tags of different metals are not mixed on individuals to avoid possible metal-metal interactions.

EXPERIMENT 2: Because small turtles (less than 14 kg) cannot carry large tags (#19, #49, and titanium tags), turtles weighing less then 14 kg are tagged with four tag types: monel #681, inconel #681, Jumbo-Roto and Riese tags.

Turtles originally assigned to Experiment 2 (based on size) remain in this experimental category for tag retention analysis even though the turtles grow above 14 kg. The size of turtles when they are tagged may be important for evaluating tag retention for the different tag designs.

EXPERIMENT 3: Initial observations suggested that the direction of tag penetration, and the resulting orientation of the tag, may be important in tag retention. To test this, Experiment #3 was initiated during the 1985 trip. Only inconel and monel #681 tags were used. Tags were applied from the dorsal surface on the right fore and hind fins, and from the ventral surface on the left fore and hind fins. During the 1986 field trip, Experiment 3 was expanded not only to test direction of tag application (dorsal versus ventral), but also position of tag. In addition to using newly-captured turtles, recaptured turtles that have lost tags are being used to test tag application in different locations. Monel and inconel tags are never used on the same turtle in order to avoid any metal-metal interactions.

Table 1 summarizes the variables in the different experiments. In all three experiments, each turtle is given a coded sequence of drill holes in the rear marginals. If an experimental turtle that has lost all four tags is recaptured during later trips, the drill holes will enable us to identify when and what type of tags were applied and when the turtle was last seen with all four tags still attached.

Of the 16 untagged turtles captured in 1990, six were added to Experiment #1 and 10 to Experiment #2. Table 2 summarizes how the turtles tagged since the initiation of this project in 1983 have been distributed among the experiments.

Results of tag retention on those turtles captured in June/July 1990 are presented in Table 3. There is no significant difference between the performance of inconel and monel #681 tags applied in 1985 (Fisher's exact probability test, $P = 0.61$), 1986 ($P = 0.28$), 1988 ($P = 0.26$), or all years combined ($P = 0.41$). There was a 26% loss of inconel tags applied in 1988. As we have discussed in earlier reports, the high rates of loss for both inconel and monel #681 tags are a result of a high percentage of those tags having been applied to small turtles. These results do not provide a good indication of the relative performance of the two metals because the tags are rapidly lost in small turtles (see below) before there is time to demonstrate differential corrosion. The results presented here, with all size classes of turtles combined, should not be used to judge relative tag retention of monel and inconel tags in large turtles. In large turtles, tags will be retained for a longer period and differential corrosion becomes more important.

The Jumbo-Roto tags applied in 1985 outperformed the #681 monel (Fisher's exact probability test, $P = 0.025$) but were not significantly different from the inconel ($P = 0.13$). For tags applied in 1988, the Jumbo-Roto tags had significantly better retention then the inconel ($P = 0.024$) but were not significantly better than the monel ($P = 0.42$). As we have discussed in earlier reports, variation from batch to batch in quality of monel and inconel from the manufacturer complicates the analysis of retention times. However, combining data for all years, Jumbo-Roto tags significantly outperformed #681 monel tags ($P < 0.0001$) and inconel tags ($P < 0.0001$).

In 1987, Jumbo-Roto tags significantly outperformed Riese tags ($P < 0.0001$). During earlier field trips, we observed that the post was separating from the male flange on the Riese tags, resulting in tag loss.

For juvenile green turtles, Jumbo-Roto tags have significantly better retention than #681 monel and inconel ($P < 0.0001$). As we have postulated in earlier reports, the sharp edges of the #681 monel and inconel tags increase the likelihood of tag loss, particularly in small turtles, compared with the smooth posts of the plastic tags. In addition, the top and bottom flanges of the plastic tags freely rotate which reduces drag on the tissue holding the tag. Although there are significant advantages of freely rotating male and female flanges, there are also disadvantages of a lack of a closed loop as in the metal tags. For example, during the June/July 1990 field trip, we observed for the first time an incidence of tag loss for a Jumbo-Roto tag applied to the rear fin as a result of hole enlargement. Presumably, the tag loss was a result of the tag twisting out of the hole. We also observed two male flanges that were broken. However, the tags were still solidly attached.

We now have sufficient data to compare retention of the seven tag types and these data will now be analyzed for publication. Our research/field effort now will focus on tag placement using Jumbo-Roto and inconel as the two tag types. Observations made during the tagging experiments suggest that where the tag is placed on the flipper may be as, or more, important than the type of tag used.

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Table 1. Summary of sizes of turtles, direction of tag application and types of tags used (+) in each of the three experiments.

	Experiment #1	Experiment #2	Experiment #3
Turtle Size	> 14 kg	4 - 14 kg	> 4 kg
Direction of Tag Appication	from dorsal surface	from dorsal surface	from dorsal and ventral surfaces
Tag Type			
#681 Monel	+	+	+
#681 Inconel	+	+	+
Jumbo-Roto	+	+	-
Riese	+	+	-
Titanium	+	-	-
#49 Monel	+	-	-
#19 Monel	+	-	-

Table 2. Total number of turtles tagged with experimental tags from 1983 - 1990.

Tag Type	Experiment #1	Experiment #2	Experiment #3
#681 Monel	17	50	44
#681 Inconel	22	78	43
Jumbo-Roto	41	73	--
Riese	25	21	--
Titanium	26	--	--
#49 Monel	18	--	--
#19 Monel	18	--	--

Table 3. Retention of tags applied in 1985-1989 on green turtles captured in 1990. Sample numbers refer to number of tags, not number of turtles.

	Year in Which Tags Were Applied				
Tag Type	1985	1986	1987	1988	1989
#681 Monel					
Sample no.	12	13	1	10	--
No. on	5	8	1	9	--
No. off	7	5	0	1	--
#681 Inconel					
Sample no.	4	16	--	70	--
No. on	2	7	--	52	--
No. off	2	9	--	18	--
Jumbo-Roto					
Sample no.	6	--	18	14	75
No. on	6	--	17	14	73
No. off	0	--	1	0	2
Riese					
Sample no.	2	--	20	--	--
No. on	0	--	3	--	--
No. off	2	--	17	--	--
Titanium					
Sample no.	--	4	--	--	--
No. on	--	4	--	--	--
No. off	--	0	--	--	--

FIGURE LEGENDS

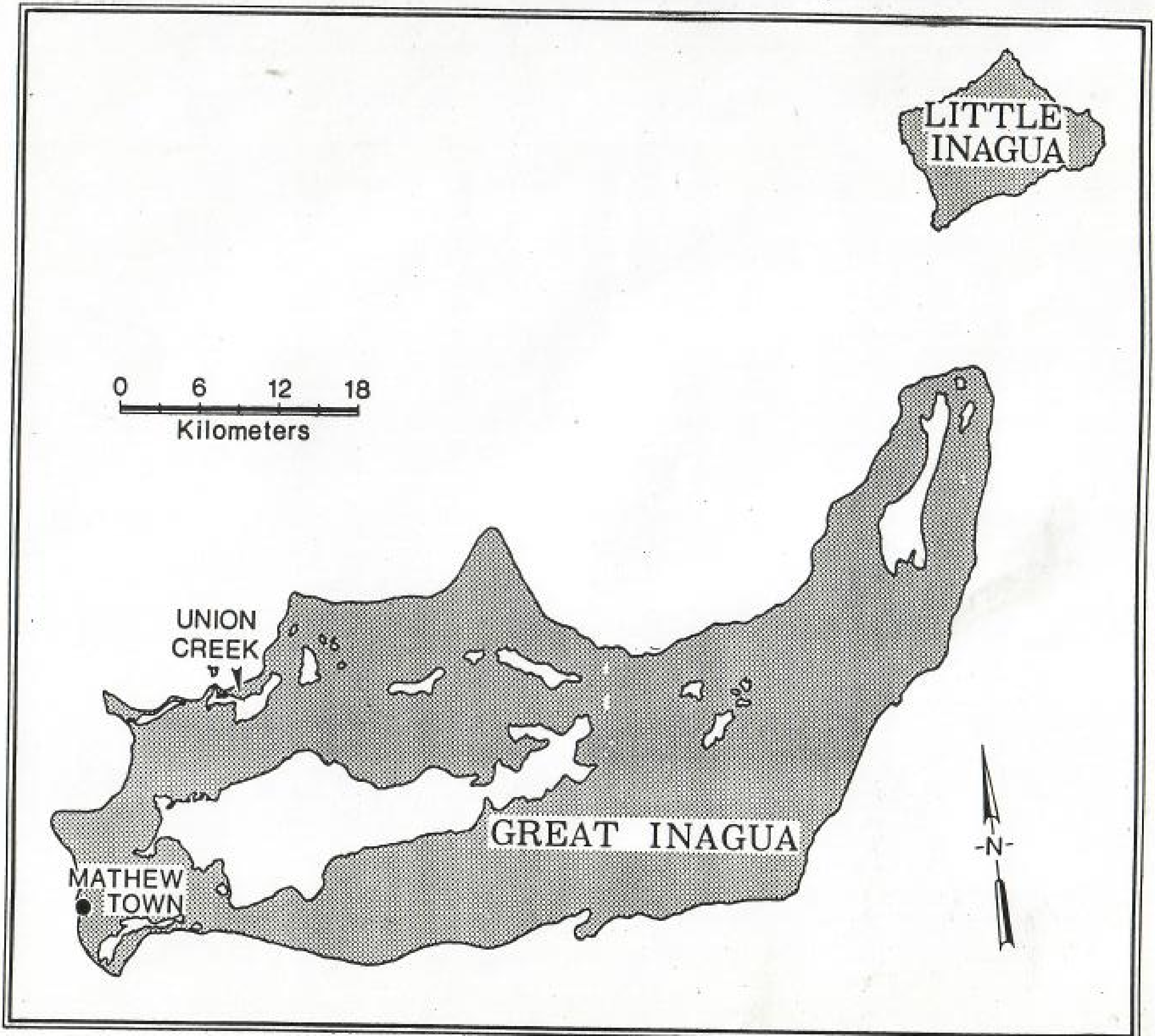
Figure 1. Map showing the location of Union Creek on the north shore of Great Inagua, Bahamas.

Figure 2. Map showing habitat of Union Creek.

Figure 3. Size distribution of green turtles captured in Union Creek during June/July 1990 field season. Straight carapace length is measured from nuchal notch to posterior marginal notch.

Figure 4. Comparison of median straight carapace length of recaptured and untagged green turtles caught in Union Creek during each annual field season since 1984. Straight carapace length is as in Figure 3.

Figure 5. Percentage of recaptured and untagged turtles caught in Union Creek during each annual field season since 1984.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UNION CREEK
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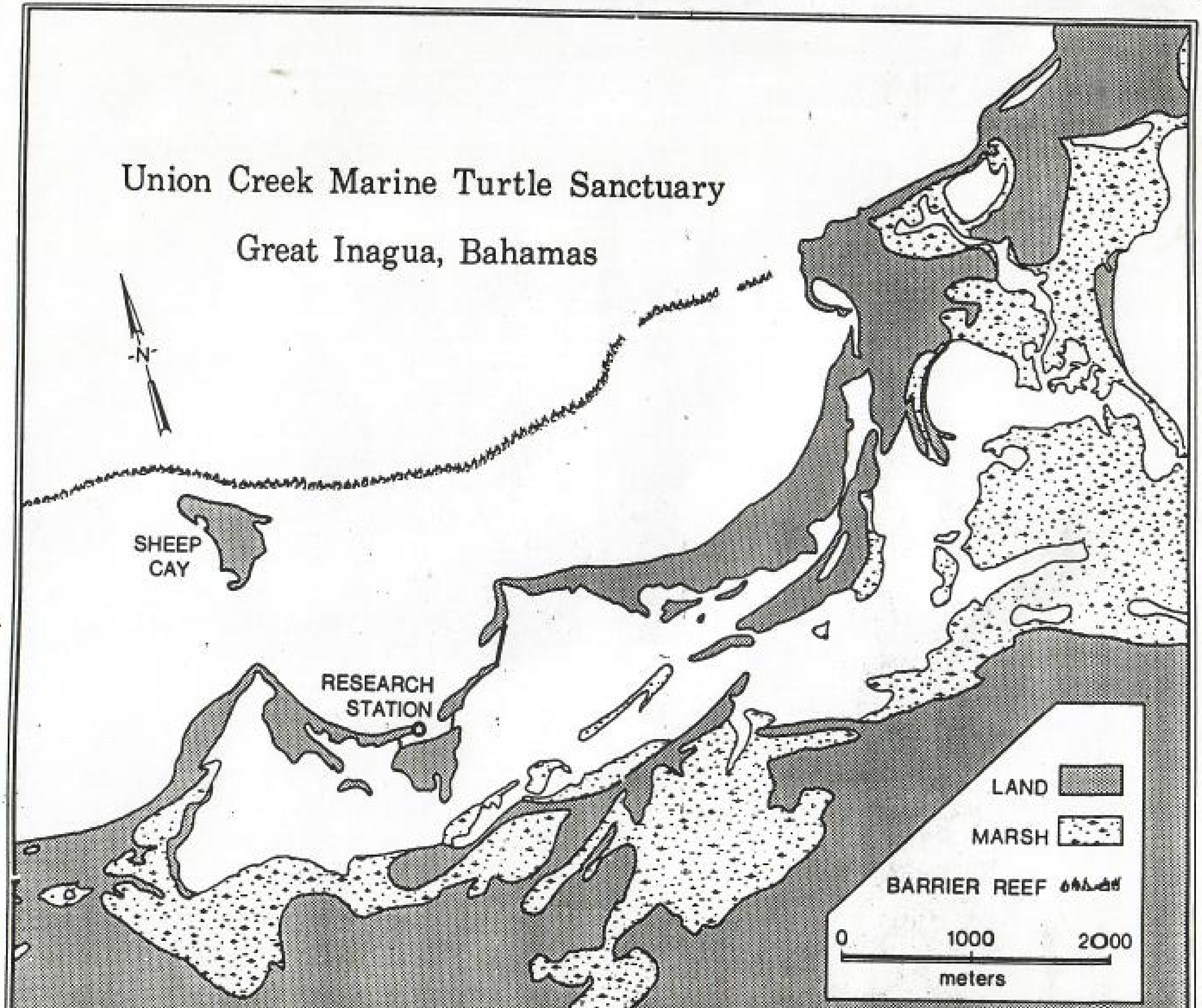
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Great Inagua, Bahamas
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RESEARCH STATION
LAND
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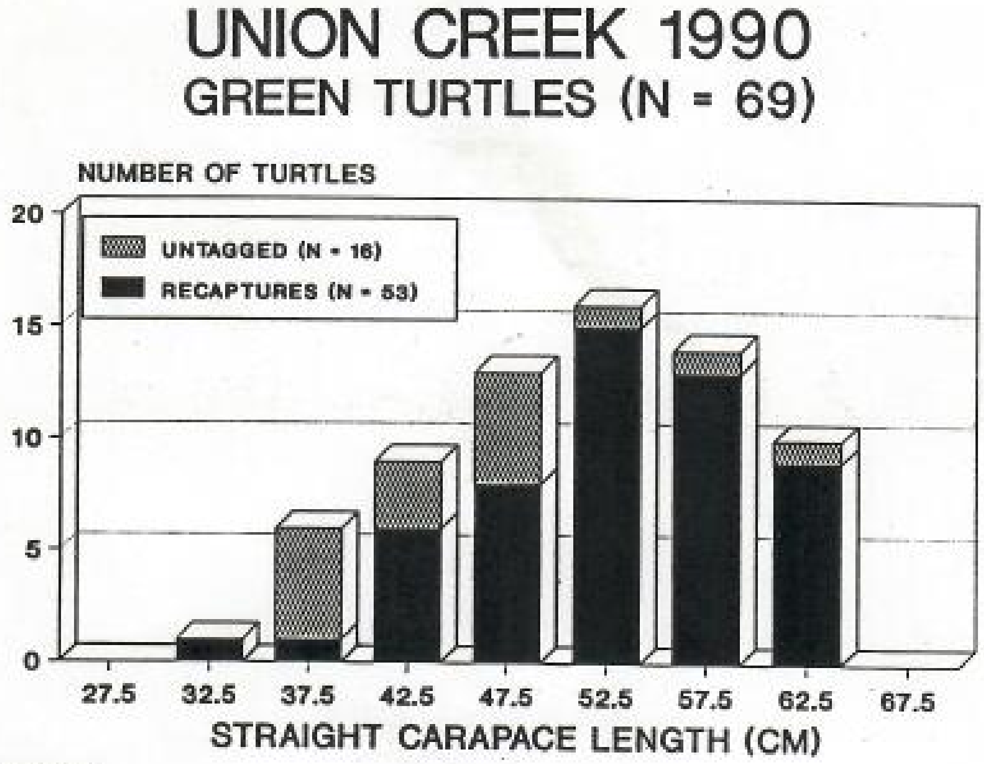

UNION CREEK 1990
GREEN TURTLES (N = 69)
NUMBER OF TURTLES
20
15
10
5
0
UNTAGGED (N = 16)
RECAPTURES (N = 53)
27.5
32.5
37.5
42.5
47.5
52.5
57.5
62.5
67.5
STRAIGHT CARAPACE LENGTH (CM)

FIGURE 3

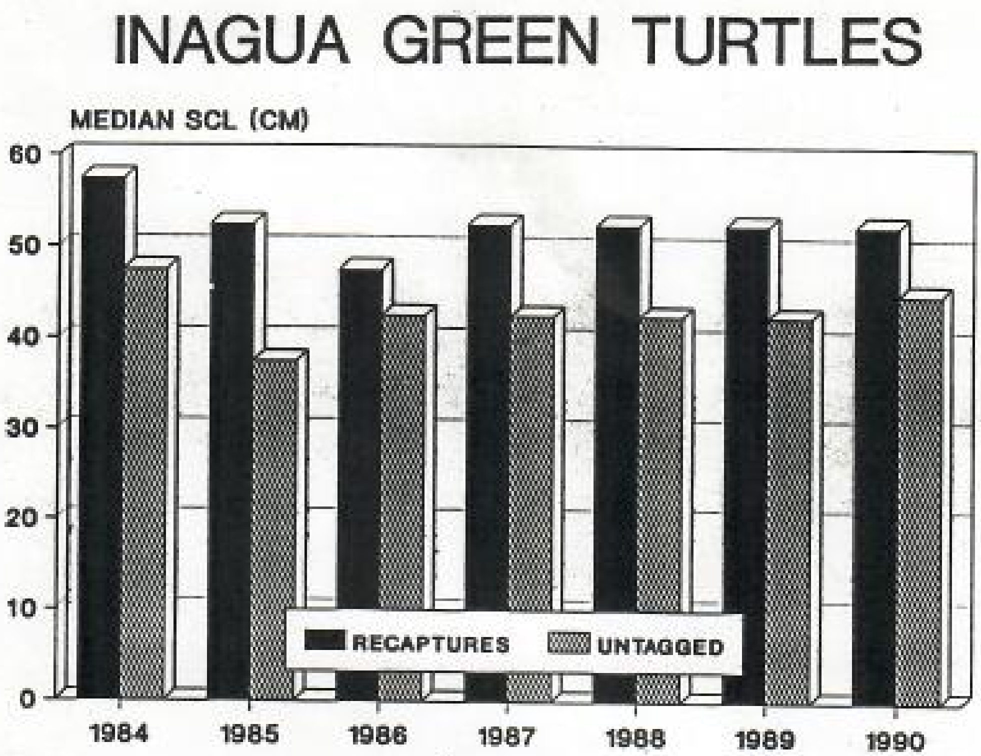

INAGUA GREEN TURTLES
MEDIAN SCL (CM)
60
50
40
30
20
10
0
RECAPTURES
UNTAGGED
1984
1985
1986
1987
1988
1989
1990

FIGURE 4

INAGUA GREEN TURTLES
RECAPTURE RATE BY YEAR

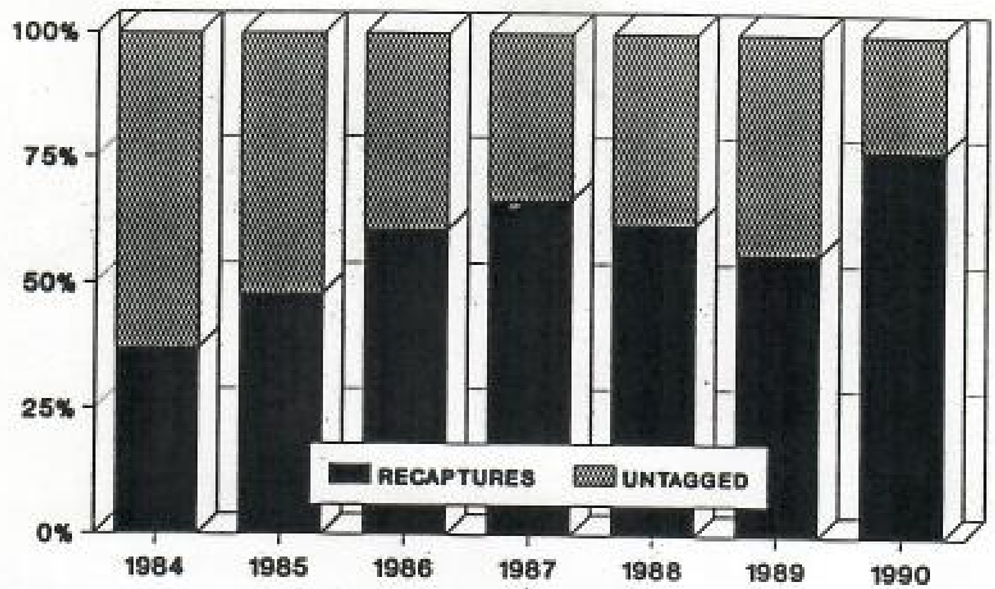


FIGURE 5

MARINE TURTLE RESEARCH

AT THE UNION CREEK RESEARCH STATION

GREAT INAGUA, BAHAMAS

Report to National Marine Fisheries Service

December 1989

Karen A. Bjorndal and Alan B. Bolten

Archie Carr Center for Sea Turtle Research
Department of Zoology
University of Florida
Gainesville, FL 32611

INTRODUCTION

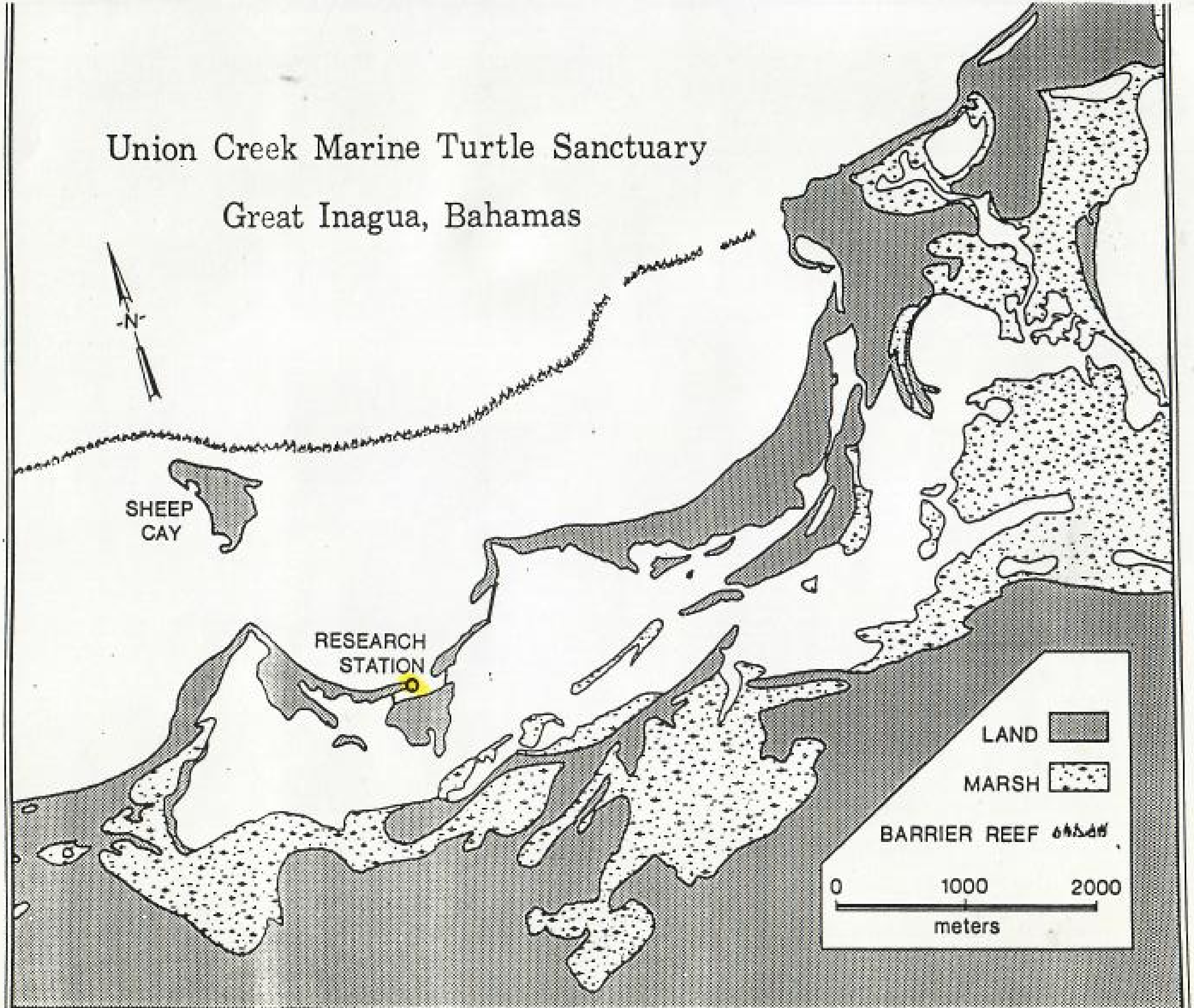
Four projects are currently under investigation at the Union Creek Marine Turtle Research Station: growth rates of juvenile green turtles (*Chelonia mydas*) and hawksbills (*Eretmochelys imbricata*), basic blood profiles (biochemical, morphological and physiological) of green turtles and hawksbills, nutritional ecology of green turtles, and a comparison of tag retention times and tag application procedures for seven types of sea turtle tags commonly used by researchers. Tag loss continues to be a critical problem in studies of individual growth and population biology in sea turtles.

Union Creek (21°07'N, 73°34'W) is a bay (in the Bahamas, the word "creek" means a salt-water bay) of approximately 20 km² located on the north shore of Great Inagua, the southernmost island in the Bahamas (see figures 1 and 2). The area is protected as a wildlife sanctuary by the Bahamas National Trust. Union Creek is a natural feeding area for all sizes of green turtles, hawksbills and loggerheads.

In 1964, Union Creek was fenced off to provide a protected area where marine turtles could be studied on their natural feeding grounds. At least 350 green turtles inhabit the study area; all of these turtles have entered from the ocean adjacent to Union Creek. Most turtles are from 25 to 35 cm straight carapace length when they enter the study area through gaps in the fences.

Union Creek offers a good opportunity to study free-living, but protected, marine turtles in a natural feeding habitat. Turtles are caught by diving on them from motor boats after a brief chase. The turtles are put ashore, blood samples are collected for particular experiments, and then the turtles are weighed, measured, tagged and released.


LITTLE
INAGUA
0
6
12
18
Kilometers
UNION
CREEK
GREAT INAGUA
MATHEW
TOWN
N


Union Creek Marine Turtle Sanctuary
Great Inagua, Bahamas
N
SHEEP CAY
RESEARCH STATION
LAND
MARSH
BARRIER REEF
0
1000
2000
meters

PART ONE: 1989 TRIP ITINERARY AND TURTLE CAPTURES

We traveled to Nassau, Bahamas, on the morning of 27 November 1989. We spent the day meeting with Gary and Susan Larson, the Director and Eduction Officer of the Bahamas National Trust, respectively. Because Union Creek is a wildlife refuge of the Trust, it is important that we remain in close communication concerning our work. We also met with Steve and Babbie Connett, captain and first mate of the Geronimo, who are tagging turtles for us throughout the Bahamas.

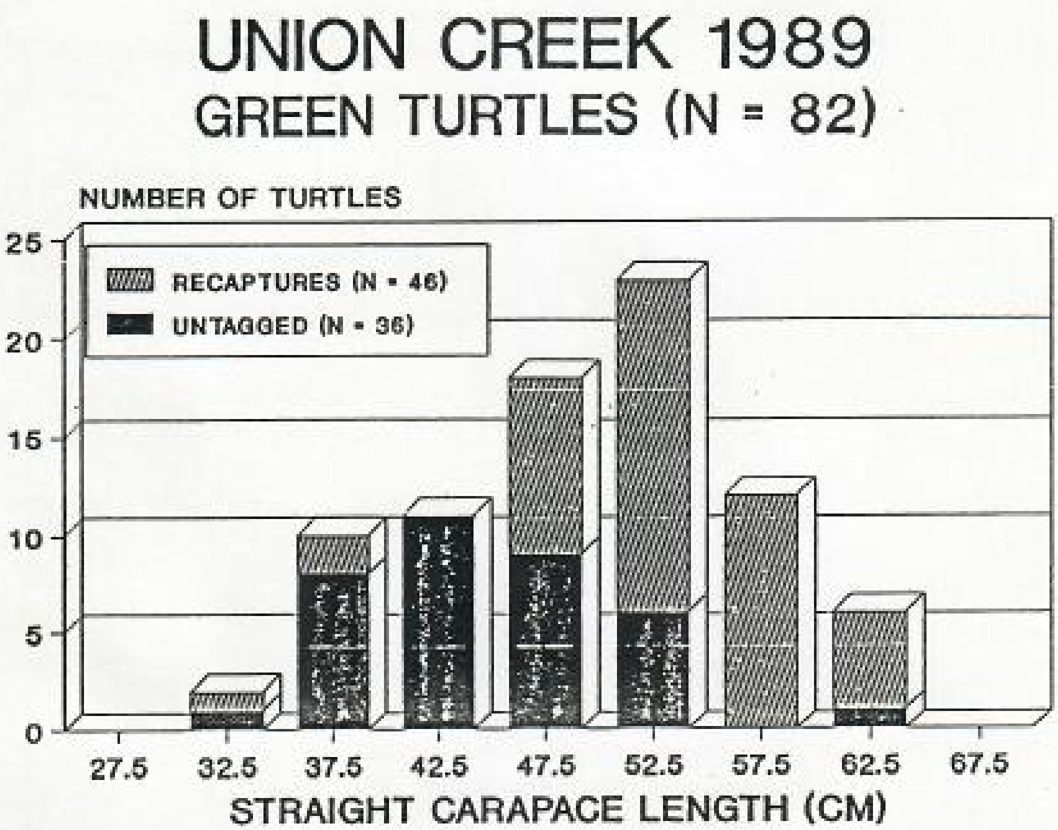
We traveled to Great Inagua on 28 November 1989. The main purpose of our trip was to capture, tag and measure as many turtles as possible for additional growth and tag retention data. It was also critical for us to check on the condition of the wall and fences. We worked with Trust wardens Jimmy and Henry Nixon, who, as always, had done an excellent job of maintaining the facilities during the year and worked very hard with us during our visit.

We caught 82 green turtles and 3 hawksbills in Union Creek. The green turtles ranged in size from 30.7 to 63.9 cm straight carapace length (figure 3). The median straight carapace length for untagged turtles was 42.5 cm and for recaptured turtles was 52.5 cm. The hawksbills had straight carapace lengths of 40.2, 46.9 and 61.6 cm. All turtles appeared to be very healthy. Of the 82 green turtles caught during this trip, 46 (56%) had been captured in earlier years and thus yielded additional growth data. The largest hawksbill had been tagged in June 1985 and recaptured in September 1986.

The facilities were in good condition. Arrangements were made to repair the stone house.

We returned to Nassau on 5 December 1989. We met with Colin Higgs of the Bahamas Department of Fisheries in the Ministry of Agriculture, Trade and Industry. We have worked with Colin for several years. His Department grants us the research and import/export permits that allow us to conduct our research in the Bahamas. Our discussions with Colin concerning sea turtle status and exploitation in the Bahamas continue to be productive. We also met with Mr. Michael Lightbourn with whom we had been unable to meet during our previous stop in Nassau. Michael is a member and past-president of the Bahamas National Trust, has had a long-term involvement in the Inagua turtle work and has given us tremendous support over the years. Again, it is important to maintain good communication with our collaborators in the Bahamas.

We returned to Florida on 6 December 1989.



UNION CREEK 1989
GREEN TURTLES (N = 82)
NUMBER OF TURTLES
RECAPTURES (N = 46)
UNTAGGED (N = 36)
0
5
10
15
20
25
27.5
32.5
37.5
42.5
47.5
52.5
57.5
62.5
67.5
STRAIGHT CARAPACE LENGTH (CM)

FIGURE 3

PART TWO: GROWTH RATES

Growth rates for green turtles ranging in size from initial straight-line carapace length of 25 to 75 cm have been evaluated since 1979. This size range includes turtles that have recently arrived on the benthic feeding grounds from their early, pelagic habitat, to large, sub-adult turtles. Following the November 1989 field season, our sample size for growth increments in straight-line carapace length is 400.

From our study of growth rates of green turtles in Union Creek, we have established a solid baseline of growth rates for turtles between 25 and 75 cm straight-line carapace length. Three publications have resulted from the growth rate research (Bjorndal and Bolten 1988a, 1988b, 1989). During our study, we have found that there is considerable variation in growth rates, even within narrow size classes of turtles. Beginning in 1988, our efforts were directed towards analyzing the potential sources of this variation and identifying the controlling mechanisms of growth in green turtles. Variables to be considered are seasonal effect, annual variation, growth hormone titers, sex, diet selection, micro-habitat differences and genotype. Union Creek offers a unique opportunity to pursue these questions. It is the only feeding ground for which the nutritional quality of the habitat for green turtles and growth rates of green turtles have been established (Bjorndal 1980, 1982, 1985).

The first two potential sources of variation that we are investigating are growth hormone titer and sex. In April 1988, we collected blood samples from 120 green turtles, ranging in straight-line carapace length from 25 to 70 cm and one hawksbill (45 cm straight-line carapace length). We have growth data for approximately three-quarters of the 120 green turtles, so we will be able to relate growth hormone titer and testosterone titer (sex) to rate of growth in green turtles to determine if either of these factors contributes significantly to the variation in growth rates that we have measured. Growth hormone titers have been analyzed by Dr. Paul Licht (University of California at Berkeley), and a publication in collaboration with him is in preparation. Preliminary analysis indicates that there is no significant effect of growth hormone titer on growth rate, but that there is a significant inverse relationship between growth hormone titer and carapace length. Testosterone titer is presently being analyzed by Dr. David Owens and Dr. Janice Grumbles (Texas A & M University). When we have the results, we will test for the effect of sex and/or testosterone titer on growth rates in green turtles. In addition, we will co-author a paper with Drs. Owens and Grumbles on the sex ratio of the southern Bahamas juvenile green turtle population.

Preliminary analysis of our data suggests that there are individual turtles that, over a period of years and a number of recaptures, grow consistently either very much above or below the mean growth rate for a given size class. The research at Union Creek gives an excellent opportunity to follow individual turtles over long periods of time. By apportioning the variation in growth rates among as many potential sources of variation as possible (such as annual and seasonal variation, growth hormone titer and sex), we will be able to evaluate the extent of genetic variation in growth rates.

We need to assess the factors controlling growth in sea turtles to understand the limits of their productivity and their demography.

PART THREE: HEMATOLOGY

We have not yet had the blood samples that we collected in April 1988 from 120 green turtles and 1 hawksbill analyzed by a commercial laboratory to develop a baseline blood chemistry profile (24 parameters). We are now collaborating with Dr. Elliott Jacobson (University of Florida, Gainesville) to compare results from different analyzers commonly in use by different commercial laboratories as well as different methods of blood collection. The results from these experiments will indicate which type of procedure is best for analyzing sea turtle blood samples. We want to complete this experiment before we submit our Union Creek sample set for analysis.

We will use the data from the Union Creek green turtles to establish baseline values for various blood parameters for healthy turtles in non-polluted waters. These values will provide an important database with which we can compare the parameters measured in sea turtles exposed to negative factors, such as disease or pollution, to assess the impact on sea turtles.

During future trips, we plan to collect blood samples to determine red cell and white cell counts, differential white cell counts, Icterus index, and hemoparasites.

PART FOUR: TAG RETENTION STUDY

In 1989, we continued our study of differential retention of commonly used types of sea turtle tags. We caught 82 green turtles, 46 of which were recaptures and 36 were added to the study. This study is composed of three experiments, as summarized in Table 1 and briefly described below.

Experiment 1: Seven tag types are being tested on green turtles weighing more than 14 kg. These tags are National Band and Tag #681, #19 and #49 (all monel); National Band and Tag #681 inconel tags; titanium tags produced in Australia and provided by Colin Limpus; and two styles of plastic tags (Riese and Jumbo-Roto) from Dalton Supplies, Ltd., in Great Britain.

Four tags are applied to each turtle, one on each fin. Tags are always applied in the same location, as shown in the first report, and always with the point of the tag entering from the dorsal surface of the fin. Tags of different metals are not mixed on individuals to avoid possible metal-metal interactions.

Experiment 2: Because small turtles (less than 14 kg) cannot carry large tags (#19, #49, and titanium tags), turtles weighing less then 14 kg are tagged with four tag types: monel #681, inconel #681, Jumbo-Roto and Riese tags.

Turtles originally assigned to Experiment 2 (based on size) remain in this experimental category for tag retention analysis even though the turtles grow above 14 kg. The size of turtles when they are tagged may be important for evaluating tag retention for the different tag designs.

Experiment 3: Initial observations suggested that the direction of tag penetration, and the resulting orientation of the tag, may be important in tag retention. To test this, Experiment #3 was initiated during the 1985 trip. Only inconel and monel #681 tags were used. Tags were applied from the dorsal surface on the right fore and hind fins, and from the ventral surface on the left fore and hind fins. During the 1986 field trip, Experiment 3 was expanded not only to test direction of tag application (dorsal versus ventral), but also position of tag. In addition to using newly-captured turtles, recaptured turtles that have lost tags are being used to test tag application in different locations. Monel and inconel tags are never used on the same turtle in order to avoid any metal-metal interactions.

Table 1. Summary of sizes of turtles, direction of tag application and types of tags used (+) in each of the three experiments.

	Experiment #1	Experiment #2	Experiment #3
Turtle Size	> 14 kg	4 - 14 kg	> 4 kg
Direction of Tag Appication	from dorsal surface	from dorsal surface	from dorsal and ventral surfaces
Tag Type			
#681 Monel	+	+	+
#681 Inconel	+	+	+
Jumbo-Roto	+	+	-
Riese	+	+	-
Titanium	+	-	-
#49 Monel	+	-	-
#19 Monel	+	-	-

Table 1 summarizes the variables in the different experiments. In all three experiments, each turtle is given a coded sequence of drill holes in the rear marginals. If an experimental turtle that has lost all four tags is recaptured during later trips, the drill holes will enable us to identify when and what type of tags were applied and when the turtle was last seen with all four tags still attached.

Table 2 summarizes how the 36 untagged turtles captured in 1989 were distributed among the three experiments. Table 3 summarizes how the turtles tagged since the initiation of this project in 1983 have been distributed among the experiments.

Table 2. Numbers of turtles added to the three experiments in 1989.

Tag Type	Experiment #1	Experiment #2	Experiment #3
Jumbo-Roto	11	25	--

Table 3. Total number of turtles tagged with experimental tags from 1983 - 1989.

Tag Type	Experiment #1	Experiment #2	Experiment #3
#681 Monel	17	50	44
#681 Inconel	22	78	43
Jumbo-Roto	35	63	--
Riese	25	21	--
Titanium	26	--	--
#49 Monel	18	--	--
#19 Monel	18	--	--

Results of tag retention on those turtles captured in November 1989 are presented in Table 4. There is no significant difference between the performance of inconel and monel #681 tags applied in 1985 (Fisher exact probability test, P = 0.34), 1986 (P = 0.18), or 1985 and 1986 combined (P = 0.57). There was a 33% loss of inconel tags applied in 1988. As we have discussed in earlier reports, the high rates of loss for both inconel and monel #681 tags are a result of a high percentage of those tags having been applied to small turtles. These results do not provide a good indication of the relative performance of the two metals because the tags are rapidly lost in small turtles (see below) before there is time to demonstrate differential corrosion. The results presented here, with all size classes of turtles combined, should not be used to judge relative tag retention of monel and inconel tags in large turtles. In large turtles, tags will be retained for a longer period and differential corrosion becomes more important.

On turtles tagged in 1985, Jumbo-Roto tags outperformed the #681 monel (Fisher exact probability test, P = 0.0002). The sample size for the inconel was small, and there was no significant difference between Jumbo-Roto and inconel (P = 0.066). On turtles tagged in 1988, Jumbo-Roto were significantly better than the inconel (P = 0.0079). Combining data for all years, the Jumbo-Roto significantly outperformed #681 monel (P = 0.0001) and the inconel (P = 0.0001).

The sample sizes for the Riese tags were too small to allow for meaningful analysis with #681 monel and inconel. However, on turtles tagged in 1987, Jumbo-Roto were retained to a significantly greater extent than were Riese tags (P = 0.0006).

Table 4. Retention of tags applied in 1984-1988 on green turtles captured in 1989. Sample numbers refer to number of tags, not number of turtles.

	Year in Which Tags Were Applied				
Tag Type	1984	1985	1986	1987	1988
#681 Monel					
Sample no.	8	16	16	--	--
No. on	5	4	10	--	--
No. off	3	12	6	--	--
#681 Inconel					
Sample no.	--	4	32	--	51
No. on	--	2	14	--	34
No. off	--	2	18	--	17
Jumbo-Roto					
Sample no.	4	10	--	12	14
No. on	2	10	--	12	14
No. off	2	0	--	0	0
Riese					
Sample no.	--	2	--	16	--
No. on	--	0	--	6	--
No. off	--	2	--	10	--
#19 Monel					
Sample no.	4	--	--	--	--
No. on	0	--	--	--	--
No. off	4	--	--	--	--

For juvenile green turtles, the plastic tags (particularly the Jumbo-Roto) have significantly better retention than #681 monel and inconel. As we have postulated in earlier reports, the sharp edges of the #681 monel and inconel tags increase the likelihood of tag loss, particularly in small turtles, compared with the smooth posts of the plastic tags. In addition, the top and bottom flanges of the plastic tags freely rotate which reduces drag on the tissue holding the tag.

We feel that we now have sufficient data to compare retention of the seven tag types. These data will be analyzed for publication. Our effort now will focus on tag placement using Jumbo-Roto and inconel as the two tag types. Observations made during the tagging experiments suggest that where the tag is placed on the flipper may be as, or more, important than the type of tag used.

PART FIVE: GREEN TURTLE NUTRITION

The nutrition of green turtles has also been studied at Union Creek. A publication on the digestion of sponges in green turtles resulting from research at Union Creek is in press in Bulletin of Marine Science and is attached.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
SEFC, Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32408

December 19, 1989 F/SEC5:LHO:prp

MEMORANDUM FOR: ✓ F/SWC - George Balayz
SERO - Terry Henwood
F/SEC9 - Sheryan Epperly
F/SEC6 - Tim Fontaine
F/SEC2P - Ren Lohoefener
F/SEC1 - Nancy Thompson

FROM: F/SEC5 - Larry Ogren

SUBJECT: Update on tag retention studies contract report from A. Carr Center for Sea Turtle Research (Bjorndal & Bolten).

Enclosed is a summary and analysis of data collected over several years on a population of free-living green turtles at Union Creek Research Station, Great Inagua, Bahamas. It is apparent that more than one type of external tag is necessary to minimize tag loss rather than a "universal" tag for all species and sizes of sea turtles, and all marine environments.

Enclosure

22 Dec 1983

Dear George -

I have enclosed a copy of my trip report to NMFS about the tag testing project. Larry read me parts of your letter to him over the phone. Any tags you can spare would be a great help. Do you use standard #681 pliers with them? I am a great fan of the #681 style - it is so easy to use & so consistent, that I am anxious to test yours. The results of these tests will almost certainly have a great effect on what tag type NMFS decides to use for its tagging network. Also, NMFS may put out a contract for tag development once we can provide the necessary biological data & requirements.

I can use bent tags for the corrosion test, if they haven't been bent to the point that it might affect corrosion (stress fractures, etc.)

Happy holidays to you, Linda & Christian.

Karen

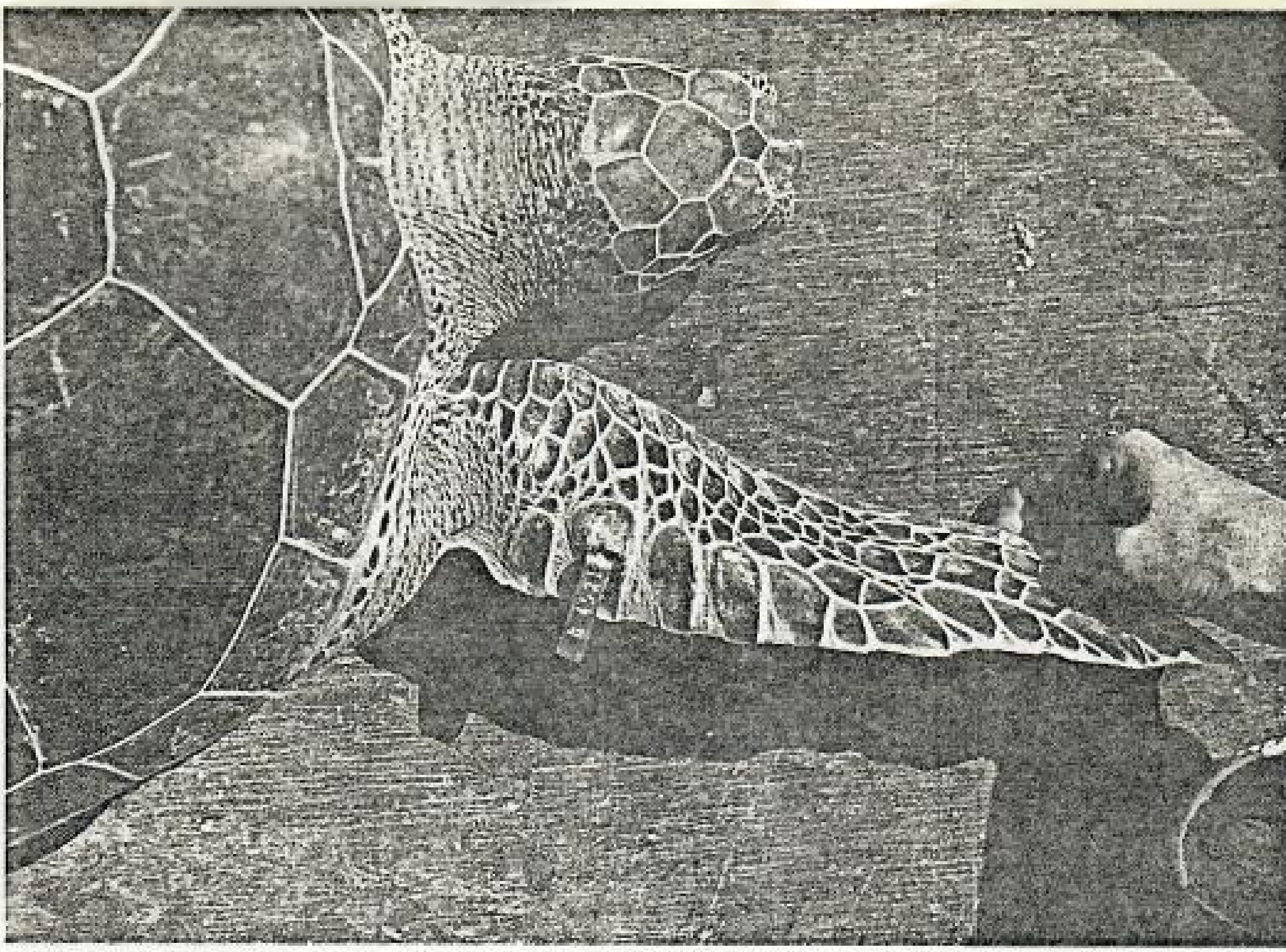

Figure 1. Placement of tag on front flipper.

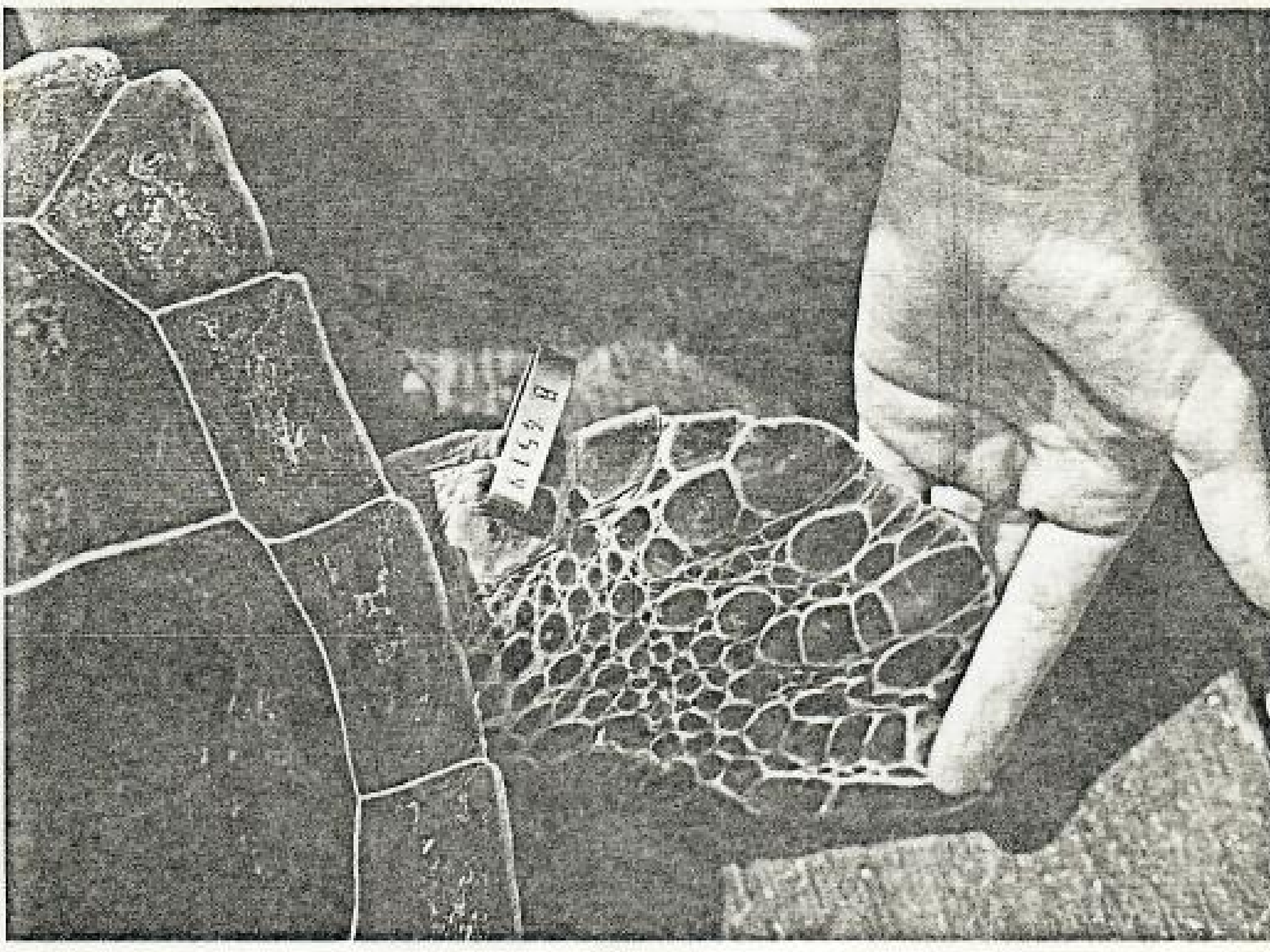

Figure 2. Placement of tag on rear flipper.

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George Balazs
National Marine Fisheries Service
Honolulu Laboratory
PO Box 3830
Honolulu, Hawaii 96812

February 13, 1985

"OUR 83rd YEAR"

Dear George:

I received the Inconel tags and your request for additional applicators. I am sending you under separate cover six pair of pliers with tags attached to show you how they clinch. With just six tags to work with, it was difficult to select the six best, but I think the ones I have selected will do the job. These pliers are $12.00 each and an invoice will follow. If you do not need all six pliers, or if there is one that doesn't meet your satisfaction, don't hesitate to return it for credit.

We hope to be in production of a new size 681 monel tag in the next 30 days and, if enough interest is shown, we at National Band, will attempt to produce the tag in inconel providing we have a firm commitment from yourself, Larry Ogren, and your associates.

Thanks again for the information you gave me on the phone the other day and for your continued interest in National Band and Tag products. I hope to hear from you and Larry soon concerning the inconel tag because, frankly, we at National Band and Tag want to supply the U.S. industry with tags for the marine wildlife programs.

Sincerely,

NATIONAL BAND AND TAG COMPANY

Fred Haas

Fred Haas

FH:lc/2

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	SHIP VIA AIR MAIL....GOVT. LABELS ATT.	
	SHIP BY: 02/15/85	

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February 5th, 1985.

Mr. G.H. Balazs
National Marine Fisheries Service,
Southwest Fisheries Centre,
Honolulu Laboratory,
P.O. Box 3830,
Honolulu,
Hawaii 96812.

Dear George,

Price for large Titanium Tags, is Aust $1.00 per tag, plus Aust $18.00 pair for applicators.

1000 Tags and 2 Applicators will cost in Freight SAL Aust $21.00, or Airmail Aust $45.00

As regards the stamping on the hatchling tags, we could make up new stamps and reduce the legend still further, however I do not think that even then we can get all of your message on.

We are stuck with the number size, unless we spend approximately $2000.00 on a new numbering machine.

George, you did not comment on any alternate method of tagging, and I would like your ideas if possible.

Yours faithfully,

JOHN FOREHAN.

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USDC-NOAA-NMFS
SEFC, Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32407-7499

January 29, 1985

"OUR 83rd YEAR"

Attn: Larry H. Ogren, Fishery Biol.(Res.)

RECEIVED

Dear Larry:

Just a note to up-date you on the progress of the inconel identification tag.

As you know, this has been a very trying year for us here at National Band and Tag Company and unfortunately, the development of the new tag has been delayed, but has not been forgotten.

We are presently tooling up to produce an improved 1005 size 681 and 1005 size 49 along with good steel applicators for each size. As soon as possible, we plan to tool up for the new style tag you and I discussed during my visit last January.

We appreciate your continued interest and keeping us posted on the needs of the researchers and conservationalists and we want to assure you and your colleagues that we will continue to work with you in any way possible.

We are looking forward to the day we can offer the identification tag that will be self-piercing and permanent. Thanks again for your help and continued interest.

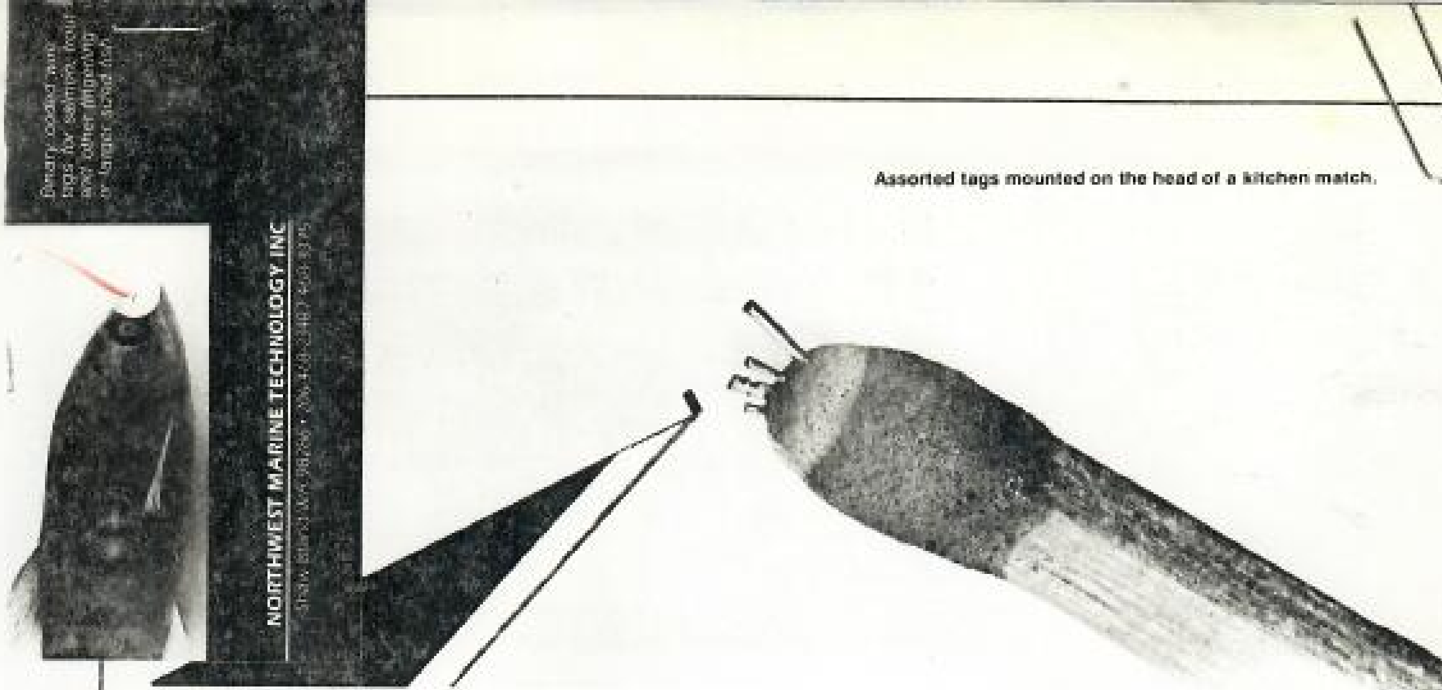
Sincerely,

NATIONAL BAND AND TAG COMPANY

Fred Haas

Fred Haas

FH:lc/2



Assorted tags mounted on the head of a kitchen match.

All tags are <u>not</u> created equal.

Because all tagging problems are not the same, Northwest Marine Technology offers four different micro-tag formats specifically designed to satisfy various tagging requirements. Now it is possible to choose a tag which is internally applied, biologically inert, produces no measureable modification of the tagged animal's behavior and is optimally suited for a given application.

1. Standard Length Coded Wire Tags for Salmon, Trout and Other Fingerling or Larger Sized Fish

The standard 0.010 inch (0.254mm) diameter by 0.042 inch (1.067mm) long tag is the most commonly used tag format. The code, which is permanently etched into the wire, is carried in four longitudinal rows spaced at 90° around its circumference. Each row constitutes a six bit binary word. One word is used as a master indicating the beginning of the word and the direction of the reading. The three other words are used for data, giving a total of 262,144 possible combinations of numbers. Used world wide, over 200 million tags of this format have been successfully implanted in fish and other marine animals. In salmonids the tag is applied beneath the skin into the nose cartilage of the fish. When used with Northwest Marine Technology's implantation equipment, tagging rates of 500-800/hour are routinely achieved. At the completion of the study/life cycle of the fish, the tag is excised and the binary coded information recovered. Magnetization of the tag aids in tag detection and recovery.

2. Half Length Coded Wire Tags for Extremely Small Fish such as Emergent Chum and Pink Salmon Fry

In some instances, fish must be tagged while still very small. For this application a tag one half the length of the standard tag has been developed. The half-length tag contains four words which are four bits long, giving a total data capacity of 4096 codes. Recent studies conducted in Alaska with emergent pink salmon fry (write for a summary report) have shown that fish as small as 1800/lb. (.25g) can be routinely tagged. In these experiments, tagging rates approaching 800/hour, with better than 90% tag retention, were achieved. Once again magnetization of the tag facilitates tag detection and recovery.

3. X-Ray Readable Tags for Long Lived/Multiple Spawners such as Atlantic Salmon and Striped Bass

When the objective of tagging is to follow growth and migration patterns or marking long lived, multiple spawners, it is important that information can be recovered from a tag without sacrificing the animal. For this application, a microtag has been developed which can be read externally using an x-ray source and an appropriate x-ray detector. This tag is made from oval wire 0.016 inches wide and is 0.042 inches long. Two sets of notches etched into each edge of the wire carry the binary coded tag information. Recent developments in x-ray equipment permit the tag to be read in real time on a standard TV screen. The tagged fish can thus be caught, x-rayed and immediately re-released as soon as the information has been recovered from the tag and verified.

4. Larger Tags for Stock Assessment of Crab and Pelagic Species such as Herring and Sardines

Since the magnetic moment of a tag scales with size, larger tags can be made more magnetic and hence easier to detect and recover than standard tags. Therefore when the body type and/or size of the animal to be tagged can accommodate a larger tag, it makes sense to use one. For this reason, larger diameter (0.014 inch) and longer (1.5 - 2 times standard) tags have been developed. In recently concluded experiments, 1.5x tags have been successfully applied to harvestable herring. The larger size tag can be easily implanted into juvenile and adult fish and readily detected using Northwest Marine Technology's conveyorized bulk screening equipment designed to routinely process the entire catch passing through a processing plant. Screening rates in excess of 20 tons/hour have been successfully demonstrated. Such a capability now makes it possible to routinely conduct tagging experiments designed to assess the size of a given stock with accuracies heretofore unthinkable. Similiarly, 2x tags have been used in pilot tagging experiments designed to assess crab stocks. A simple factory modification to Northwest Marine Technology's standard tag injector is all that is required to implant these larger format tags.

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DEPARTMENT OF ZOOLOGY
223 BARTRAM HALL
904-392-1107

10 April 1984

Mr. Larry Ogren
National Marine Fisheries Service
3500 Dellwood Beach Road
Panama City, FL 32407

Dear Larry:

I wanted to let you know about the latest development in our tag testing study. As you know, we had planned to test Inconel tags, but it seems that we will not be able to do so. George Balazs has just sent 26 tags that had previously been misapplied. These are the only tags he can spare. As you know, there are repeated references in the literature to the fact that every time metal is bent, stress fractures form. Therefore, these tags would not be fair representatives of the Inconel tag in a comparative study. Also, because we place four tags on each turtle, we would only be able to tag six turtles--a very small sample. I have returned the tags to George. 12

It is unfortunate that we won't be able to test Inconel tags, but I am sure you will agree with our decision. During our May trip we will be applying two kinds of plastic tags for the first time and will continue applying titanium tags and three styles of monel tags.

Sincerely,

Karen Bjorndal

Karen Bjorndal

It's too bad we can't test the Inconel, because NMFS might have been able to kick in the $50,000 necessary for Inconel tag production ~~if~~ if they tested out best at Inagua, but I can understand that you can't spare them.
Karen

4-16-84

Karen -

Was disappointed to see the tags returned to me, along with your letter to Larry. I didn't feel the tags were really bent that bad. And if they were used (tested) in that condition, and did hold up without corrosion, then all the more credit could be given to the durability of Inconel size 681. But your comment about low numbers (6) being tagged is a problem I can't argue. Unless you go to just double tagging for some tag types. Variables like this are bound to occur. For instance, are all of your test animals adults? How does the size range break down? How many animals total are you using? I really am interested in your study, since it holds potential for making valuable recommendations. If you're just interested in corrosion resistance of Ireanel, remember that I can always send you a few tags that have been on Hawaiian greens for 6-7 years, both captive and wild.

Thought you would be interested in the enclosed review by Leo from CDC newsletter. As would be expected.

I've given the 26 tags to Larry in the event that he would like to use them elsewhere - or return them to you, if you change your mind somewhere along the line.

Best regards,

George

cc Larry

Larry + Frazer + TMR + hatchling draft

30 Dec 83

Dear Karen -

It was interesting reading your trip report on testing tags at Great Inagua. Thank you for sending it to me. I knew nothing of this worthwhile project until Larry asked if I could send you a small supply of Inconel tags. Be assured that I will mail you at least 50 perfect ones plus a dozen or so slightly bent ones. (before mid-April) Yes, regular #681 pliers are used. However, not all the pliers I get from National Band & Tag lock the tags as they should. Some must be filed slightly on the "stops" located under the spring where the handles come together. It's an easy adjustment. Nevertheless, it may be best for me to just send you a plier that works right. I should also mention to you that, if you are going to tag right through a scale, the piercing point should go through the ventral surface of the flipper. With my Inconels on larger turtles, trying to "self-pierce" the dorsal surface of the scale will result in improper application (distorted incomplete locking). I'm certain this is also the case for Monel #681.

~~Does~~ "badly tarnished" PAGE 3 mean greenish surface corrosion?

Based on my experiences, I feel the only true test of corrosion-resistance for turtle tags is on the turtle itself. Electrical potential is established whenever dissimilar metals are placed in salt water. How close are your tags on the plexiglass plates? Are the rods they are fastened to made of metal? You may want to further consider these aspects.

On a separate topic, I recently received a letter from Nat Frazer concerning the Marine Turtle Newsletter. I've sent a copy to Wayne, and asked him to pass it on to Archie, you and Anne. An obscure 1981 paper on tumors at CTF too. At least not previously known to me!

Best wishes for 1984.

George

PS. A copy of this is being sent to Larry so he knows what I [am] doing relevant to his request.

I can't find my copy of the minutes of the Turtle Group meeting. Please send me another one eventually, please. Many thanks.

2 apr 84

George -

I've enclosed another contribution for your Hawaiian archives. I came across this slide when I was going through Dr Carr's slides preparing for a lecture I gave at Smithsonian two weeks ago, & thought you might like a copy. I really worked hard preparing for my Smithsonian lectures (I gave it twice in one evening) & am very relieved to have it over.

I spent the weekend in Nassau. I went down for the Bahamas National Trust annual meetings. I am working w/ them to get 2-4,000 sea turtle coloring book-education packets for their schools from CEE. They are very enthusiastic about it & Mike Weber seems fairly optimistic that he can get funding for it. He has arranged already for a two year distribution in the Dominican Republic of the same number.

Alan & I plan to leave for Inagua on 15 May. Can you send us Inconel tags & pliers by then? I've ordered 2 styles of plastic tags from Dalton to test also. Give my regards to your family.

Karen

4-4-84

Dear Karen –

Enclosed are 26 Inconel tags that I can afford to send you for your tagging experimentation. My remaining supply is lower than I previously thought. I keep honoring requests for tags to do tagging at various sites in the Pacific. As you know, its unlikely that any more of these will be made by NBTC, unless someone comes up with big bucks.

All of these 26 tags have been misapplied for one reason or another – usually operator deficiency or applicator maladjustment. You will therefore probably have to put these tags on manually. If your study objective is testing for corrosion, or causing tissue necrosis at the tag site, then this shouldn't make any difference.

(OVER)

Incidentally, I'm finding that tags applied so they pierce a scale are more susceptible to loss. The whole edge of the scale breaks away apparently from motion of the tag. This goes for both immatures and adults, although I do not have great numbers to prove this right now. A tag in the webbing between the 3-4th scale (see enclosed) stays on very well. Also on that proximal flap of flesh (my primary tagging site.) shown in the photo too.

I'm anxious to learn how your study is going. Write to me sometime when you have the opportunity.

The final report on the Johnston turtle study will be sent to Dr. Carr's lab in the near future.

Best regards,

George

Copy to Jerry - Review comments sent 3/1/84 to him

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Fisheries Center
Mississippi Laboratories
Pascagoula Facility
P.O. Draser 1207
Pascagoula, MS 39567-0112

February 21, 1984 F/SEC23P:TAH/lg

TO: George Balazs

FROM: Terry Henwood TAH

SUBJECT: Tag losses

Andy Kemmerer and Larry Ogren have suggested that I send you a copy of my tag loss manuscript. Since you have recently published a report in which green turtle tag losses were addressed, these results may be of interest. As you can see, our tag losses were much higher than those observed in your research. We believe that improper tag application may be the major cause of our high loss rates but we have no real evidence to prove this theory. It could be a combination of several factors, including improper application.

Enclosure: as

corrosion? cite me 1983

(One signed copy of this form should accompany each copy of the manuscript)

NOAA Form 25-700
(4-71)

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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Tag Losses in Monel Alloy Flipper Tags Applied to Loggerhead Sea Turtles, *Caretta caretta*

By

Tyrrell A. Henwood

National Marine Fisheries Service
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Pascagoula, Mississippi 39567

INTRODUCTION

A major problem faced by sea turtle researchers throughout the world is that no reliable cost effective method to permanently mark or tag individual animals has been developed. In recent years, most sea turtle tagging programs have used either monel alloy flipper tags (National Band and Tag Company, Newport, Kentucky) or plastic jumbo Rototags (Dalton, Henley, England)* (Hughes, 1982). Although there are advantages and disadvantages associated with both tags, neither has been shown to be very effective as a permanent attachment (Cornelius and Robinson, 1982; Schultz, 1975; Hughes, 1974; Richardson et. al., 1978; Carr, 1980; Green, 1979). The need to address the tag loss problem has received considerable attention in recent years, but debate continues on which tag is best and what can be done to improve retention rates (Marine Turtle Newsletter Nos. 1, 2, 3, 5, 13, 19, 20, 22).

The purpose of this study was to estimate probabilities of tag loss in monel alloy flipper tags applied to loggerhead sea turtles (Caretta caretta). Known probabilities of tag loss over time are essential in the development of meaningful population estimates. Failure to consider tag losses in estimating population size will lead to an overestimation of true population abundance. If tag loss rates are high, population estimates can be profoundly biased.

* Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

MATERIALS AND METHODS

National Marine Fisheries Service (NMFS) sea turtle tagging activities have been conducted in the southeastern U. S. waters since 1978. During the first two years of tagging all turtles were tagged with a single monel flipper tag (NBTC size 49 or 681) attached to the trailing edge of the proximal portion of either foreflipper. By 1980, it had become apparent that tag losses were occurring, and the practice of double tagging was instituted. The double-tagging procedure was expected to enhance the possibilities of recognizing individuals by increasing the chances that at least one tag would remain on the turtle. Double-tagging also provided a means of assessing tag losses for use in population estimation. In the fall of 1980 the NBTC size 49 tags were replaced with NBTC size 19 tags which were expected to improve retention rates due to a superior locking mechanism (Balazs, 1982). Triple-tagging with NBTC size 19 tags was begun in the fall of 1981 to further enhance chances of long-term recognition.

Over the study period, approximately 4400 sea turtle captures were recorded. Ninety eight percent of these animals were loggerhead sea turtles Caretta caretta. Tag returns were obtained from shrimp fishermen, gill net fishermen, surf fishermen, power plant intake canals, sea turtle strandings, sea turtle nesting beaches and NMFS project recaptures.

The data were analyzed according to procedures outlined in Seber (1973) where:

$$\pi = M_C/(M_C + 2\ M_{AB})$$

π = Maximum likelihood estimate of the probability that a tag is lost by the time of the second sample

M_C = Members of the second sample bearing only one tag

M_{AB} = Members of the second sample bearing both tags

The same formula was utilized in analysis of triple-tagged recoveries by redefining the terms as:

π = Maximum likelihood estimate of the probability that one or more tags are lost by the time of the second sample

M_C = Members of the second sample bearing one or two tags

M_{AB} = Members of the second sample bearing three tags

While not analogous, these values are sufficiently comparable for comparisions in trends. The triple-tagged data base consists of only fifty eight (58) recoveries, and is included primarily to corroborate results of double-tagging experiments.

Multiple captures of the same turtle were treated as independent events and the number of days from the date of original capture as days at large. The data were then treated as if all animals were tagged as part of a single sample and the tagged population continuously sampled thereafter. This approach assumed tag loss rates were constant throughout the year and no tag loss was associated with capture. The final step in the analysis was to arbitrarily group recoveries by 100-day increments and calculate probability of tag loss over these time frames.

RESULTS AND DISCUSSION

A total of 649 recaptures of loggerhead sea turtles bearing NMFS tags were recorded since the tagging program began. Of this number, 146 were originally single-tagged, 445 were double-tagged and 58 were triple-tagged.

Probability of tag loss over 100 day time increments was calculated for double and triple-tagged turtles (Table 1). Results were plotted and linear regression analyses were performed (Figure 1). Correlation coefficients from each regression were tested for significance at the 95% confidence level and found to be significant in both cases (double-tagged t = 4.77, d. f. = 7; triple-tagged t = 3.04, d. f. = 4).

Although both data sets indicate the existence of a positive correlation between probability of tag loss and days at large, the importance of sample size must be considered in evaluating these results. If either M_{AB} or M_C are equal to zero, probability of tag loss will equal 100% or 0%, respectively. Probabilities calculated from small samples may change dramatically based on a single capture in either category. For this reason, the double-tagged data base regression was recomputed after omitting any increments with a sample size of less than five (Figure 2). The resultant regression line was significant at the 95% confidence level (t = 11.91, d. f. = 5). For purposes of estimating probability of tag loss over time, this equation is recommended.

The results of this study are similar to tag losses observed in green turtles of the Galapagos Islands (Green, 1979). In a study designed to compare retention rates of monel flipper tags versus plastic rototags, Green found that 35 of a total of 116 turtles had lost the monel tag within 500 days. Mrosovsky and Shettleworth (1982) using Green's data, calculated the probability of losing a metal tag during the time interval of 101-500 days to be 0.38 and from 501-1000 days to be 0.63.

It should be noted at this point that the recommended regression equation is based on observed tag losses in animals recaptured after less than 700 days at large. The use of the equation for predicting probability of tag loss over longer time spans therefore is questionable. From published information on nesting female turtles renesting after 3 and 4 year intervals and still retaining monel flipper tags, it is apparent that tag loss rates must diminish at some point in time (Richardson et al., 1978; Hughes, 1974). Our regression equation predicts a 100% probability of tag loss after 967 days at large.

immatures vs adults

A second analysis of the double-tagged data was performed by dividing the 0-99 day segment into 5 day increments and calculating tag loss probabilities for each shorter time period (Table 2). The purpose of this analysis was to determine if initial high probabilities of tag loss attributable to improper tag application could be discerned. Time increments in which M_c equalled zero were omitted from the analysis. The probability of tag loss was regressed against time; and the correlation coefficient was significant at the 95% confidence level (t = 6.48, d. f. = 15) (Figure 3).

While the second analysis did not suggest initial high probabilities of tag loss which could be directly attributed to improper tag application, the linear fit ($r^2 = 0.71$) does not preclude the possibility that improperly applied tags have a significant effect on tag loss. There is no reason to suspect that all tags not properly secured would be lost over any given time span. We have captured turtles in the field bearing unlocked tags up to two years after initial tagging.

Schultz (1975) conducted an experiment in which 80 nesting female green turtles were tagged and simultaneously marked with paint. Within one month 12 of these animals were recovered with persistent paint marks, but missing tags. He estimated 15-20% of the turtles tagged would lose their tags within one month. Comparing Schultz' results with our data required a recomputation to reflect percent tag loss in 30-day increments (Table 3). Tag loss percentages based on the 30-day periods ranged from 8 to 19 percent and averaged 15 percent which is compatable to Schultz' results. Our calculations, however, may have underestimated tag loss as no provisions were made for turtles having lost both tags.

A final analysis of the double-tagged data was conducted to compare performances of NBTC 19 and 681 versus NBTC 49 tag (Table 4 and Figure 4). Regression analyses were performed on both data sets omitting those samples where either M_{AB} on M_C were equal to zero. An F test for differences between regression coefficients was performed and found to be non-significant at the 95% confidence level ($F = 1.358$, d. f. 1, 13).

The lack of significant difference between the two groups of tags may stem from the small sample sizes, the universality of improper tag application, or tag failure. The apparent poorer performance of the 19 series tags could have been due to unfavorable conditions under which the tags were applied. The majority of the 19 series tags were applied during sea turtle removal operations in the Canaveral Ship Channel where most tagging was at night and the turtles were often held on deck for several hours due to large numbers being captured (as many as 40 in a single night). These conditions may have resulted in an increased failure to properly lock tags.

CONCLUSIONS

The probability of tag loss over time with NBTC monel alloy flipper tags applied to loggerhead sea turtles was linear over the first 700 days at large. Estimates of probability of tag loss approached 70% near the end of this time period.

Examination of probabilities of tag loss over the first 100 days at large indicates that early losses of tags are a function of time. The relationship of probability of tag loss to time was linear with no indication of early peaks which could be attributed to improper tag application. During the first three months, tag loss rates approached the 15-20% losses observed by Schultz (1975) with green turtles.

No significant differences in tag loss probabilities were found when series 49 tags were compared to series 19 and 681 tags. The apparent poorer performance of the 19 series tags may have been due to unfavorable conditions under which the tags were applied.

The monel alloy flipper tag does not appear a reliable permanent tag for loggerhead turtles. The specific reason or reasons for the poor performance of the tags is unknown although it is suspected that it is a combination of factors including improper application and tissue rejection.

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Table 1. Probabilities of tag loss calculated for double and triple-tagged turtles by 100 day increments.

DOUBLE-TAGGED TURTLES			
Days at Large	M_{AB}	M_C	Probability of tag loss (π)
0-99	261	44	.08
100-199	31	9	.13
200-299	30	13	.18
300-399	13	10	.28
400-499	5	11	.52
500-599	2	5	.56
600-699	1	4	.67
700-799	2	2	.33
800-899	-	2	1.00

TRIPLE-TAGGED TURTLES			
Days at Large	M_{AB}	M_C	Probability of tag loss (π)
0-99	37	1	.02
100-199	9	2	.10
200-299	1	1	.33
300-399	1	1	.33
400-499	-	2	1.00
500-599	1	2	.50
600-699	-	-	
700-799	-	-	
800-899	-	-	

Table 2. Probabilities of tag loss calculated for double-tagged turtles by 5 day increments.

DOUBLE-TAGGED TURTLES (49, 19 and 681 Series)			
Days at Large	MAB	Mc	Probability of tag loss (π)
0-4	38	2	.026
5-9	24	1	.020
10-14	23	1	.021
15-19	26	1	.019
20-24	20	3	.070
25-29	22	5	.102
30-34	20	2	.048
35-39	7	-	0
40-44	9	-	0
45-49	8	5	.238
50-54	10	5	.200
55-59	8	3	.158
60-64	10	1	.048
65-69	4	1	.111
70-74	5	2	.167
75-79	5	4	.286
80-84	6	-	0
85-89	4	-	0
90-94	6	4	.250
95-99	6	4	.250
100-104	2	2	.333

Table 3. Percent of turtles having lost one tag computed by 30 day increments.

DOUBLE-TAGGED TURTLES (49, 19 and 681 Series)				
Days at Large	M_{AB}	M_C	M_{Total}	% Loss
0-29	153	13	166	8
30-59	62	15	77	19
60-89	34	8	42	19

Table 4. Probabilities of tag loss in tags with different locking mechanisms by 100 day increments.

DOUBLE-TAGGED TURTLES (49 Series)			
Days at Large	M_{AB}	M_C	Probability of tag loss (π)
0-99	75	12	.07
100-199	21	5	.11
200-299	25	8	.14
300-399	8	1	.06
400-499	2	2	.33
500-599	2	2	.33
600-699	1	1	.33
700-799	1	2	.50
800-899	-	1	1.00

DOUBLE-TAGGED TURTLES (19 and 681 Series)			
Days at Large	M_{AB}	M_C	Probability of tag loss (π)
0-99	186	32	.08
100-199	10	4	.17
200-299	5	5	.33
300-399	5	9	.47
400-499	3	9	.60
500-599	-	3	1.00
600-699	-	3	1.00
700-799	1	-	.00
800-899	-	1	1.00

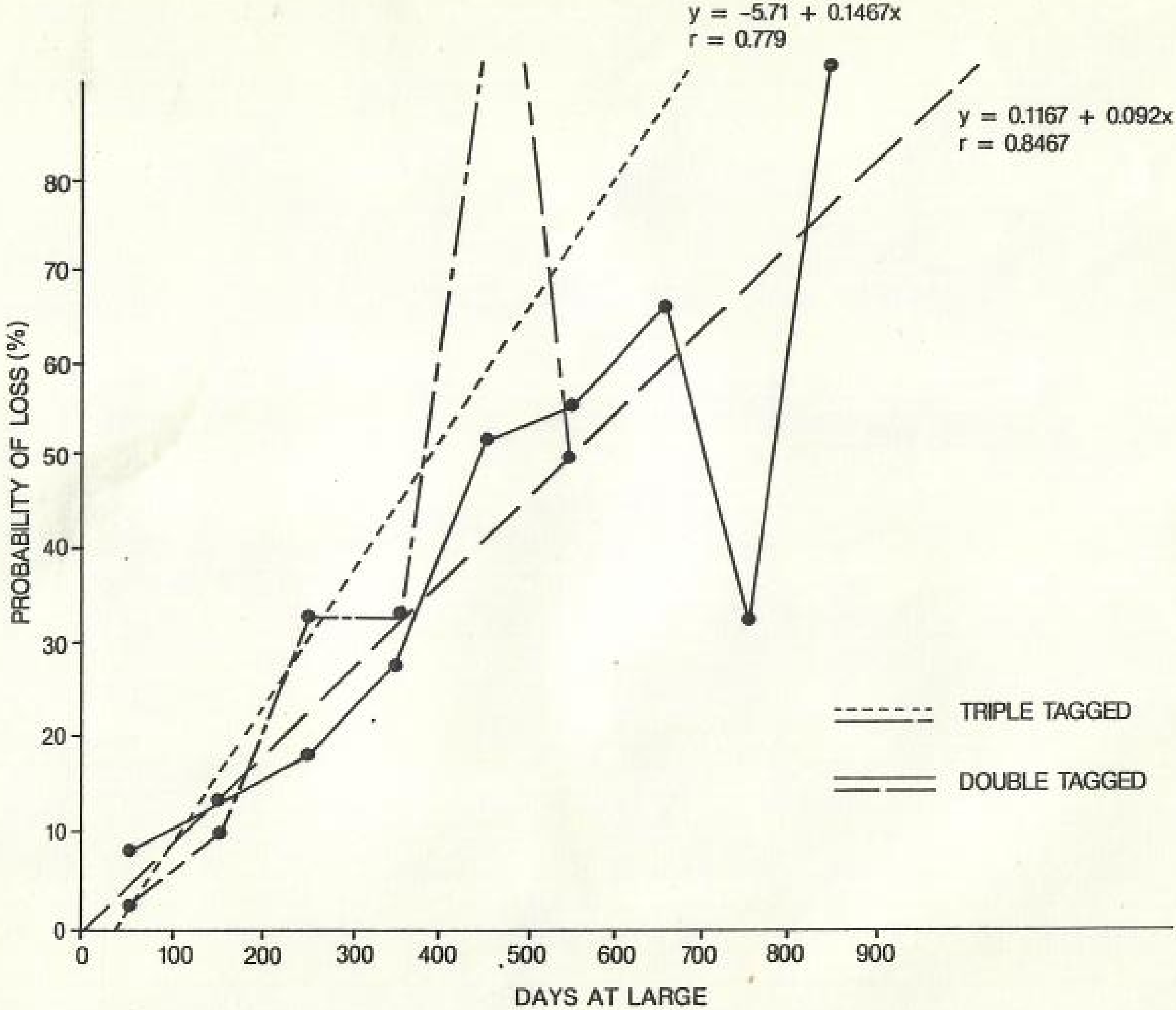

Figure 1. Relationship between probability of tag loss and days at large in loggerhead sea turtles, *Caretta caretta*, based on returns of double and triple-tagged animals.

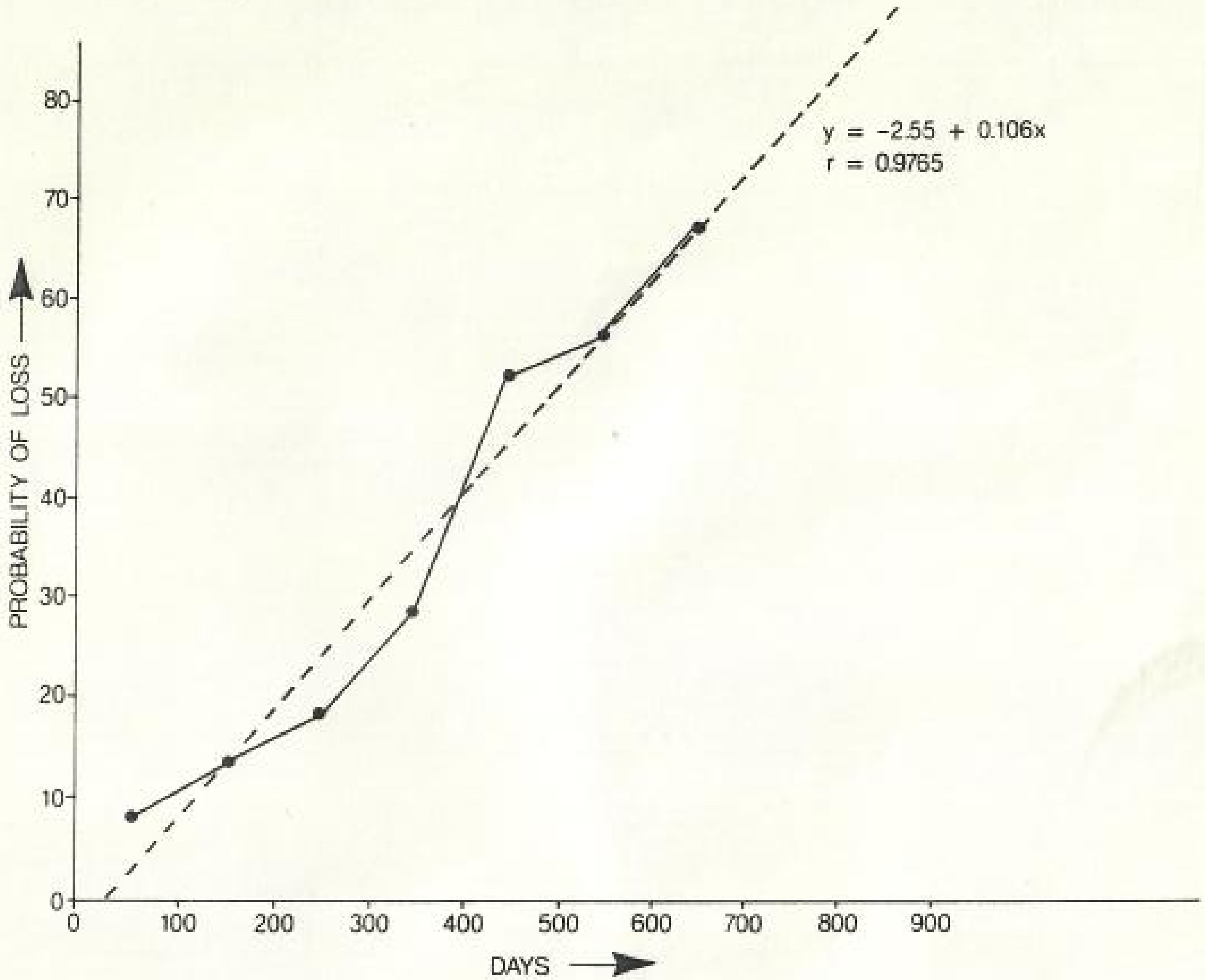

Figure 2. Relationship between probability of tag loss and days at large in loggerhead sea turtles, *Caretta caretta*, based on double-tagged returns.

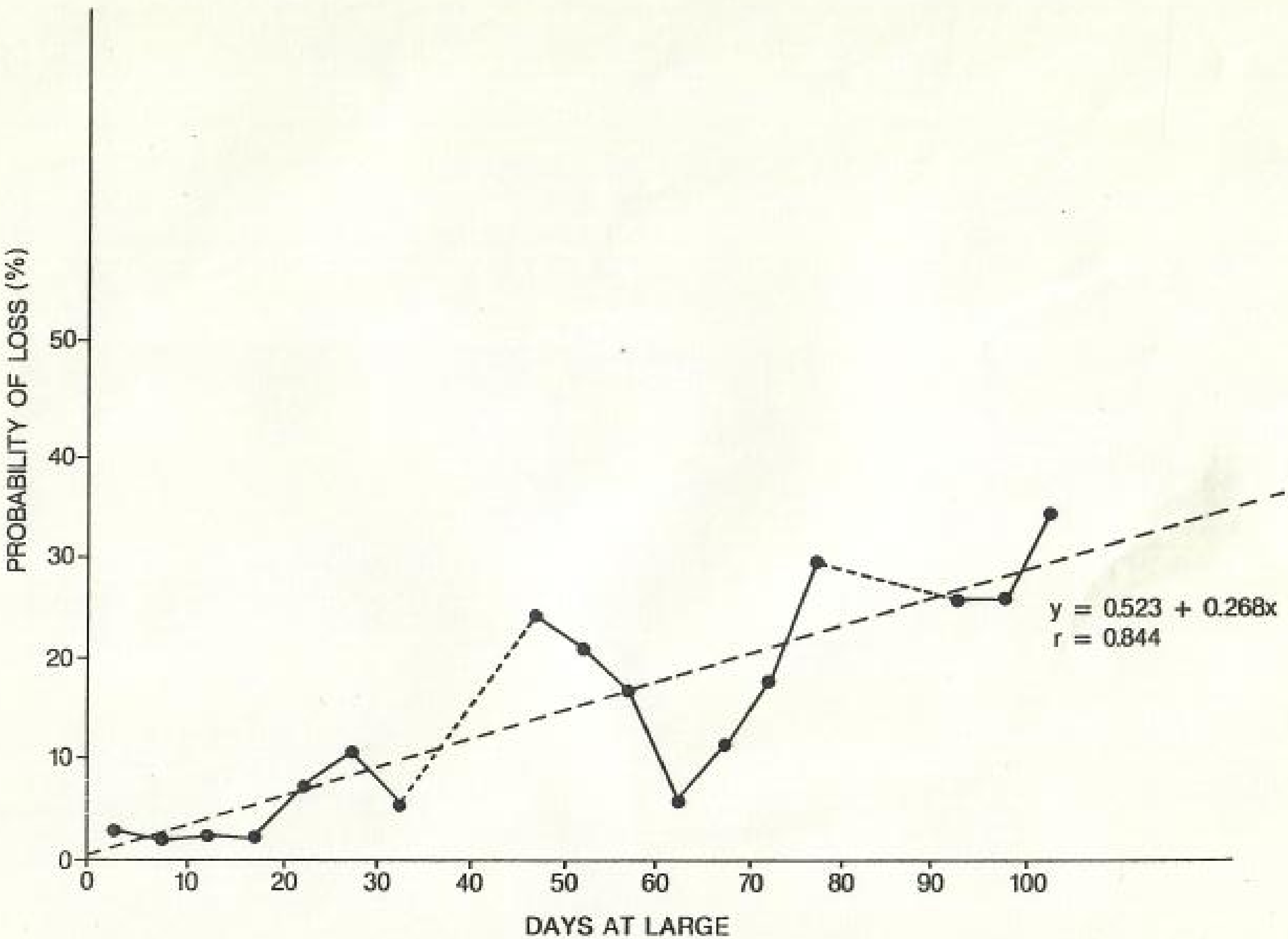

Figure 3. Relationship between probability of tag loss and days at large in loggerhead sea turtles, *Caretta caretta*, calculated by five-day increments.

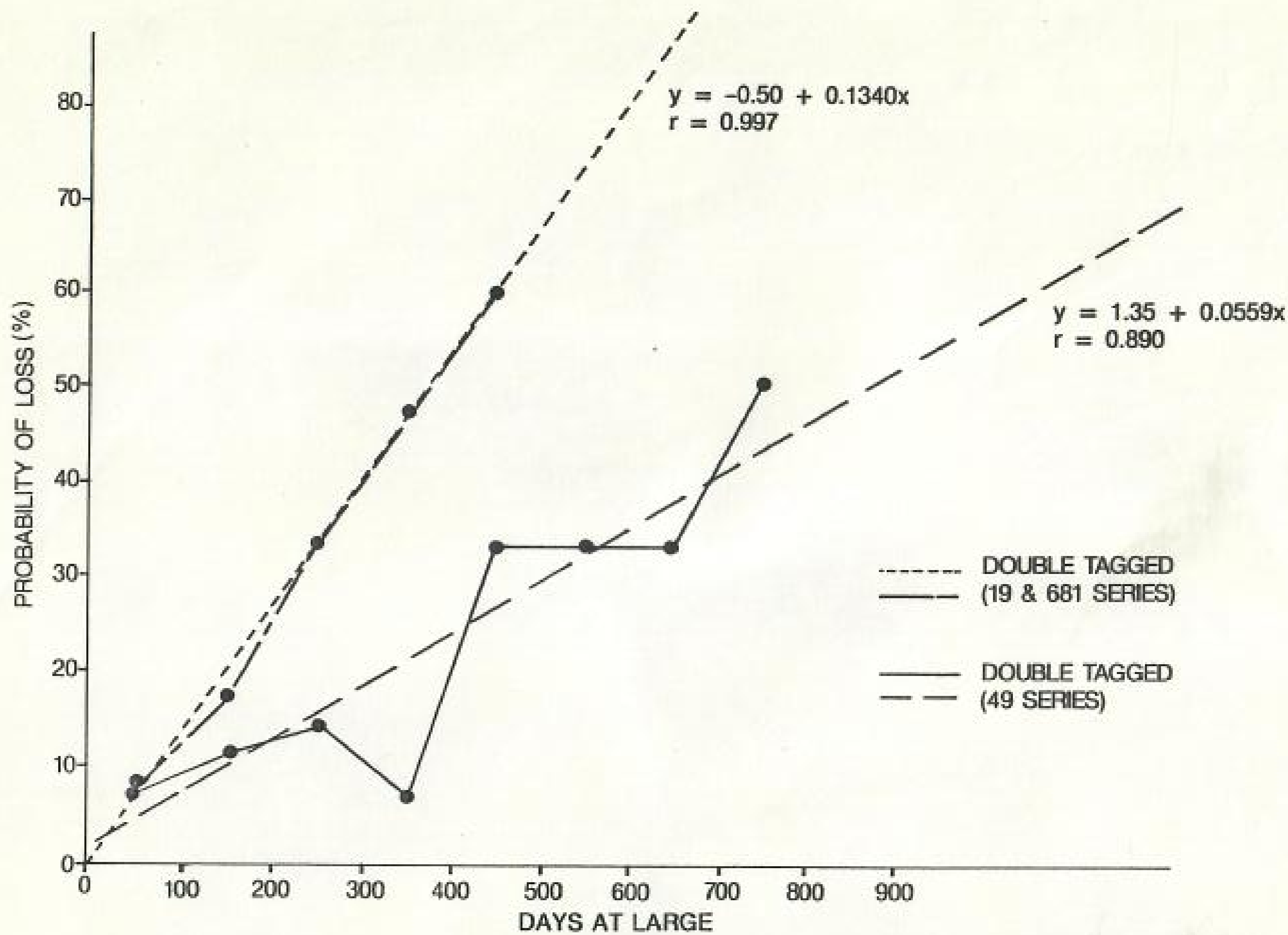

Figure 4. Relationship between probability of tag loss and days at large in loggerhead sea turtles, *Caretta caretta*. Two types of locking mechanisms are compared.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

2/9/84

To George

From: Larry

Yes, get your tag paper out now — will do a Tech Memo protocol later. How about the resuscitation note & the glottal stop. I believe it was Richard Wolke, U. Rhode Island, who described the contraction of the glottis at a meeting 2-3 yrs ago (it seems he was surprised that this condition existed after death)

(over)

TRANSMITTAL FORM CD-82A (10-67)
PRESCRIBED BY DAO 214-2
U.S. G.P.O. 1982-564-008/1147

SCIENCE '83 NOVEMBER
4(9):74

Lake Tanganyika suggested that sound waves were breaking apart and then recombining the boric acid ions in the water. The process soaked up acoustic energy, weakening the sound. It turned out that this sound absorption is related to the acidity of the water, which explains why the more acidic Pacific absorbs sound less than the Atlantic—again, on average. There are always those local variations.

"What we've found," said Stevenson, "is that the ocean is variable at every parameter—temperature, pressure, salinity, you name it." In classical antisubmarine warfare, protecting a ship from a marauding submarine, this variability doesn't matter quite so much: The waters around the ship can be monitored carefully for changes. But a ballistic missile submarine makes for a whole new problem.

Shhh . . .

Since 1960, when the first Polaris went on duty, I forgot all the circumstances he described that may have been responsible for this condition he observed in the corpses necropsied by him.

Sorry, it was not Peter Lutz.

I should have something on this — if not you (or I) can get in touch with him. Drop him a line.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

12/13/83

To : George

From: Larry

Thanks for considering sending Karen 50 inconel tags — she is sending you the report she prepared.

This is a spin-off from our old Bioglass TM bone tag project that was "terminated" early on because of personnel

TRANSMITTAL FORM CD-82A (10-67)
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National Oceanic and Atmospheric Administration

To :

From:

changes in the "bone" lab. It still holds promise as a permanent mark but a different type of porcelain screw will have to be produced, ie., shorter.

Sending you a few extra copies of the excellent manual II. Will work out distribution to all NMFS Labs with Mike later. So hang on to these for now for yourself. Merry Xmas

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UNIVERSITY OF HAWAII AT MANOA
Hawaii Institute of Marine Biology
P.O. Box 1346 - Coconut Island - Kaneohe, Hawaii 96744
Cable Address: UNIHAW

September 21, 1982

Stockbrands Company
53 Edward Street
Osborne Park
Western Australia 6017

Dear Sirs:

I am interested in trying your self-piercing sheep tag as a means of marking sea turtles. I would greatly appreciate receiving several samples of these tags to use in a small trial. I hope that this will be possible.

Thank you for your assistance.

Sincerely,

GEORGE H. BALAZS
Assistant Marine Biologist

GHB:ec

MROSOVSKY

supplied upon request.

DEREK GREEN
Texas Memorial Museum, 2400 Trinity, Austin, TX 78705 USA.

WHAT DOUBLE TAGGING STUDIES CAN TELL US

Double tagging, as advocated in the first Marine Turtle Newsletter (1976), is not merely a way of obtaining more returns. It also enables estimates to be made of tag loss. This knowledge may be helpful in tackling other questions such as what are the chances of turtles remigrating in future years to their nesting beaches. What is it that is missing in the "lost majority" (Carr, 1980) of turtles tagged at Tortuguero? Is it the turtles or the tags?

Estimating tag loss. First we consider the case of dissimilar tags, or tags which are the same but may have a different probability of loss (e.g. one on the back and one on the front flipper, or one tag and a notch on a scute). All estimates apply only to a given time span. Also, if concerned with tag loss itself, one must assume that tags have an equal probability of being noticed. When a trained person systematically inspects a turtle on the beach, this may be a safe assumption. When a fisherman who is unaware of the tagging programme pulls a turtle out of his net, visibility of a tag may be important (Cornelius and Robinson, 1982). Where returns are predominantly from fishermen, it may be preferable to speak of tag irrecoverability rather than tag loss. This would encompass tag loss, tag visibility and the chances that a tag will be returned. Irrecoverability could be calculated in the same general way as given here for tag loss:

Let P_a be the probability of tag type-a being lost
Then $1-P_a$ is the probability of tag type-a remaining on
Let P_b be the probability of tag type-b being lost
Then $1-P_b$ is the probability of tag type-b remaining on.

Thus, for example, the probability of tag type-a remaining on while tag type-b is lost is $P_b(1-P_a)$.

Let T be the total number of turtles initially double-tagged
Let R (unknown) be the proportion of T returning
Let N_o be the number of returning turtles that have lost both tags
Let N_{1a} be the number of returning turtles with just tag type-a on
Let N_{1b} be the number of returning turtles with just tag type-b on
Let N_2 be the number of returning turtles with both tags on.

Then $N_o = P_a P_b \times TR$ eqn (1)
$N_{1a} = (1 - P_a) \times P_b \times TR$ eqn (2)
$N_{1b} = (1 - P_b) \times P_a \times TR$ eqn (3)
$N_2 = (1 - P_a)(1 - P_b) \times TR$ eqn (4)

From equations 3 and 4:

$$\frac{N_{1b}}{N_2} = \frac{P_a}{1 - P_a}$$

Rearranging: $P_a = \dfrac{N_{1b}}{N_2 + N_{1b}}$ eqn (5)

Similarly $P_b = \dfrac{N_{1a}}{N_2 + N_{1a}}$ eqn (6)

If the tags are the same and are assumed to have an equal probability of loss, then the expression may be simplified. If N_1 is the number of turtles with one tag, then $N_1/2$ may be substituted for either N_{1a} or N_{1b} in equations 5 or 6. And P (the probability of losing one tag) may be substituted for either P_a or P_b in the same equations:

$$P = \frac{\frac{N_1}{2}}{N_2 + \frac{N_1}{2}} \qquad \text{Rearranging:} \quad P = \frac{N_1}{2N_2 + N_1} \qquad \text{eqn (7)}$$

<u>Examples of tag loss/irrecoverability</u>. 1) <u>Green (1979)</u> gives data from a double tagging study on a population of green turtles resident around the Galapagos Islands. These were tagged with monel metal on the front flipper and plastic (Rototag) on the hind flipper. After 4 years, 63 turtles had been seen again with both tags, 45 with just the plastic tag and 4 with just the metal tag. From equations 5 and 6:

$$\text{Probability of losing the metal tag} = \frac{45}{63 + 45} = .42$$

$$\text{Probability of losing the plastic tag} = \frac{4}{63 + 4} = .06$$

These probabilities are for a time span of 101-1,000 days from the time of tagging. Fortunately Green also gives the time between tagging and recapture. Although the data are few for the longer intervals, they can be used to illustrate how probabilities of tag loss only refer to particular time spans:

	<u>by 101-500 days</u>	<u>by 500-1,000 days</u>
Probability of losing the metal tag	.38	.63
Probability of losing the plastic tag	.05	.14

2) Cornelius and Robinson (1981, 1982) double tagged 2415 olive ridleys on the west coast of Costa Rica. A metal tag was attached to one of the front right flippers and a plastic tag (Allflex) to any of the four limbs: 97 turtles were seen again with both tags on, 117 with just the plastic and 150 with just the metal. From equations 5 and 6:

$$\text{Probability of losing the metal tag} = \frac{117}{97 + 117} = .54$$

$$\text{Probability of losing the plastic tag} = \frac{150}{97 + 150} = .60$$

Comments on examples: Neither of these studies demonstrate the superiority of one type of tag material. It may have been that the hind-foot location rather than the plastic was the important factor in the Galapagos study. With leatherbacks, as first noted in the Marine Turtle Newsletter (Hughes, 1978, see also in press), switching tag location from the front to rear flipper was followed by a jump in recovery rates. With the double tagging of the olive ridleys in Costa Rica, the time span of the study needs to be made explicit and considered. Perhaps over several years one of the tags used will have superior staying power. Also both the location and the colour of the plastic tags varied. Yellow tags had very poor recovery rates (Cornelius and Robinson, 1982). Before drawing definite conclusions from this study it will be necessary to wait for further details on these variables and their interrelationships. What is asserted here is that expressing results in terms of the probability of tag loss is an easy, useful and standard way of describing and comparing tag loss as a function of material, colour, location and time after application. Also the surest progress will be made by studies that do not confound variables. Whether a tag is put on the left or right flipper might even make a difference. Leatherback turtles in French Guiana more often have injured left than right flippers (Fretey, 1981). All variables except the one under consideration should be equated.

But one substantive point is evident. In two separate studies, on different species in different parts of the world, there was a probability of about .5 that a monel metal tag on the front flipper would be lost. This is still the most commonly used tagging method in turtle research. Clearly if around 50% of the tags fall off, it is hardly satisfactory, as had been recognized qualitatively (Balazs, 1982).

Scar method: At Tortuguero tag loss of monel metal tags has been estimated at 26.4% from scars left by missing tags (Carr, 1980). Is the tagging method superior at Tortuguero, or do green turtles from that population live in an environment conducive to tag retention or are scars unreliable as a way of assessing tag loss? Many people have wondered if scars may heal over altogether. Validation of the tag scar method is needed. This could easily be done by double tagging. Any turtles found with no tags should either have two scars or none. The same general formulae as given above could be used to assess the chances of scars becoming unrecognizable. If single tagging had been done in the area previously, then one could look for scars on those turtles from the double tagging experiment that returned with only one tag. Richardson et al. (1978) have been both double tagging loggerheads for many years and recording tag scars. They may well have relevant data.

Remigration Rates

By definition: $TR = N_o + N_{1a} + N_{1b} + N_2$

The number of turtles with no tags is composed of those that have lost both tags (N_o) and of neophytes. N_o cannot be measured directly. Therefore for N_o we substitute P_aP_bTR from equation (1).

$$TR = P_aP_bTR + N_{1a} + N_{1b} + N_2$$

Rearranging and cancelling:

$$R = \frac{N_{1a} + N_{1b} + N_2}{T(1-P_aP_b)} \qquad \text{eqn (8)}$$

In the case where the tags are the same and are assumed to have an equal probability of loss, calculations may be simplified by substituting P (the probability of losing one tag) for both P_a and P_b, and by substituting N_1 (the number of turtles with one tag) for $N_{1a} + N_{1b}$ in equation 8:

$$R = \frac{N_1 + N_2}{T(1 - P^2)} \qquad \text{eqn (9)}$$

These formulae look attractive but their application for calculating remigration rates is debatable. One problem is that turtles come back to the nesting beach after varying numbers of years. One cannot lump tag returns for a number of years (to ensure that each turtle has had a chance of coming back and being seen in one year or another) and still use equation 8 because the probability of tag loss is increasing over those years. P_a and P_b in equation 8 are not constant. Instead it would be necessary to treat each year separately, calculating both probability of tag loss and remigration rate for that year. Remigration rates for a number of separate years could then be summed. For this approach it might be simplest to tag intensively over a relatively short time span, but if not enough turtles could be tagged in one season, then the number of years since tagging could be used for assembling remigrant turtles into different groups for assessing tag loss and remigration rates.

Presumably calculations of the kind given in this note are to be found elsewhere. No claim to originality is made. We hope, however, with double tagging becoming widespread, that it may be useful for turtle researchers to have formulae for deriving tag loss readily available and that they may be stimulated to explore further how data from double tagging studies can be made instructive (see Seber, 1973 and Eberhardt et al., 1979 for further reading).

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DOES TURNING GREEN TURTLES ON THEIR BACKS AFFECT SUBSEQUENT REPRODUCTIVE PERFORMANCE?

In a recent issue of the Marine Turtle Newsletter it was suggested that turning turtles on their backs may be one cause of the widely observed low percentage of turtles that return to nest in later years (Pritchard, 1982, #21, 3-4). The research program directed by Dr. Archie Carr at Tortuguero, Costa Rica, provides data that allow us to evaluate the potential for danger in turning turtles. The northernmost 5 miles of the 22 mile Tortuguero beach are patrolled nightly. Until 1976, all turtles were turned on their backs after nesting so they could be tagged and measured shortly after dawn. In 1976, we experimented with tagging some of the nesting females at night without turning them. In 1977, we adopted this system for the northern 2.5 miles of the beach.

One approach to assessing the possible effect of turning turtles would be to compare the reproductive performance of turtles that were turned on the southern 2.5 miles with those that were not turned on the northern 2.5 miles in 1977. However, comparing the reproductive histories of turtles nesting on the northern half of the patrolled area with those of turtles nesting on the southern half is unsatisfactory, because turtles emerging on the southern half are more likely to return to nest south of our 5-mile patrolled study area, and thus not to be recorded. Therefore, I have compared the subsequent renestings and remigrations of turtles from the northern half of the study

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January 2, 1984

G. Balazs
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service F/SWC2
P.O. Box 3830
Honolulu, Hawaii 96812
U S A

Dear George:

Finally, what I promised in Costa Rica, a copy of the photo you asked for.

I know I have been remiss in not attending to various things you have sent me over the last few months....it is just a matter of too much to do. The flow of information you keep up is appreciated!

Everything seems quiet (?stagnant) on the turtle conservation front, as far as I know. Having said my piece in my book (I'm sure you agreed 100% with every word!) I'm trying to complete my sex ratio project. We will have some very extensive and interesting data to report in a few months.

Have a good 1984.

Nicholas Mrosovsky

P.S. I have listed your 1983 Technical Memorandum in the MTN. I was puzzled by the first sentence of p 5, paragraph 3, because in the MTN article you cite we computed and published such data. We could still compute shedding probability for a particular tag in a particular place. One could just as well say your data only applies to front flipper location, or a particular person who did the tagging etc. Whenever one puts a tag on, there are a number of factors.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

7/25

To George

From: Larry

I don't think I'll be able to come up with anything significant re "debris in the oceans" soon. I noticed the deadline for abstracts is near — I am very sorry. Also, with travel restrictions and all, I seriously doubt I would get approval — the Gulf & Carib. Fish. Inst. meetings are in November in Mexico, and I have to go to that re WATS II stuff. Maybe next time?

TRANSMITTAL FORM CD-82A (10-67)
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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

— 2 —

To : In the meantime don't let Alika Cooper's lust

From: for turtle meat get you down ... his argument is very weak and self-centered (albeit, it has certain political appeal).

Thought you might be interested in some problem the Culebra Island folks had with titanium tags. I agree, a better test would be (or should include) nesting ♀♀'s.

Best ever
Larry

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LIBRARY OF
GEORGE H. BALAZS

A LONG TERM INTERNAL TAG FOR SEA TURTLES

Sea turtles are rare and endangered reptiles that are of concern by states (Schwartz, 1977a,b), nation (Anonymous, 1973; Henderson, 1978; Christman and Lippencot, 1978), and world (ICUN, 1969). Although various aspects of their biology have been studied we lack basic information concerning their life span or how they migrate long distances to and from a nesting beach, perhaps even to their beach of origin. These gaps in our knowledge stem from the inability to tag and follow a sea turtle throughout its life.

External tags such as Peterson Disk or plastic Roto tags pull out or deteriorate through sand abrasion. Only Monel tags exhibit long-term retention or resistance to sea water or the elements (Carr, Carr and Meylan, 1978). Recent use of tag telemetry has proven costly, time consuming, and of limited tracking potential (Timko, 1980).

Carr *et al.* (1978) aptly noted, "Because of the difficulty of developing a tag for the hatchling that will remain in place when the turtle bearing it grows from a weight of 25 grams to 575 kilograms or more, it has not been possible to prove that homing turtles return to the place at which they hatched." Thus, to meet such a formidable task a tag has to be of light weight and size, inert, retained by the sea turtle throughout its life span (regardless of age or size), should not induce sores or shedding, and not impair the swimming activites of the turtle. A tag that met these requirements was the internal wire coded tag developed on the west coast of the United States for salmon (Jefferts *et al.*, 1963; Bergman *et al.*, 1968; Ebel, 1974; Hager, 1975; Moring and Moring, 1976) and recently used in the spot prawn *Pandalus platyceros* (Prentise and Rensel, 1977).

Binary or color coded wire tags, either of round or flat stainless steel design are available in one or two millimeter lengths. Insertion is via an expensive sophisticated injector or a modified manually operated hypodermic syringe. I chose the latter less expensive method. Tag retention rates above 90% have been achieved for fishes and prawns (Moring and Moring, 1976; Opdycke and Zajac, 1981). While Ebel (1974), Lesh and Rowell (1981), Smith (1980), and Zirges (1976) have devised special equipment for tag holding prior to decoding or retrieval (Hager, 1975), no such devices were necessary in this study. Cost/turtle, other than a one time syringe cost, has remained the same from 1977 to 1981 at 06¢/tag/turtle or $30-60/1000 tags (cost is dependent on 1 or 2 mm length tags.)

Other than that mentioned in the text, 390 hatchling green sea turtles have been released in 1980 with internal tags in their front flipper into the Atlantic Ocean at Camp Lejeune and Ft. Macon, N.C. These resulted from the first documented multiple nesting in North Carolina (Schwartz *et al.*, 1981). Likewise, 3037 internal tagged loggerhead hatchlings, hatched from other nests, were released at the same sites in 1979 and 1980.

STORAGE FACILITIES

Between April and December all tagged and control sea turtles were kept in large outdoor 9.1 x 18.2 meter rectangular concrete tanks of 1.2 mil liter capacity. Continuous flow through water was pumped from nearby Bogue Sound (salinity range 10-34 ppt.). All specimens were transferred indoors for the winter once water temperatures dropped to 10° C and held in round 1.5 m metal tanks of 900 liter capacity. Indoor tank water was changed every 2-3 days from reservoirs where the incoming water was stored and warmed to ambient room temperatures above 10°C. Food, during the test period 1977-1980, consisted of a variety of fresh or frozen fishes and invertebrates.

TAGS AND TAG SITES

Initially, in 1977, a standard, binary-coded, grooved, type 302, stainless steel, rod tag 0.254 mm diameter x 2.0 mm long was inserted into hatchling or subadult Atlantic loggerhead and green sea turtles. A fault of this tag design was that the round configuration of the rod tag permitted a maximum of only 16,384 consecutively different identification numbers. Because of this numerical limitation, a flat binary-coded, stainless steel, grooved tag 1.067 mm wide x 0.406 mm deep x 2 mm long was devised for the 1978 tagging studies. The flat surfaces of that tag permitted greater combinations of available tag numbers and, more importantly, made the tag code number easier to read by eye or from radiographs.

Rod tags were inserted into the neck (midway between the skull and shell) and dorsal surface of the flippers of each hatchling or subadult sea turtle tagged in 1977. Flat rectangular tags were similarly inserted in the surviving hatchlings tagged in 1978. Neither tag was injected into the body cavity. Some test specimens received multiple tags per appendage. Tags were inserted via a modified metal syringe fitted with a 24-gauge hypodermic needle. Initially the tagging time to insert 50 tags varied from 6 to 22 min but with experience 225-250 turtles/hr were tagged. Insertion was accomplished by approaching the insertion site at about a 20° angle to the flipper or body surface (Fig. 1). Periodically radiographs were taken of all specimens, to note if the tags were shed or had moved as a result of the turtle's body movements. Tags were readily visible on the radiographs and tag number was read directly without magnification over fluorescent lights or through a dissecting microscope (Fig. 2a).

Figure 1. Tagging hatchling green sea turtle illustrating hand held injector syringe and angle of tag insertion.

RADIOGRAPH METHODS AND VALUE

Radiographs of any tagged sea turtle can be easily achieved with permanent laboratory or portable field units. Field detection of the tag site is by noting a white scar on the front flipper (the best tag site is near the distal end of the humerus of the front flipper). Tags need not be removed from the turtle, as is done for fishes (Hager, 1975; Smith, 1980) once implanted.

The utility of the wire coded tagging method will be best realized in areas, such as Tortugero, Costa Rica, etc. where large nestings by adult sea turtles occur or where mass hatching and release from turtle hatcheries (Mexico, Texas, Florida, North Carolina) exist. While the wire coded tag method is best suited for areas of mass nesting or hatchling production the low costs involved per tagged turtle make it an attractive alternative to present external tagging methods. The ability of the tag to be retained by a sea turtle throughout its hatchling to adult life now resolves one of the long-term retention problems noted by Carr, Carr and Meylan (1978). Further, periodic recaptures of tagged sea turtles will permit a continuous monitoring of their activities and will shed light on their age and growth, possible return to original beach of release, subpopulation status, and a host of other aspects now unresolved.

OBSERVATIONS AND RESULTS

Green Turtles

Twelve of sixteen (10 hatchling and 2, 2-yr old) green turtles, *Chelonia mydas*, obtained from the state of Florida, were tagged in each limb and neck area with the rod tag in 1977 (Figure 2b). Six tagged turtles survived the three-year study. Four (3 hatchlings and 1, 2-yr old turtle) tagged and two untagged control turtles succumbed during the 1977-78 winter to an eye fungus to which green sea turtles are susceptible (Witham, 1973), although all turtles were treated several times per week to baths of $KMnO_4$ and boric acid solutions in efforts to control the infection. Two additional tagged small green sea turtles and the remaining two controls succumbed to the eye fungus during the winter of 1978-79. These deaths were also attributable to the fungus and not to the tags as no sores were evident in relation to the tag site(s). Turtle behavior was normal in that feeding or swimming was also not impaired by the tag.

All green turtles that died within the first six months of tagging retained the internal tags. Of the 60 rod tags implanted in 1977 in the six turtles that survived one year of tagging, only three tags, which had been inserted into the right rear, left front and left rear flipper of three separate turtles, were lost. Rod tags were retained best (80%) in the neck and right front flipper during the year 1977-78.

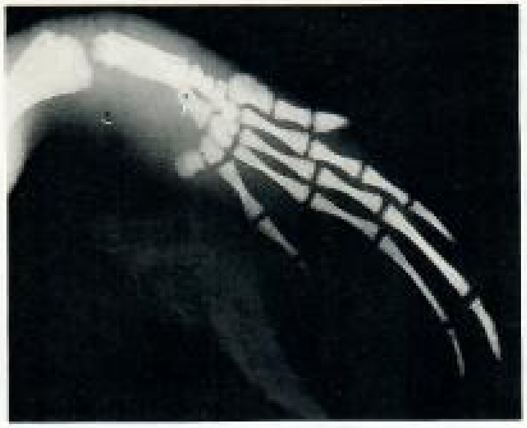

Figure 2a. Enlargement of right flipper of two year old green sea turtle illustrating binary coded wire tags (x 5.88). F = flat tag, R = rod tag.

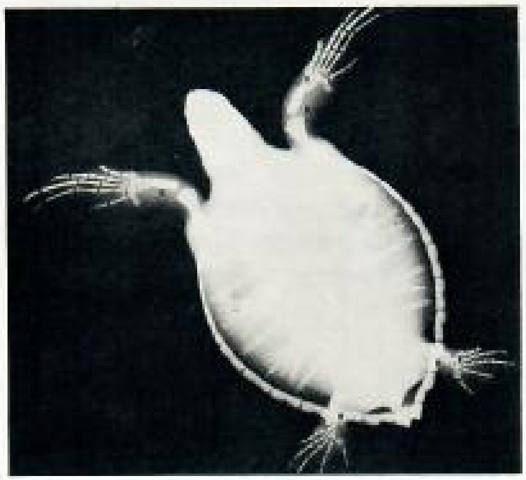

Figure 2b. Two year old Atlantic green sea turtle illustrating internal tags in each flipper. Both rod (R) and flat (F) tags visible in the right rear flipper (x 1.79).

The same six green turtles tagged in 1977 were retagged with flat tags in 1978 and retained all flat tags in the right forelimb during 1978-1979 but lost one neck and one left forelimb tag to yield an overall (2-year) flat tag retention of 73%. No further round or flat tag loss was evident during the 1979-80 year. The five largest specimens were released into the wild 18 September 1980 at Ft. Macon, N.C. following additional external tagging with Monel strap tags. One was subsequently recaptured a month later in the nearby Newport River, North Carolina. Growth of all surviving tagged green turtles was not impaired by the internal tag as substantial individual length and weight increases were achieved each year (Table 1).

Atlantic Loggerhead

Thirty hatchling and four subadult Atlantic loggerhead (3 female, 1 male, weight 43-81 kg) turtles *Caretta c. caretta* from three geographic areas were tagged in 1977 with rod tags (Table 2) in each limb and in the neck, similar to that of the green turtles. The 14 survivors were also retagged with flat internal tags in 1978. The flat tag was harder to insert as the rectangular flat end offered more resistance than did the circular end of the rod tag used in 1977. The tagging site was checked visually immediately to ascertain that the flat tag had not backed out. Round tag retention for the hatchling turtles, after one year, varied between 73 and 90%, with the right forelimb exhibiting best retention. No further loss of round tags was evident in 1978-1980. After two years 70-90% of the flat tags had been retained by 10 surviving turtles (Table 2). Right forelimb tag retention was the best. Overall, forelimb and neck areas, regardless of type of tag, seemed to be better retention areas than were the hind limbs (Table 2).

Only 10 tagged hatchling loggerhead turtles survived for more than two years. Death was attributed to an eye fungus, which affected or killed tagged and 14 control turtles during the 1977-78 winter, and not to either type of tag. The subadults having developed no eye infection retained all inserted tags, survived the three year study and achieved substantial growth.

Growth of the small loggerheads (Table 2) was not impaired by tagging but size and growth-rate differences were evident in the hatchlings, which were offspring from eggs obtained from three different geographic areas (Table 2). The

Table 1. Growth of Atlantic loggerhead sea turtles from three geographic localities and six (five hatchling and one 2-yr old) green sea turtles from Florida tagged with internal wire tags during study period 1977 through 1980.

Geographic Area	Original Hatching 1977 $\bar{x}$ (c)Carapace Length* (w)Weight** C	N			September 1978 $\bar{x}$ (c)Carapace Length (w)Weight C	N			September 1979 $\bar{x}$ (c)Carapace Length (w)Weight C	N			September 1980 $\bar{x}$ (c)Carapace Length (w)Weight C	N		
Atlantic Loggerhead																
Melbourne, Fla.	5	11	(c)	55.7	0	6	(c)	175.5	0	2	(c)	280.0	0	2	(c)	339.0
			(w)	40.9			(w)	904.5			(w)	2975.5			(w)	5999.0
Pea Island, N.C.	5	15	(c)	52.9	0	5	(c)	166.8	0	5	(c)	260.6	0	5	(c)	283.0
			(w)	30.5			(w)	733.9			(w)	2343.5			(w)	3410.0
Onslow Beach, N.C.	4	4	(c)	51.6	0	3	(c)	133.7	0	3	(c)	253.0	0	3	(c)	315.0
			(w)	28.4			(w)	743.0			(w)	2581.0			(w)	4845.0
Green																
Florida	4	10	(c)	71.4	2	7	(c)	189.8	0	5	(c)	281.0	0	5	(c)	311.8
			(w)	55.6			(w)	954.2			(w)	2837.0			(w)	3575.0
	0	2	(c)	129.7	0	1	(c)	265.0	0	1	(c)	330.0	0	1	(c)	353.0
			(w)	279.5			(w)	2368.4			(w)	4163.0			(w)	4930.0

$\bar{x}$ = mean
* = millimeters
** = grams
C = controls
N = number tagged

Table 2. Number of tagged Atlantic loggerhead hatchlings obtained from three geographic sources retaining internal tags inserted in five body locations during the test years 1977 through 1980.*

Geographic Area	Number Tagged	RF T	RF R	RR T	RR R	N T	N R	LF T	LF R	LR T	LR R	Overall Percent
1977-1978												
Melbourne, Fla.	11	11	11	10	8	12	5	13	8	10	7	70
Pea Island, N.C.	15	15	12	12	9	14	13	10	9	14	14	88
Onslow Beach, N.C.	4	4	4	3	3	4	4	3	3	4	4	100
Total Retention	30	30	27	25	20	30	22	26	20	28	25	
		90%		80%		73%		77%		82%		81
1978-1979												
Melbourne, Fla.	2	2	2	2	2	2	2	2	2	2	1	90
Pea Island, N.C.	5	5	4	5	4	5	4	5	3	5	3	72
Onslow Beach, N.C.	3	3	2	3	3	3	2	3	3	3	3	80
Total Retention	10	10	7	10	9	10	9	10	8	10	7	78
		70%		90%		80%		80%		70%		

RF = Right front flipper
RR = Right rear flipper
N = Neck
LF = Left front flipper
LR = Left rear flipper
T = Total number tags inserted
R = Total number tags retained
*No further tag loss occurred during 1979-1980.

largest and heaviest loggerhead hatchlings were from Melbourne, Florida. Pea Island, North Carolina, hatchlings (from eggs transferred from Cape Romain, South Carolina) were next largest, while those from Onslow Beach, Camp Lejeune, North Carolina, were the smallest (Table 2). These size differences persisted after three years growth when the Melbourne turtles were the heaviest, by weight, followed by Onslow Beach and Pea Island turtles (Table 2). All but three of the tagged turtles were fed the same whole natural food diet. The three Onslow Beach specimens had been held at a nearby aquarium facility and fed a fish meal diet. This apparently accounted for their size differences in 1978 rather than any impairment resulting from the tagging. Florida (Melbourne) loggerhead turtles were more susceptible to the eye fungus than those from northern egg clutches. Growth and swimming abilities of all survivors were not impaired by tagging. The five Pea Island test specimens were released in 1980 into the Atlantic Ocean at Pea Island.

An additional internal tag study was performed in 1978 using 35 loggerhead hatchlings from Surf City, N.C. eggs. Fifteen specimens were maintained as controls in the same holding tank as the tagged turtles. Ten of the 20 tagged specimens were tagged in the neck, right fore and hind flipper, while 10 were tagged in the neck, left fore and hind flipper. No noticeable effects of the tags were evident other than a white mark developed at each injection site. Tags inserted within the flippers were better retained than those within the neck. Tag loss during the 1978-79 year, per 20 turtles, was: right flipper - I, left flipper - 1, rear flipper - none, as opposed to 7 of 20 neck tags were lost. Neck tag loss resulted if the tag was sluffed when the turtle retracted its neck. Tag retention, after one year, was 85% regardless of side tagged. All the controls as well as 18 tagged turtles succumbed to eye fungus by February (control) or April (tagged) 1979. The two survivors were released into the sea following the one year observation.

CONCLUSIONS

Thus, the internal binary-coded wire

tag proved to be a potentially long-term, efficient, and harmless tag for sea turtles. It can be magnetized to permit field detection of a previously tagged sea turtle prior to field X-ray detection of the tag. The recent availability of portable X-ray units, with daylight development of the film, also permits quick identity of a previously internally tagged turtle. When one is hesitant in using the internal tag alone, turtles one year or older can be doubly tagged with the standard Monel external tag. Thus, use of the internal tag permits more reliable data to be accumulated on hatchling sea turtle survival per nesting site, frequency of beach use by subsequently mature females, as well as data on the longevity and movement patterns of adult turtles on land or sea without fear of tag loss. This tag breakthrough also enhances our long-term understanding of these endangered animals.

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I thank Ross Witham and Dale Beaumariage of the State of Florida for providing the green sea turtles used in these experiments. Loggerhead turtles were provided by Jon Dodrill (Melbourne, Florida), J. Wooten and C. Peterson (Camp Lejeune), and N. Williamson (Pea Island). James Tyler and members of the Law Enforcement Unit, North Carolina Dept. of Natural and Economic Resources, provided eggs from Surf City which produced specimens tagged in 1978 with flat tags. Dr. K. Jefferts, Northwest Marine Technology, Inc., Shaw Island, Washington, enthusiastically helped design and modify the internal tags used. G.W. Link provided the radiographs. Drs. A.F. Chestnut, W.E. Fahy and G.W. Link of the Institute reviewed the manuscript. M. Provancha assisted with the original tagging. Jacqueline Tate fed and cared for all turtles. Study support was a University of North Carolina Research Council grant VC793.

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Frank J. Schwartz, *Institute of Marine Sciences, University of North Carolina, Morehead City, N.C. 28557*

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

11/28/83

To : George

From: Larry

Hope you can spare some tags for the next tagging trip to Great Inagua in May. This is part of our tag evaluation contract w/ Karen & Wayne King. Used the memo request style for your files to document inter-agency cooperation between turtle researchers!

TRANSMITTAL FORM CD-82A (10-67)
PRESCRIBED BY DAO 214-2

☆U.S. G.P.O. 1982-564-008/1147

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
SEFC, Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32407-7499

November 28, 1983 F/SEC5:LHO:el

TO: F/SWC2- George Balazs

FROM: F/SEC5 - Larry Ogren Larry Ogren

SUBJECT: Inconel tags

In order to assess the tag loss problem we are investigating the retention rate for several types of sea turtle tags currently in use. We are solicitating your collaboration in this project in order to broaden the scope of the investigation to include the long-term corrosion resistant qualities of various alloys. Colin Limpus has provided us with 100 titanium tags. We would like a similar number of inconel tags to test. However, recognizing the problem you had obtaining these tags, we would appreciate receiving whatever number you could spare, especially if your supply is low. Karen Bjorndal will be going to Union Creek, Great Inagua, this month and again in the early spring to tag her wild, semi-captive stock of green turtles.

A copy of Karen's field trip report, including the tagging protocol she followed will be sent to you. I hope you will be able to help us out in evaluating the best tagging method and the best tag for sea turtles.

cc: K. Bjorndal
F. Berry

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

November 17, 1982

Mr. Colin Limpus
National Parks and Wildlife Service
Pallarenda
Townsville, Qld. 4810
Australia

Dear Mr. Limpus:

I have been in contact with John Forehan of "Stock Brands" regarding titanium tags for sea turtle marking. Mr. Forehan suggested I write you since you are involved in an Australian project using this particular tag material and can perhaps give me your thoughts on the pros and cons of this type tag.

We are involved in a number of cooperative sea turtle projects in Costa Rica, Mexico, and the U.S., and, as you are aware, the problem of tag durability and corrosion resistance continues to plague us. Much effort, time, and expense go into tagging efforts, only to have the tags corrode and fall off or be lost in some other manner within a relatively short time. Our basic tag material is monel, and we are not at all satisfied with this material and have questions regarding factory quality control. We had hoped to switch to inconel, but the cost is prohibitive since we would have to pay to have the dye/stamps made, plus the increased cost of the material. Although I'm not sure of the current exchange rate between the U.S. and Australian dollar, it would appear that we could afford an experimental trial, using titanium tags.

My question is--do you think the titanium tags are significant improvement over monel, or hasn't enough time elapsed to make this judgement? Are there problems with application or locking of the tags? Is there any reason why native beach workers couldn't use these tags and pliers under limited supervision, etc.? The species of turtle we are working with are the Mexican black turtle (C. agassizi), Kemp's ridley (L. kempi), Pacific ridley (L. olivacea), and the leatherback (D. coriacea). Should we decide to try these titanium tags, we would choose one project and one species, either L. kempi or C. agassizi, and attempt to mark all the turtles we can on the nesting beach for three or more seasons.

Any information or suggestions you can offer in regard to this or other tags would be most helpful. We are using (experimentally) the plastic "all-flex" tag, which does show promise after 3 years of use in Mexico and Costa Rica; however, a detailed analysis has not been completed.

We have also extended our contract with John Hendrickson to continue research on the "living" tag and will institute field application in Surinam, South America.

I look forward to hearing from you.

Sincerely yours,

J. B. Woody

Jack B. Woody
Acting Assistant Regional Director
Federal Assistance, Fishery
Resources, and Engineering

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

November 18, 1982

Dr. N. Mrosovsky
Department of Zoology and Psychology
University of Toronto
Toronto, Ontario
M5S 1A1, Canada

Dear Nick,

On a recent trip to Michoacan and the black turtle project, I met a young biologist, Javier Alvarado Diaz, from the University of Michoacan who is heading up much of the effort to protect the nesting beaches, and I fully expect him and the university to play an expanded and important role in efforts to protect the Mexican black turtle.

At any rate, the purpose of this letter is to ask if it would be possible for you to place Javier on the mailing list for the "Marine Turtle Newsletter." If this can be done, I think it will go far in further stimulating interest and involvement by an important group within Mexico. Javier's address is:

Bio. Javier Alvarado Diaz
Apartado 35A
Morelia, Michoacan
Mexico

I noted in the recent newsletter that you made a very valid point of the need to plan and coordinate use of the "living tag" marking system that John Hendrickson has developed. My office has renewed our original contract with John to continue work and development on the living tag technique. I am quite optimistic that this technique will work, under field conditions, and; as you pointed out, it holds considerable promise for helping to answer many of the questions still facing us. However, I am very concerned that this technique will "catch on" and be used willy-nilly by any number of individual turtle workers without consideration of what others are also doing, and we could end up with not only a hodge-podge of marked turtles in two or more oceans but no way to separate out populations, age classes, etc. Use of this technique must be planned and coordinated internationally if it is to provide the data inherently possible and needed. It would be a shame to lose the full potential of this technique in the early stages because it is "in vogue."

How and by whom this can be coordinated, I don't really know. I can try to influence some of this in the U.S., Mexico, Costa Rica, etc., but it will take far more than what I can do to plan and coordinate an effort.

I am looking at using titanium tags on selected projects. Australia has initiated use of this material and I'm waiting to hear their comments. The Australian manufacturer of these tags assures me they are far superior to inconel in resistance to corrosion.

Hope you can send the newsletter to Javier.

Sincerely yours,

Jack B. Woody
Acting Assistant Regional Director
Federal Assistance, Fishery
Resources, and Engineering

bcc: SE
K. Dodd (OES)
C. Freese (IA)
G. Balazs (Hawaii)

Identification Designers and Manufacturers

STOCKBRANDS CO. PTY. LTD

53 Edward Street, Osborne Park, W.A. Telephone 444 4877

All correspondence to P.O. BOX 80, MT. HAWTHORN, WESTERN AUSTRALIA 6016

November 5 1982

SHCK
DB

Admin.
ACTION
FILE

United States
Department of the Interior
Fish and Wildlife Service
P.O. Box 1306
Albuquerque New Mexico 87103
USA

Dear Mr Woody

Your contact in Australia regarding the performance of titanium bands for turtle tagging is

Colin Limpus
National Parks & Wildlife Service
Pallarenda
Townsville Qld 4810 AUSTRALIA

Wrote 11/17
JRW

It is too early yet for results, the tagging having been in use for only a year, but we do maintain that these tags will prove to be absolutely corrosion resistant and superior to previously used metals such as stainless, inconel etc.

Some problems were encountered with application, mainly when tagging a struggling beast, but we have gone to a grade of greater tensile strength for the most recent tags, and will be increasing the guage in future supplies.

We apologise for misleading George Balazs regarding these tags in the U.S., we understood that some had been sent to the U.S. for trial from Queensland, but do not have further details.

The tags cost in the vicinity of one dollar Australian each, and applicators, twelve dollars Australian.

Identification Designers and Manufacturers

STOCKBRANDS CO. PTY. LTD

53 Edward Street, Osborne Park, W.A. Telephone 444 4877

All correspondence to P.O. BOX 80, MT. HAWTHORN, WESTERN AUSTRALIA 6016

November 5 1982

We would be pleased to provide samples for trial, and additionally would be interested to quote for any other specialized type of tag.

We would be interested also to have details and literature if available from you on popular tags.

Additionally, we will be pleased to assist with the development of new tags of your design or suggestion.

Yours faithfully

JOHN FOREHAN

We did originally mfg duck bands from titanium with excellent results where very saline lake habitats were causing problems with stainless & monel bands!

PRAWN TAGS

June 12, 1980

"OUR 78th YEAR"

University of Hawaii at Manoa
Hawaii Institute of Marine Biology
PO Box 1346
Coconut Island,
Kaneohe, HI 96744
Attn: George H. Balazs, Asst.Mar.Biol.
& Deputy Chairman, IUCN/SSC Mar.Turtle Group

Dear Dr. Balazs:

Receipt is acknowledged with thanks of your letter dated May 29th. Unfortunately, we have absolutely no scrap left from the Inconel material which we had in 1976, and we have been unsuccessful in all attempts we have made to obtain small amounts of this material from various suppliers. Therefore, until a Federal grant or contract is awarded for these tags, we would be unable to furnish any Inconel tags.

Within the next several days, we will be producing our style 4-1005 monel tag in a special size 19, per sample enclosed. Many agencies are purchasing this special size tag to mark turtles as although it is the same size as the 49 tag, the locking mechanism is the same as the size 681. These will be produced before the end of this month, and another production run will not be made until September or October. If you are interested in having us furnish you with a lot of these tags or the size 681 in monel, please let us know at once.

We are sorry we could not give you a more satisfactory answer in this instance.

Yours truly,

NATIONAL BAND AND TAG COMPANY

Tom V. Haas

Tom V. Haas, Manager

lc/2

HUNTINGTON ALLOYS

HUNTINGTON ALLOYS, INC., HUNTINGTON, WEST VIRGINIA 25720

J. W. CUNDIFF
MARKET DEVELOPMENT MANAGER

December 4, 1975

RK-6

Mr. George H. Balazs
University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P. O. Box 1346
Coconut Island
Kaneohe, Hawaii 96744

Dear Mr. Balazs:

This responds to your letter of November 11, 1975 which discusses in detail the inadequacy of MONEL alloy 400 for marine turtle tags. It is indeed regretable that you have experienced major set-backs in your research just because tag identifications have been obliterated by corrosion. It is equally regretable that a more noble alloy, one that can stand up to the rigors of sea water exposure for many many years without corroding, was not chosen at the outset of your research efforts. Were this the case Mr. Balazs, many of the set-backs could have been averted. In light of your unfortunate experiences, it is, of course, timely to set about to correct the situation but we will get into that a bit later.

MONEL alloy 400 is manufactured to a limiting chemical range. Compositions within this limiting range are regarded to react essentially the same way in their corrosion behaviors, provided, of course, that all the variables that influence corrosion and corrosion reactions are fixed. We can, I'm sure, assign some minor differences in corrosion behavior to metallurgical variations within this chemical range but when the differences are major and out of proportion as you have indicated, then one is led to suspect variations in the corroding medium; in this case sea water. I am not familiar with the life cycle of sea turtles, their migration patterns, the nature of their body fluids, or the corrosive character of these fluids, so I can offer no comments as these relate to the tag corrosion problems you have sensed. I shall however address myself to the sea turtles habitat, sea water, because I suspect that herein lies the answer as to why MONEL alloy 400 is showing pronounced differences in its corrosion behavior. You, I'm sure, know better than I the complex solution that sea water represents. Its composition, its salinety, its oxygen content, its temperature, etc. all vary with depth and vary as well with location. These are the agencies that make sea water, for example, in Kaneohe Bay different from sea water in Banderas Bay, Mexico; and it is these same agencies that bear so much on the corrosion behavior of alloys in sea water.

It follows from what has already been said that what is needed for the turtle tags is an alloy that is insensitive to the variations in sea water. I cannot promise total immunity from corrosion over a 40 year period for after all even gold dissolves in sea water, but I strongly suspect that INCONEL alloy 625 will handle the problem. I have enclosed our technical bulletins for MONEL alloys and INCONEL alloy 625 so that you may judge for yourself the merits of the alloy from a simple comparison of 3 to 7 year exposure studies. I do believe, Mr. Balazs, that you will be impressed with its resistance to attack by sea water and, therefore, its performance as turtle tags.

Now then, a word or two about the availability of INCONEL alloy 625. It is a standard alloy of Huntington Alloys, Inc. manufacture and is produced in all mill product forms. It services the needs of a large corrosion resistant alloy market and is stocked at Huntington Alloys, Inc., its distributors worldwide, and by strip and wire convertors of Huntington Alloys, Inc. products. INCONEL alloy 625 is not difficult to procure but there are practical limitations in terms of minimum quantities that influence economy. The economy aspect of its procurement, I believe, is responsible for the 5000 tag quote issued to you by National Band and Tag Company.

By now you should have received my telex and the sample material described in that telex. I hope you will see fit to put these samples through your paces to judge them worthy for tags. Mr. Balazs, if I can be of further service, please let me hear from you.

Very truly yours,

L. A. Yerkovich

L. A. Yerkovich
Senior Technical
Coordinator

LAY/rrk

HUNTINGTON ALLOYS

HUNTINGTON ALLOYS, INC., HUNTINGTON, WEST VIRGINIA 25720

J. W. CUNDIFF
MARKET DEVELOPMENT MANAGER

May 24, 1976

RK-5

Mr. George H. Balazs
University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P. O. Box 1346
Coconut Island
Kaneohe, Hawaii 96744

Dear Mr. Balazs:

We regret that you are having difficulty obtaining turtle tags of INCONEL alloy 625. However, as Mr. Yerkovich explained in his 2 January 1976 letter to you, the product that National Band & Tag uses to make tags is not manufactured directly by us. We supply an intermediate size product to a converter who rolls and slits the strip to the final size used by National. Hence, once the product leaves our plant, its intermediate processing and delivery time is no longer under our control.

Should National be able to manufacture turtle tags from wider stock such as 36" x 96" sheet in this thickness (.034"), we can provide material from our stock, subject to prior sale. We understand that this is not the case however, and regret that we are unable to provide the assistance you request.

Very truly yours,

James W. Young

J. W. Young
Market Coordinator

JWY/rrk

HUNTINGTON ALLOYS

HUNTINGTON ALLOYS, INC., HUNTINGTON, WEST VIRGINIA 25720

J. W. CUNDIFF
MARKET DEVELOPMENT MANAGER

June 7, 1976

RK-5

(215) 489-7811 Route 113

Mr. George H. Balazs
University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P. O. Box 1346 Coconut Island
Kaneohe, Hawaii 96744

Dear Mr. Balazs:

In response to your request for the name and address of the converter supplying INCONEL alloy 625 strip to National Band and Tag for turtle tags, we understand that National has approached several converters and suggest that you contact them for this information. We do know that they requested a quotation from the Techalloy Co., Inc. in Rahns, Pennsylvania but cannot confirm that this was the basis of their quotation to you.

Again, we believe the most direct route to obtain the information and assistance you desire is through your supplier, National Band and Tag.

If we may be of further service, please let us know.

Very truly yours,

J W Young

J. W. Young
Market Coordinator

JWY/rrk

5/16" wide

.034"

HUNTINGTON ALLOYS

HUNTINGTON ALLOYS, INC., HUNTINGTON, WEST VIRGINIA 25720

— INCONEL strip

J. GADBUT
TECHNICAL SERVICE AND
SPECIFICATIONS MANAGER

TS-32477-D4
March 24, 1977

1977

Mr. J. R. Haas
National Band and Tag Company
721 York Street
Newport, KY 41072

Dear Mr. Haas:

As we discussed by telephone possibly the best way to quench the criticism leveled at the Hawaii Institute would be to show actual sea water corrosion data on INCONEL alloy 625 versus Chromel A. In essence Chromel A is 20 Cr - 80 Ni while INCONEL alloy 625 is 21.5 Cr - 61 Ni - 9 Mo - 3.6 Cb. For alloy materials in sea water, crevice corrosion or pitting is the most damaging form of attack. Molybdenum is specifically added to alloys for sea water service to prevent pitting. Note that Chromel A has none and is very prone to crevice attack in sea water.

I have enclosed published information showing pitting and crevice data as well as general corrosion rates. In particular note the discussion which I have underlined on the last page concerning the insufficiency of 80 Ni - 20 Cr in sea water. I hope this is helpful to you and if I can be of further assistance, please let me know.

Very truly yours,

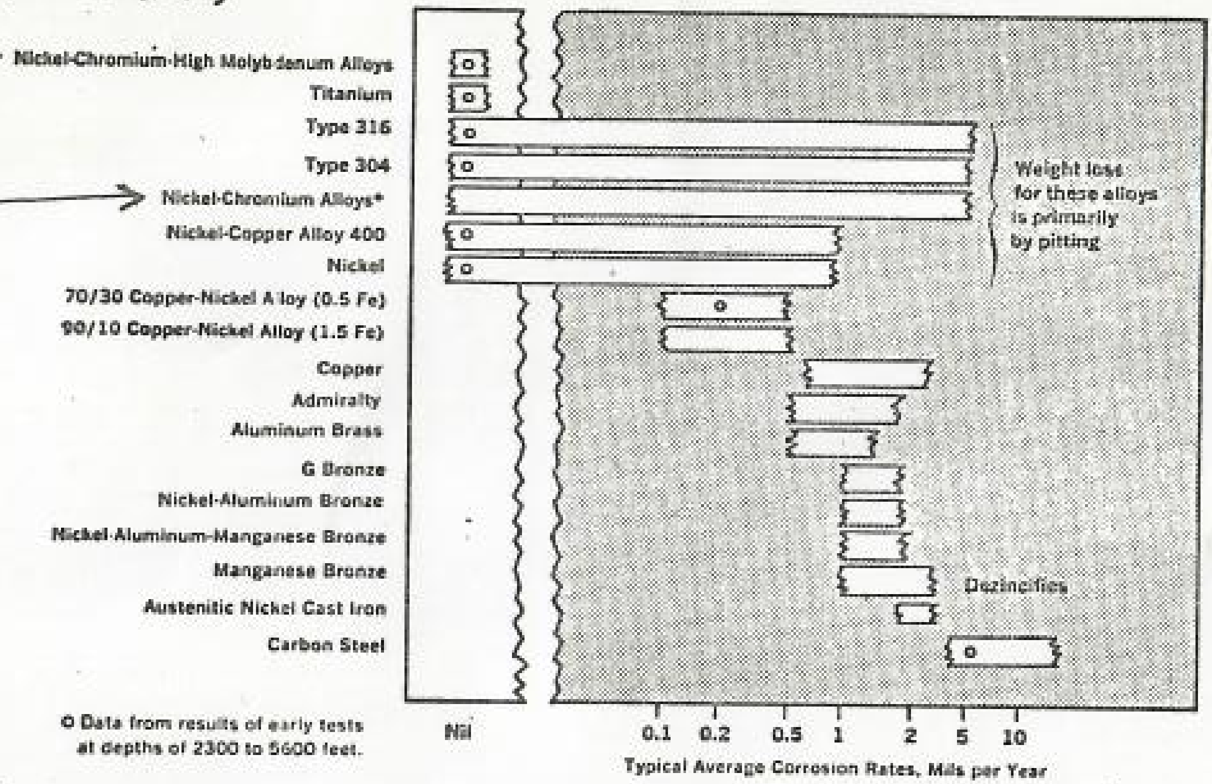
David L. Graver

David L. Graver
Chief Corrosion Engineer

DLG/ds
Enclosures

This would represent Chromel A, Nichrome V or Inconel alloy 600. These exhibit serious pitting. They do not exhibit general uniform corrosion, therefore representations as general wastage are misleading

Inconel 625 (no attack)



NOTE (* Nickel-chromium alloys designate a family of nickel base alloys with substantial chromium contents with or without other alloying elements all of which, except those with high molybdenum contents, have related seawater corrosion characteristics.)

Figure 4-47. Rates of general wastage of metals in quiet sea water.

①

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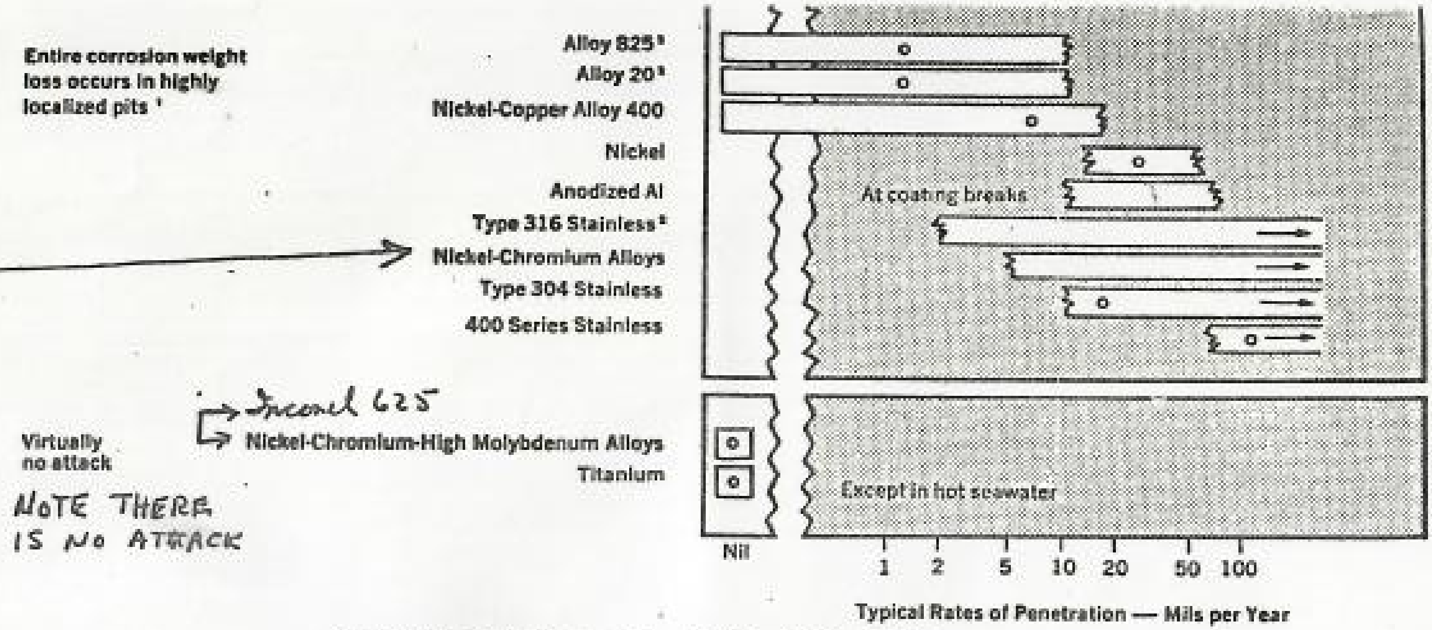

o Data from results of early tests at depths of 2300 to 5600 feet.

(1) As velocity increases above 3 fps pitting decreases. When continuously exposed to 5 ft. per sec. and higher velocities these metals, except Type 400 series, tend to remain passive without any pitting over the full surface in the absence of crevices.

(2) These grades have an advantage over Type 304 stainless steel and related grades in that there is a substantial reduction in the number of pits, i.e., probability of pitting even though the depth of such pits as do occur is not greatly reduced.

Figure 4-48. Rates of pitting of metals in quiet sea water.

This represents Chromel A, Nichrome V or Inconel 600
Note the serious pitting that they exhibit, anywhere from .005"/year to in excess of .1"/year in quiet sea water

From "Marine Corrosion - Causes and Prevention"

From "Marine Corrosion – Causes and Prevention"

This represents Chromel A, Nichrome V and Inconel 600. Note that they exhibit deep pitting in flowing sea water at the lower velocities

Inconel 625 (no attack in flowing sea water)

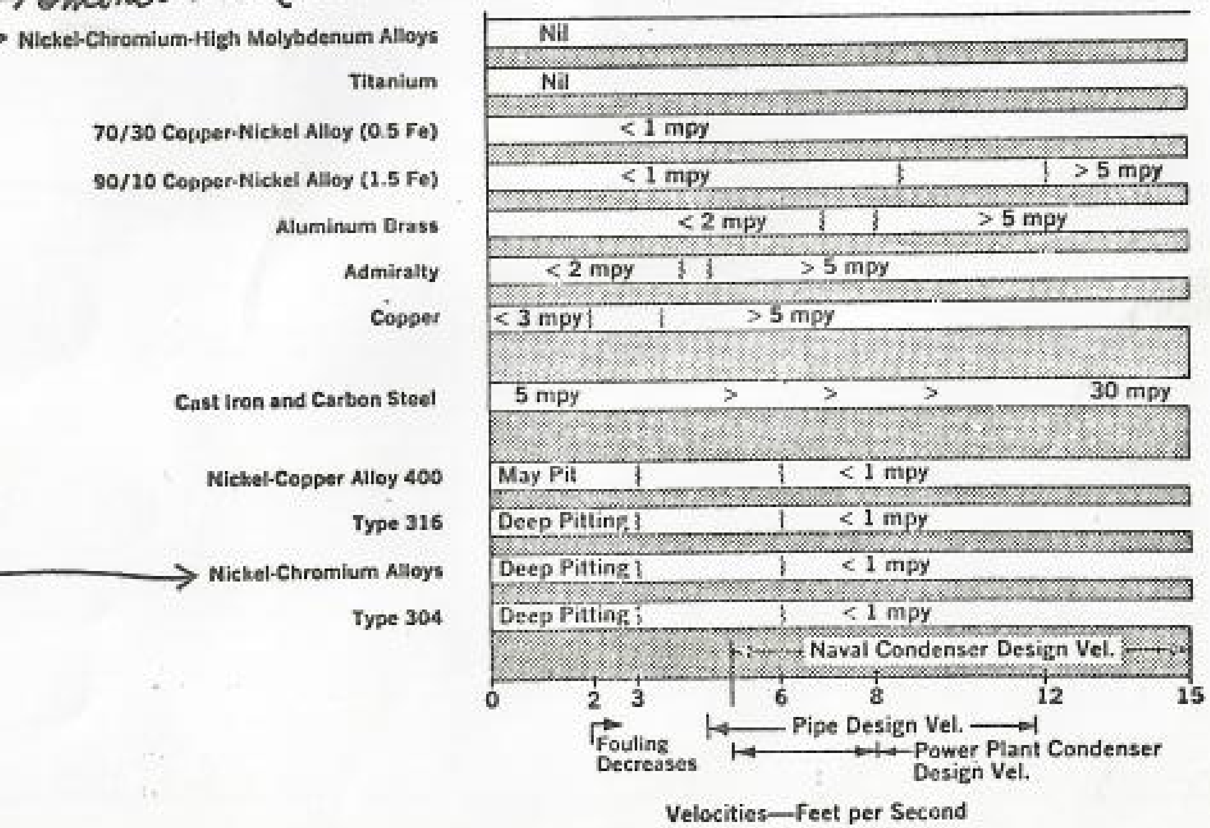

Figure 4-49. Rates of attack of metals by sea water moving at moderate velocities.

3

intensity of crevice corrosion of types 304 and 316 stainless steel were demonstrated also in studies by Vreeland and Bedford[4] of prevention of crevice corrosion by cathodic protection. With the control specimens of the type 304 alloy exposed for 1 year, 82% of the crevices were affected; with the 316 alloy, 64% of the crevices were affected. The maximum depth of crevice corrosion of the 304 alloy was perforation of specimens 0.063 in. thick. The maximum depth with the 316 alloy was 0.033 in.

Another technique for studying both the probability and intensity of crevice corrosion, employed at the F.L.L. Laboratory, makes use of the setup illustrated in Figures 5-7 and 5-8. The appearance of crevice corrosion within the crevices on a stainless steel is shown in Figure 5-9. With a high copper alloy the attack occurs just outside the crevices (Figure 5-10). A practical example with a copper alloy appears in Figure 1-7.

As noted previously, crevice corrosion of stainless steels involves not only the intensity of attack but its probability as well. This is illustrated by results of test with the setup shown in Figures 5-7 and 5-8, as covered by Figure 5-11 comparing two grades of cast stainless steel. The CF 8M grade was superior to the CA 15 grade with respect to both the probability and intensity of crevice corrosion. Here, again, the practical advantage was greater with respect to intensity than with respect to probability.

Note

The probability factor for crevice corrosion of the straight chromium grades of stainless steel containing from 12 to 18% chromium is about 100%. The probability factor decreases with the more highly alloyed compositions of the stainless steel type that contain high percentages of nickel supplemented by molybdenum and copper, known by the trade names Incoloy 825 and Carpenter 20. Probability of

CREVICE CORROSION TEST

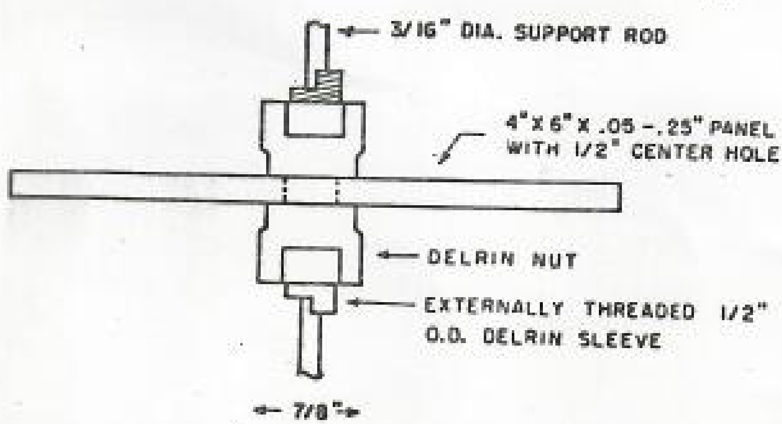

Figure 5-7. Crevice corrosion test specimen assembly.

From "Marine Corrosion - Causes and Prevention"

Right at the top of the list. The number designations on the tags should stay intact

TABLE 5.2 ORDER OF RESISTANCE OF ALLOYS TO CREVICE CORROSION IN SEAWATER

Inconel 625	Most resistant	Incoloy 825
Hastelloy C 276		Carpenter 20
Titanium		Type 317 stainless steel
Al 6 ×		Type 316 stainless steel
IN 748		Type 26 chromium/molybdenum
MP 35 N		Incoloy 800
70–30 copper nickel		Type 310 stainless steel
90–10 copper nickel		Inconel 600
Tin bronzes		Type 304 stainless steel
Aluminum bronzes		Type 347 stainless steel
Yellow brass		Type 321 stainless steel
Aluminum brass		Type 301 stainless steel
Red brass		Precipitation hardened stainless steel
Silicon bronze		Type 303 stainless steel
Copper		Type 430 stainless steel
Monel nickel copper alloys		Type 440 stainless steel
Austenitic cast irons		Type 430 F stainless steel
Cast irons		Type 410 stainless steel
Carbon and low alloy steels		Type 416 stainless steel

This is where Chromel A fits in the listing. It will be seriously attacked in the crevice.

crevice corrosion becomes zero with titanium and the nickel chromium alloys containing high percentages of molybdenum, represented by Inconel 625, Hastelloy C 276, AL6X, MP 35N, and IN 748. A listing of alloys in order of resistance to crevice corrosion in seawater appears in Table 5-2.

PREVENTION

In the tests designed to find a reliable caulking compound to prevent crevice corrosion of stainless steels, none of the petroleum base greases with or without additions of inhibitors turned out to be useful. Lanolin by itself was not effective, but did prevent crevice attack when mixed with zinc oxide. Most of the greases not only failed to prevent crevice corrosion but permitted this to occur in the crevices formed by patches of the greases applied to the stainless steel surfaces. Incidentally, petroleum jelly patches and smears remained free from fouling by marine organisms.

In another series of experiments[5] it was found to be possible to prevent crevice corrosion of stainless steels by the application of cathodic protection currents. The current density required, based on the total area of the test specimen, was found to

From "Marine Corrosion - Causes and Prevention"

NOTE (6)

Incoloy 800, as shown in Table 36, does well in deep-ocean environments. This excellent behavior is unexpected and is not consistent with its composition, since it is closely related to the pit-susceptible austenitic-grade stainless steels.

TABLE 36. DEEP-OCEAN BEHAVIOR OF Ni-Cr-Fe, Ni-Cr, AND Ni-Cr-Mo ALLOYS(43)

Alloy	Exposure Time, days	Depth, feet	Corrosion Rate, mpy: Water	Corrosion Rate, mpy: Mud	Crevice Corrosion, mils: Water	Crevice Corrosion, mils: Mud	Notes on Attack
Inconel 600	123-1,064	2,340-6,780	<0.1-0.5	<0.1-0.3	4-51	3-10	Mostly local crevice, some pitting
Inconel X750	123-1,064	2,340-6,780	<0.1-0.4	<0.1	0-47	0-9	Crevice attack in water and mud
Inconel 718	402	2,370	<0.1	<0.1	0	4	Slight crevice in mud zone
Incoloy 800	123-1,064	2,340-6,780	<0.1	<0.1	0	1-6	Trace of crevice in mud zone; most samples OK
Incoloy 825	123-1,064	2,340-6,780	<0.1	<0.1	0-22	0-8	Most samples OK
Inconel 625	402	2,370	<0.1	<0.1	None	None	
Hastelloy C	123-1,064	2,340-6,780	<0.1	<0.1	None	None	

like Chromel A

NOTE

Under immersed conditions, Incoloy 825 may be locally attacked in quiet seawater under fouling and at crevices. However, its resistance to pitting and crevice attack is much greater than that of the austenitic-grade stainless steels. The rate of attack after 3 years was 0.018 mpy for the totally immersed condition, as well as in the half-tide and the splash zones. In these particular exposures, local attack did not develop in the well-aerated splash zone, nor under the totally immersed condition. In the latter condition, pitting may eventually take place, unless the surface is continuously provided with well-aerated seawater. (See Table 35 for shallow-water results for Incoloy 825.) In hot seawater, this alloy is resistant to stress-corrosion cracking and thus finds application in seawater heat-exchanger service.

Hastelloy C and Inconel 625 are the best known of the nickel-chromium-molybdenum alloys. Under immersed conditions, their corrosion resistance is equaled only by that of titanium materials.

An example of the resistance of Inconel 625 in shallow seawater environments is given in Table 37. No corrosion of any significance was observed in any of these aggressive environments after exposures of up to 3 years. Circular welds on material annealed at 1800 F prior to welding also showed no significant attack after 1 year of exposure.

TABLE 37. DESCRIPTION OF SEAWATER CORROSION TESTS ON INCONEL 625 IN WHICH NEGLIGIBLE ATTACK WAS OBSERVED(a)

(1) Tests with 0.25 inch diameter 7 x 19 wire rope at Wrightsville Beach, North Carolina, in ambient seawater.

Exposures: (a) trough at 2 fps, (b) water line, (c) tidal zone, and (d) partial mud burial.

(2) Tests with 4 x 12 panels with plain crevice (1.25-inch fiber washer), and welded configurations (2-inch-diameter circular weld ground flush).

Exposures: (a) quiet seawater and (b) trough at 2 fps.

(a) Data provided by The International Nickel Company, New York, N. Y. (1968).

Hastelloy C has been tested in a great variety of seawater environments and found extremely resistant. A few selected examples are presented in Table 38. Note that Hastelloy C will withstand high velocity, elevated temperatures, stagnant

TABLE 38. CORROSION OF HASTELLOY C IN SEAWATER ENVIRONMENTS(a)

Type of Test	Site	Seawater Conditions: Temp, F	pH	Velocity, fps	Oxygen, ppm	Duration	Corrosion(b), mpy	Notes
Spool	Curacao	82	6.6	(Pump suction)	3.5	3 yr	0.4	No pitting
Spool	–	325	–	0.5	–	3.3 yr	<0.1	
Coupon	Wrightsville Beach, N.C.	51	8.0±	128	Sat'd	30 days	0.2	
Sandblasted plate	Ditto	Ambient	8.0±	Low	Sat'd	10 yr	0.016	No pitting or crevice attack
Sheet tensile rotating in autoclave	Navy Laboratory at Annapolis, Md.	350	–	10	–	1080 hr	(Weight gain)	
Navy erosion test	Wrightsville Beach, N.C.	86	8.0±	20	Sat'd	60 days	0.63	

(a) Taken from literature supplied by The International Nickel Company and Union Carbide Corporation.

(b) Weight losses were so small that cleaning and weighing errors may be the major factor, especially for plate samples.

From "The corrosion of Metals in Marine Environments"

A comparison of a few other well-known metals with Monel-400 is shown in Figure 40. From the standpoint of weight-loss penetration, Monel-400 corrodes at about the same order of magnitude as zinc. The 6061 aluminum alloy shows much less attack, but experiences deeper pits in the same exposure.(40) Cupronickel and aluminum bronze are found superior to Monel-400 in respect to both pitting and weight-loss penetration. Corrosion rates in quiet seawater for Monel and stainless steel are compared in Table 35. Note that the pits on the Monel alloys are broader and less deep. Monel was less susceptible to crevice attack than were the stainless steels.

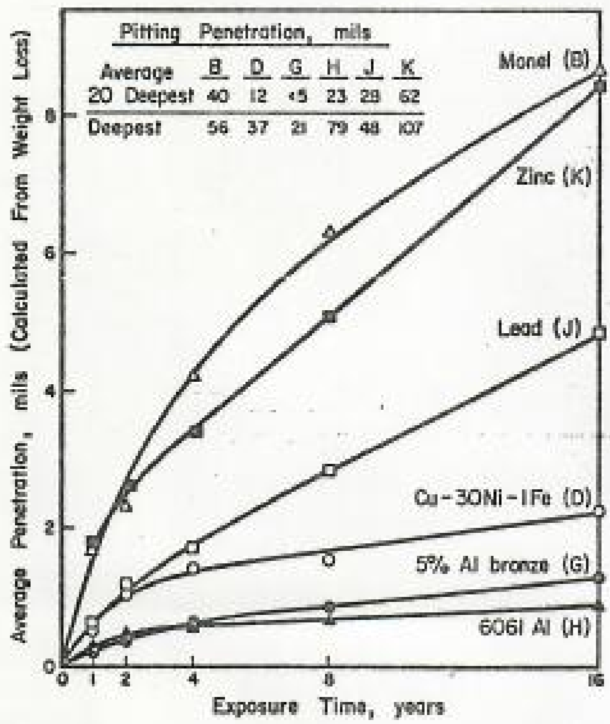

FIGURE 40. COMPARISON OF VARIOUS METALS AFTER 16 YEARS' IMMERSION IN LOW-VELOCITY PACIFIC SEAWATER OFF THE PANAMA CANAL(40)

Used with permission of National Association of Corrosion Engineers

As shown in Figure 41, the weight-loss penetration of Monel-400 in deep-ocean environments, is typically about 1 mpy or less. However, Monel-400 is subject to severe pitting attack in the deep ocean, as illustrated in Figure 42. Under these conditions, the weight-loss penetration typically ranged from 0.3 to 1.1 mpy and crevice attack ranged from negligible to complete perforation or 125 mils.(43)

To control the tendency for pitting in quiet seawater, it would be desirable to provide cathodic protection, as by galvanically coupling a Monel item to a large steel surface. As with nickel, if impressed current is used, it may be necessary to polarize just to the pitting potential, since the general corrosion is not excessive.

Monel-400 and Monel-K500 are used mainly in high-velocity applications in the immersed condition. These applications include such items as pump impellers and small propellers.

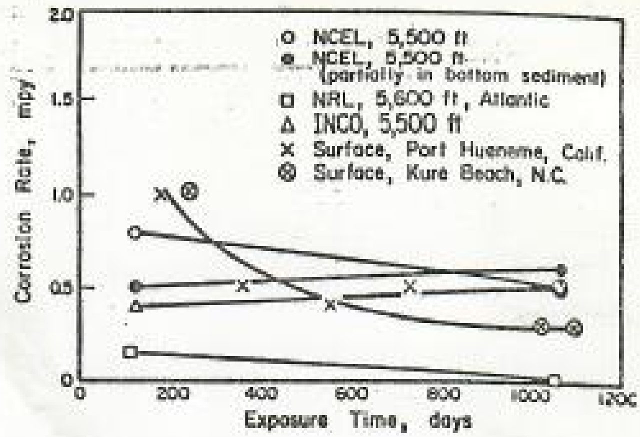

FIGURE 41. CORROSION OF MONEL-400 ALLOY IMMERSED IN SEAWATER AT SHALLOW AND DEEP OCEAN SITES(1)

NOTE.

Nickel-Chromium-Molybdenum. Before discussing the individual alloys for which information is available, one can cite some general effects of alloy composition on the corrosion behavior of nickel-chromium-molybdenum alloys. Nickel, itself, is prone to pitting. When chromium is added to nickel, as represented by the 80Ni-20Cr composition (Nichrome) or by Inconel 600, the passive film is strengthened greatly but not sufficiently to prevent crevice and pitting attack in seawater. Thus, the nickel-chrome and nickel-chrome-iron compositions can be used in seawater only where the velocity will be such as to maintain the passive film or if cathodic protection is used. In general, these alloys are much more resistant to local attack than nickel; local breakdown may take years to develop under some conditions.

When molybdenum is added to nickel, the tendency to local attack is virtually eliminated, as is the case with Hastelloy B (which contains 28 percent molybdenum and 5 percent iron). When the nickel is modified with suitable amounts of both chromium and molybdenum, the extremely good resistance of such alloys as Hastelloy C, Inconel 625, etc., is obtained. Thus, each of these additions contributes to the improvement of the corrosion behavior of the nickel-base composition.

Like Chromel A

Inconel 600 and X750 alloys will remain passive in flowing, well-aerated seawater, but will be attacked at crevices. Pitting also occurs. Both these alloys do well with cathodic protection in quiet seawater and both are resistant to chloride-ion stress-corrosion cracking. Deep-ocean crevice-attack results for Inconel 600 are presented in Figure 43. It is to be noted that the crevice attack has led to perforation in one case.

Inconel 718 is much more resistant to crevice attack, no doubt because of the 3 percent molybdenum addition. It is a good alloy for erosion corrosion and strength. Recent applications in the marine field include hydrofoils, bolts, and propellers.

From "The Corrosion of Metals in Marine Environments"

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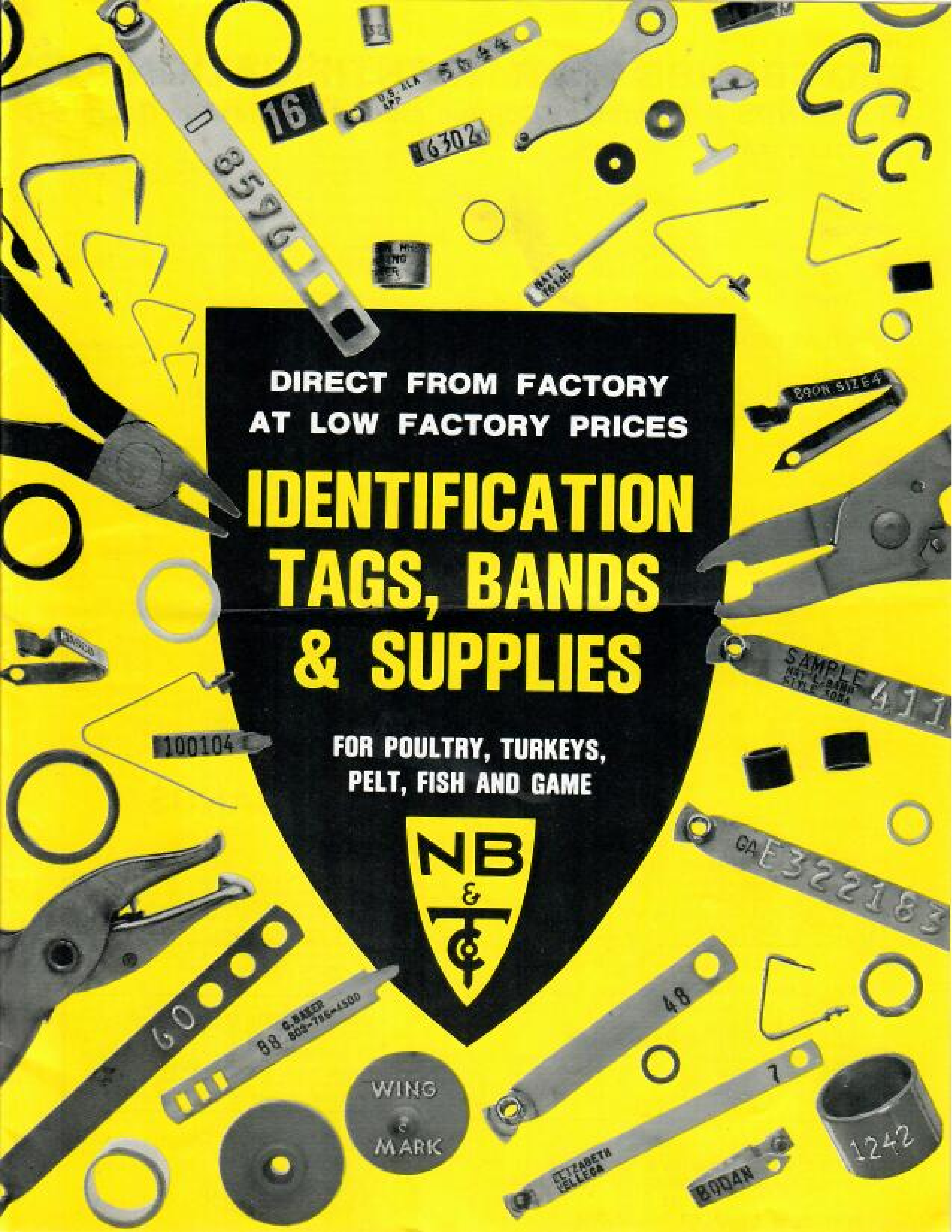


U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

10 sent 6/25/83 (see daily log) 5/11/83

To: George

From: Larry

Got your argument against subsistance take — reads real good. Hope Hawaii & Guam read it and respond the only logical way they can.

Just a short note to say that John Fletemeyer is doing a long-term test on various tags and requested some samples of inconel tags (2 - 10, 12 tags). Can you respond to this — if so just send them directly to Fletemeyer. Thanks

TRANSMITTAL FORM CD-82A (10-67)
PRESCRIBED BY DAO 214-2 ☆ U.S. G.P.O. 1982-564-008/1147

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

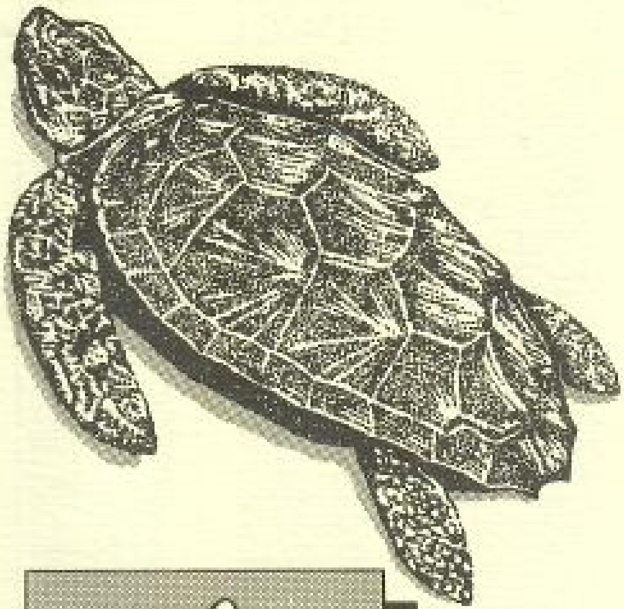
To:

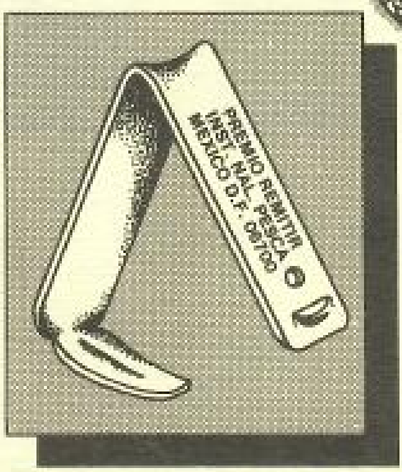
From:

John Fletemeyer
Ocean Sciences Center
Nova University
Dania FL 33004

George: if you can't spare them or don't want to, just ignore this request and I'll explain it away next time I see John.

TRANSMITTAL FORM CD-82A (10-67)
PRESCRIBED BY DAO 214-2 ☆ U.S. G.P.O. 1982-564-008/1147





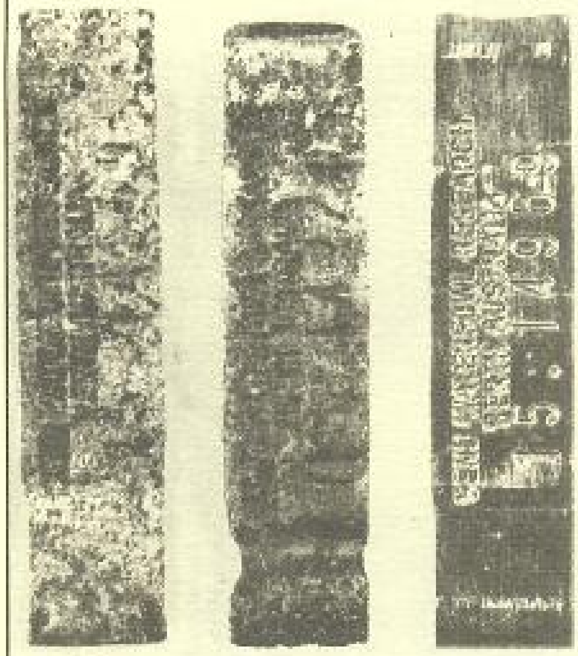
Turtle Tags

(mfg commercially, pure TITANIUM)

For samples and assistance with all your tagging programmes (Bird Bands, Fish Tags etc.)
Write:

STOCKBRANDS CO.
P.O. BOX 80, MT. HAWTHORN 6016,
WESTERN AUSTRALIA.

MONEL



407 417 NEW

DAYS OF WEAR

The West Australian Fisheries and Wildlife Department commenced banding water fowl in 1967 using Monel bands, which showed considerable deterioration to the point of loss or illegibility within 417 days. (see photo)

Titanium bands were used starting 1967 for banding Wild Duck on Rottnest Island under lake conditions ranging in salinity from 5% to 22% (sea water 3.5%). These bands evidenced no deterioration over the 10 year period to 1977.

(Ref: RIGGERT Dr. T. The Biology of the Mountain Duck on Rottnest Island.)

February 10, 1983

Mr. John Forehan
Stockbrands Company, Pty. Ltd.
P. O. Box 80
Mt. Hawthorn
Western Australia 6016

Dear Mr. Forehan:

Mr. Richard Croft, Chief Fisheries Officer of Ponape, recently visited with me here in Hawaii to talk about sea turtles and tagging. I told him of Stockbrands ability to manufacture titanium flipper tags in small quantities for about $1 each. Mr. Croft is interested in ordering about 300 of the small size tags (approx. 8x30 mm) with appropriate numbering and return address inscription. He will also need at least two of the applicator pliers. I told Mr. Croft of our earlier correspondence on this subject, and indicated that I would write to you again on his behalf. At your earliest convenience, would you please provide Mr. Croft with the necessary price quotation, production time, and other details. I know that he is anxious to obtain these tags as soon as possible. His address is:

Mr. Richard Croft
Chief Fisheries Office
Ponape District
Kolonia, Eastern Caroline Is. 96941

Thank you again for your help.

Sincerely,

George H. Balazs
Assistant Marine Biologist

mk
cc: R. Croft

Identification Designers and Manufacturers

STOCKBRANDS CO. PTY. LTD

53 Edward Street, Osborne Park, W.A. Telephone 444 4877

All correspondence to P.O. BOX 80, MT. HAWTHORN, WESTERN AUSTRALIA 6016

December 7 1982

University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P.O. Box 1346 - Coconut Island
Kaneohe, HAWAII 96744.

Dear Mr Balazs

Regarding small tags, we would be pleased to supply 200 tags if that is all you require at this time.

Yours faithfully

JOHN FOREHAN

UNIVERSITY OF HAWAII AT MANOA
HAWAII INSTITUTE OF MARINE BIOLOGY
P. O. BOX 1346
KANEOHE, HAWAII 96744

October 22, 1982

Mr. John Forehan
Stockbrands Co. Pty. Ltd.
P. O. Box 80
Mt. Hawthorn
Western Australia 6016

Dear Mr. Forehan:

Thank you very much for your letter of 30 September along with the sample of tags. We are indeed interested in your superior Titanium tag for sea turtles. I am somewhat familiar with their trial use in Australia, but did not know that they have been used in the United States. Would you please let me know what project in the U.S. used them and what results were obtained. Also, could these Titanium tags be made in a one-third to one-half smaller size of the same design? If so, what would the price be? Is there a minimum number that must be ordered?

Thank you for your continuing help with this inquiry.

Sincerely,

George H. Balazs
Assistant Marine Biologist

GHB:md

bcc: Larry Ogren
Jack Woody
George Hughes

Identification Designers and Manufacturers

STOCKBRANDS CO. PTY. LTD

53 Edward Street, Osborne Park, W.A. Telephone 444 4877

All correspondence to P.O. BOX 80, MT. HAWTHORN, WESTERN AUSTRALIA 6016

November 1 1982

University of Hawaii At Manoa
Hawaii Institute of Marine Biology
P.O. Box 1346
Kaneohe HAWAII 96744

Dear Mr Balaza

We can supply a smaller selfpiercing tag in titanium, (samples enclosed from aluminium) and the cost would be approximately 80¢ each.

I am sorry if we misled you regarding tagging in US, but we understood that our tags supplied to Australian research had been passed on to the US for trials.

Yours faithfully

JOHN FOREHAN

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UNIVERSITY OF HAWAII AT MANOA
Hawaii Institute of Marine Biology
PO Box 1346 - Coconut Island
Kaneohe, HI 96744

September 26, 1983

"OUR 81st YEAR"

Attn: George Balazs

Dear Dr. Balazs:

Receipt is acknowledged of your letter dated September 21st together with Inconel tag enclosures.

I have sealed one of your tags with my old style plier that seems to work real well. I am sending you this plier under separate cover together with your Inconel tags which you requested that I return to you. Feel free to keep this plier and use it to seal the tags you have on hand; when it has served its purpose, if you will return it to me, I will appreciate it.

Thank you for writing.

Yours truly,

NATIONAL BAND AND TAG COMPANY

Tom V. Haas

Tom V. Haas, Manager

TVH:lc/2

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DEPARTMENT OF THE INTERIOR
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POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

October 29, 1982

Mr. John Forehan
Stockbrands Company, Ltd.
P. O. Box 80
Mt. Hawthorn
Western Australia 6016

Dear Mr. Forehan:

George Balazs in Hawaii recently informed me that your company is producing titanium turtle tags and that these are evidently being used on some project in the United States. Since hearing from Balazs, I have been checking with other sea turtle workers in the United States, Mexico, and Central America and I have not found anyone familiar with your titanium tags, nor have I located anything in the literature available which speaks to this material in tags.

As you well know, there is a constant search for a sea turtle marking device which is permanent and easily recognizable anywhere in the world. The tags we presently use are recognizable but they don't generally last more than two or three years at most.

It would be greatly appreciated if you could send me any information regarding use and field testing of this tag, costs, delivery time (to U.S.), etc. I am especially interested in learning who is using this tag in the U.S., so that I may contact them for particulars on tag use and results.

Any information you can provide will be greatly appreciated.

Sincerely,

Jack B. Woody
Acting Regional Director

cc: SE (RO)
OES (Dodd)
Balazs
Berry, NMFS

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

7/19/82

To: George Balazs

From: Larry Ogren

Have you got $5K? If so, make up a requisition for inconel tags and send to J.R. Haas!

Perhaps next FY, FWS & NMFS can come up with the bucks to get NBT equiped to punch out these tags. We will see what can be done.

Best ever
Larry

TRANSMITTAL FORM CD-82A (10-67)
PRESCRIBED BY DAO 214-2

P.S.

Nothing to report
on ES status review
so far (ie, no word).
Technical Manual on Conservation
& research Techniques coming
off the press — will send you copy
as soon as I receive them &
Sent extra copies of dissection &
necropsy manuals to you under
separate cover ∴ thought you might
distribution them to your
colleagues in Hawaii

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RABIES CONTROL AND ANIMAL LICENSING • ELECTRICAL AND INDUSTRIAL USES

NATIONAL BAND AND TAG COMPANY

Established 1902 • • GENERAL OFFICES: 721 YORK STREET NEWPORT, KENTUCKY 41072, U. S. A. • • Phone: Area (606) 261-2035

USDC-NATIONAL MARINE FISH.SERV.
3500 Delwood Beach Rd.
Panama City, FL 32407

July 15, 1982

"OUR 80th YEAR"

Attn: Larry H. Ogren

RE: Inconel 625 Turtle tags

Dear Mr. Ogren:

Confirming our telephone conversation on July 8th, we would propose production of the turtle tags manufactured from Inconel 625 in two sizes -- our size 681 and size 19 utilizing a common width (tag width) 11/32" rolled edge flat wire material having an .036" to .038" thickness. Exact thickness yet to be decided.

Initially, a minimum order for a quantity of 7000 size 681 tags would be required, the cost would be $815.00 per 100. Or, a size 19 tag could be ordered out in minimum quantities of 3000 at a cost of $1767.00 per 100. Terms net 30, F.O.B. factory. Shipment 3 to 6 months. Subsequent orders for either tag size would be priced at substantially less, to estimate now what this might be in a year or two is difficult. But to provide you with some idea, if we were today in a "subsequent order position", the tags would cost about $98.00 per 100 in lots of 1000 or more per size, less than 1000 per size would involve an additional $75.00 per lot make-ready charge. Time required for shipment would be 4 to 6 weeks.

The utilization of a common width and thickness material for both tag sizes would relieve the expense and availability problems in material procurement, also it simplifies the production and improves availability of both the tags and tag applicator.

I trust my interpretation of our telephone conversation is accurate and should you require any additional information, please let me know and I'll do my best to oblige. Pricing quoted is good for 60 days, beyond this time, I reserve the right to requote.

Sincerely,

NATIONAL BAND AND TAG COMPANY

J. R. Haas

JRH:lc/3

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All quotations and orders are entered subject to Federal Regulations, Government Priorities and conditions beyond our control.

April 16, 1981

Dr. Steve Cornelius
RR3, Box 216
Mountain View, MO 65548

Dear Steve:

Many thanks for your interesting and informative letter of March 31. I greatly appreciate the details that you took the time to provide on tags and tagging problems.

A few years ago, Delta Plastics of New Zealand (manufacturers of Allflex) sent me an assortment of tags following a visit to our laboratory by one of the company officials. I applied a number of the tags to adult green turtles in captivity at Sea Life Park here on Oahu. Unfortunately, the retention rate was poor and all of the tags eventually came off. However, this was at least in part due to biting by other turtles, which is always a problem in a captive situation. I have also documented biting of tags in the wild, as evidenced by "squashed" metal tags. I believe that George Hughes and Col Limpus have had problems with plastic tags due to biting.

I applaud your strategy to use two or more tags on each turtle. Everyone should be doing this, in my opinion. After all, the cost of the tags is only a fraction of the cost of the research. The tags are the very basis of the research.

Best regards.

Sincerely,

George H. Balazs
Assistant Marine Biologist

mk

S.E. Cornelius
R.R. 3, Box 216
Mtn. View, MO 65548

24 February 1982

George H. Balazs
National Marine Fisheries Service
P.O. Box 3830
Honolulu, Hawaii 96812

Dear George:

I enjoyed very much your summary of the tag loss problem in the last MTN. It was much needed.

There is an aspect of tagging techniques that I have never seen discussed, at least in a formal way. That is the location on the trailing edge of the flipper at which the tag is applied. Metal tags at Nancite have always been applied between the second or third proximal scute. Last year I changed the location during the last arribada and put them through the second or third scute. My initial reaction to the new site was that the tag "fit" better, that it was not as loose as sometimes occurs when placed between the scutes. What is your reaction to this?

Approximately 14,000 additional female ridleys were marked at Nancite and Ostional in 1981, 5,000 with Allflex plastic the remainder with the size 19 monel. Reobservation of 1980 tags were many at both beaches and the initial analysis suggests that loss rate was about the same for both types. Actually, the rate was higher with plastic until I eliminated one color (yellow) afterwhich there was no difference. This is only Nancite return information, Ostional still to follow. Next year I am ordering a smaller plastic, staying with a subdued color (green) for Ostional and going completely to the 681 monel at Nancite. I was leaning in that direction (re: the 681 size) anyway and your article was the push needed. You should receive our report by the end of March.

I hope your program is not suffuring too greatly from the budget cuts. I look forward to hearing your reaction on the tag site question.

Sincerely,

Steve

Steve Cornelius

a volunteer in the Caribbean Conservation Corporation's turtle-tagging project, learning many of the techniques now used in the Little Cumberland Island Turtle Project.

When he received the turtle tags, he could hardly wait for nightfall so he could begin. He hurried down to the beach and found four loggerheads crawling up the beach or busy nesting. Following Carr's instructions, he punched a hole through the flipper, squeezed on the tag, and recorded the time, locality, and the number of eggs. From that day on, every turtle found on Little Cumberland Island was tagged.

Some scientists believe that loggerheads, perhaps more than any other sea turtle, tend to wander from beach to beach to lay their eggs, but Jim's computerized data clearly showed that was not the case. There were a few turtles that strayed from one island to another, but they were a minority. A turtle tagged by Caretta Research, Inc., on the Gulf Coast of Florida turned up the following year on the Atlantic side, but that was the exception.

Over and over again, the records of Cumberland Island, Ossabaw, and other beaches showed that loggerheads were faithful renesters, returning to the same beach season after season. The Little Cumberland Island Project had been kept alive and funded by the association of landowners, who believed that something should be known about these ponderous reptiles. They hired students to patrol the beaches and do the tagging, provided them with vehicles, built hatcheries, and moved hundreds of thousands of eggs from the wild beaches to the protected zone. The project grew and grew, and other islands, including Ossabaw, joined them. They kept in touch with Caretta Research, Inc., on the Gulf Coast, a similar organization made up of landowners and citizens. They compiled notes, collected data, and compared common problems.

The biggest problem, next to shrimpers drowning the turtles, was tag loss. Although Carr's Monel tags worked well for green turtles off Costa Rica, they didn't hold up at all in the temperate Atlantic waters. They became encrusted with bryozoans and sooner or later were eaten away by electrolysis and fell off.

Turtles came ashore bearing callused scars where tags had been inserted and then lost, and occasionally turtles' tags would turn up lying next to a crawl and nest area. The projects experimented with plastic tags, but the plastic became brittle and broke off even sooner. The experimenters decided to double-tag the turtles after two seasons.

The average life of a tag, at best, is only four to six years—that is, except for the tag D-4, which is still attached to a very ordinary-looking turtle. Over the years, since that first night when Jim Richardson tagged her, the Monel tag D-4 has remained in mint condition. The turtle isn't remarkable at all, except for the large number of assorted tags she wears. She is no larger than any of the others, although she is now in her sixteenth year. She has a chunk of her rear shell missing from a shark bite, but many turtles bear the wounds of sharks.

Jim, now a graduate student at the University of Georgia, speaks about her in a tone of reverence and affection, because this turtle has never let him down. She holds the world's record for a continuously renesting loggerhead, faithfully returning to the beach every two years without fail, almost on schedule. Most loggerheads nest every two years, although some are on a three-year cycle. They may lay up to six nests in a season, or they may lay only three. But across the ocean in Tongaland, South Africa, the turtles have a more frequent nesting pattern. While many there are on a two-year cycle, others are annual nesters, coming back to the same beach year after year, something no other sea turtle has been reputed to do.

George H. Hughes, a turtle biologist who has been tagging turtles since 1963 in South Africa, has found that half the turtles nest only one time and are never seen or heard from again. On Cumberland, half the turtles tagged also fall into this category of the "lost turtle." Jim's printout was full of tag numbers, dates, and localities of single nestings, and no further entries.

Almost half of Cumberland's tag returns came from shrimp trawlers and a few from other turtle beaches, but none of them were the one-time nesters. There were simply too many of these lost turtles to think they were all drowned by shrimp nets or eaten by sharks after they left the beach. Unless their mortality was much higher than anyone imagined, there was obviously some very strange and mysterious gap in their natural history.

Could these one-timers be nesting someplace else, on some distant shore? They weren't nesting on any of the turtle beaches that were patrolled by turtle workers and game wardens. And turtle beaches were being heavily patrolled each year. Even the one or two turtles that crawled out on a Virginia beach were reported. And there were patrols in North Carolina, Florida, and over to the barrier islands of Mississippi and Texas.

To get a feel for an "average" nesting turtle on Little Cumberland, I flipped through the computer paper and randomly selected C-0388. She "began" officially on June 24, 1968, when the D tags had given way to C tags, and "ended" on May 31, 1974. When the patrol first met her, she was untagged, but "callused" in the midst of a "false crawl." Perhaps she found too many logs and snags on the beach that year for her liking, or perhaps she had been scared off by the motorized vehicles of the turtle patrol.

The students headed her off before she could make it back to the water, flipped her over, and waited until she quit flapping and snapping. Jim often took new turtle workers out at the beginning of the season to teach them respect for the loggerhead. All he had to do was put a stick in one's mouth, and when the workers saw it shatter, they knew enough to stay clear of a flipped turtle. The loggerheads would never bite when they were on their bellies, but when turned over they went wild and tried to defend themselves.

When the loggerhead finally calmed down, she was given a new identity. Now she bore the tag number C-0388 on the inner side of her flipper, near the juncture of her limb and her shell, right next to the tough white scar of her previous tag. The computer record listed her as callused. Somewhere in the sediments of the Atlantic Ocean, her previous metal D tag was buried.

The tagging crew flipped her back and watched the big barnacle-covered shelled creature indignantly lurch down the beach and vanish into the waves. She couldn't have been too disturbed by this encounter, because three hours later, according to the record, the turtle patrol again met her down the beach, wearing her new tag and digging her nest. The students watched her deposit her eggs, cover them, and then start back down to the water. They dug up her nest, counted out 119 eggs into a plastic bucket, and moved it off to the hatchery.

On July 5, C-0388 returned to Little Cumberland and laid another batch of eggs in the sand. All sea turtles have an internesting period during which they disappear from the beach for an average of two weeks. No one knows where they go during their absence between nestings, although most turtle workers believe they swim offshore and hang around the rocks to feed and forage. Scuba divers have seen loggerheads blissfully sleeping off the Georgia coast, wedged up under the limestone outcrops and artificial reefs. Even though they invariably feel compelled to roust up the turtle and make it swim, just to see the big cumbersome thing move, they have never reported seeing a shiny steel tag affixed to the flippers.

Because loggerheads love to hang around offshore rock piles feeding on turkey wing clams, sponges, conchs, lobsters, and anything else they can find, the old-time snapper fishermen, who sailed by dead reckoning to find the snapper banks, considered the loggerhead a friend. Long before the days of diesel power and sophisticated navigation equipment like radar, loran, and fathometers, these men would travel forty or fifty miles out to sea to fish the "live bottoms." These are rocky outcrops grown over with all sorts of sponges, sea fans, corals, and other invertebrates. They provide habitats for spiny and slipper lobsters, gorilla crabs, featherduster worms, and a variety of other invertebrates. And they provide both food and shelter to bottom-feeding snapper, grunts, porgy, black sea bass, grouper, and big jewfish.

These rich rocky bottoms weren't easy to find for the wind sailors. Often they were separated by miles and miles of sandy

TO TURTLE MOTHER—
and all her allies on
turtle beaches everywhere

Penguin Books Ltd, Harmondsworth, Middlesex, England
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Cars - Discs wired on shell, use of plastic.

other methods besides tags - schmitt - branding - my tattoo

other reptiles - titanium discs - branding.

Use of Monel 400 ("stainless steel") Size of tags,

styles of bridges - ; Plastic - Rototags - Location of tagging

Special problems tagging less than adult -

Plastic TAGS ① HATChlings ② Juvenile - Adult

See Banks - 1937

Hendrickson, 1958 page 488 plate 7c

~~Bustard Book~~ page 116

Toxicity Aspect –

TAG LOSS ASPECT – Low % Return

Electric portable drill –

Notes on the Edible green turtle

Harrisson, 1960 #8 page 278 – Tag in perfect condition

write NBT

(Was 1953 the first year NBT made Monel tags? – previous for seals? Other companies?

H. Robert Bustard "Queensland Protects Sea Turtles"

30 MAY 1981 Airplane departed for Honolulu at 2:15 PM
SATURDAY

Question: How many tagged turtles-baskers on Trig, W-S, Gins have ever showed up later at East Island.

3:45 PM depart for Whale-Skate assessment - fairly calm seas. Arrive 4:10 PM. Noted fishing boat moving back and forth by La Perouse.

(Need - TO compute tag recovery rate (%) of Whale-Skate-encountered turtles.

TAG WRITE-UP: FOR ADULTS IN WHICH NO further growth will occur

There are two basic sets of problems related (as with certain other marine animals) to the tagging of sea turtles. The first area is the integrity of the material from which the tag is manufactured. Corrosion can result from the effects of sea water, or the biochemical environment that exist where the tag comes in contact with the turtles body tissue, and fouling organisms (algae, barnacles, etc.) that growth on the tag's surface. Breakage of the tag can result if the tag material does not have sufficient strength to withstand impacts normally encountered during the sea turtles life history, such as biting by other turtles during courtship, and nesting excavation and

ABRASION WITH UNDERWATER SUBSTRATE - "WEARING"

but Allflex Teflon

⑥ if bend in tag is squeezed slightly with pliers, the "spring" action is eliminated.

⑤ Tag size

⑦ Two views ⓐ apply early in nesting season, then check later ⓑ apply later, bypassing abuse from nesting that season.

filling which on land.

31 MAY 81 SUNDAY The second set of problems in sea turtle tagging deals with loss of tags due to failure of the tissue where the tag is affixed to the body. This would include tearing through the flesh, necrosis and sloughing. The causes of these failures will be discussed later. Third set - failure of the tag's locking mechanism.

ALSO - ① Size of Tag (increased drag for larger tags) and shape (streamline) ② Special problems of female's wacking shell when nesting; and Male's biting one another (ie tag placement) ③ To minimize tearing, having the tag too tight may be better than too loose.

Ⓐ Length of tag available for tag application. Consider - Ehrhart and Maylan comments about limits of tagging results.

1 JUNE 81 Monday Many different turtles were up to nest last night.

At 11:40 AM 4-engine Navy P-3, with one engine shut off, flew low (~500') over East Island out of the east - went over La Perouse and circled back for another pass over East Island then departed in the direction of Whale-Skate. John Andre reports that since December, when the people were stranded on Gin, a Navy plane has flown over every so often. Happened once when they were at East.

No. 15745

OTHER CONSIDERATIONS

1) multiple tagging
2) changing tag recoveries - Difficult to inspect size 49
3) length of time available to work on & tag turtles
4). Cost of tags small percentage of overall research costs, but one of most important tools
Area that has been neglected - more attention needs to directed
key item

K-2
September 1, 1981

Mr. George H. Balazs
University of Hawaii at Manoa
P. O. Box 1346
Coconut Island
Kaneohe, Hawaii 96744

Dear Mr. Balazs:

This responds to your letter of August 18 in which you requested comparative data on corrosion rates of sea turtle tags which you had recovered after as much as 4 years' - 9 months' of service.

There is no possible way to make the determination unless the actual surface areas and exact weights of the individual tags were known before they were placed in service. In any event, we have recorded the following information on the chance that you may have made those measurements before putting the tags in service.

Tag. No.	Wgt. - Gms.	Thickness - In.	
		Edge	Center
2060	3.0245	0.027	0.031
2083	3.0435	0.027	0.030
2146	2.9924	0.026	0.030
2164	2.9657	0.026	0.029
2270	3.0533	0.027	0.030
2493	--	0.027	0.030

Tag No. 2493 was a new tag which was sectioned to supply sample for chemical analysis. Since the total tag was not available, weight determination was not possible.

In the environment where turtles reside, sea water temperature, salinity, oxygen content, level of pollutants, diets of turtles and their discharges, in all likelihood, will not reduce the corrosion resistance of INCONEL alloy 625. Typically, I would expect that the rate will remain reasonably constant and something of the order of 0.0001 in./year. Your identification numbers, I am confident, will be retained and legible for decades.

Very truly yours,

L. A. Yerkovich

L. A. Yerkovich
Senior Technical Coordinator

LAY/kbz

Monel — multiple tagging
made for domestic —
not harsh use

Basic weakness of Monel

Corrosion

to such as reported by most writings

1) description — historical overview

2) causes — ocean, seawater — growth

3) solutions

compounds

in lettering "worked"

Thickness of strip

other considerations?

ABRASION

Monel*
Inconel*

*trademarks of International Nickel

Acknowledgements

Yerkovich
Haas family — NBTC
numerous researchers

University of Hawaii at Manoa

Hawaii Institute of Marine Biology
P.O.Box 1346 • Coconut Island • Kaneohe, Hawaii 96744
Cable Address: UNIHAW

June 25, 1981

Mr. L.A. Yerkovich
Senior Technical Coordinator
Huntington Alloys, Inc.
Huntington, West Virginia 25720

Dear Mr. Yerkovich:

Thank you very much for your letter of June 2nd that arrived in Honolulu while I was out in the field tagging turtles at French Frigate Shoals. I was pleased to learn of your willingness to examine some of my Inconel tags that have been attached to turtles. The tags that I have enclosed are as follows:

	Tag No.	Description
1.	2270	Recovered after 4 years, 1 month attached to an adult turtle at French Frigate Shoals
2.	2060	Recovered after 4 years, 9 months attached to an adult turtle maintained in captivity at Sea Life Park, a commercial display facility.
3.	2146	Recovered after 1 year, 4 months attached to an immature turtle off the Island of Hawaii
4.	2083	Recovered after 1 year attached to an immature turtle at Kure Atoll
5.	2164	Recovered after 1 year attached to an immature turtle at Midway Islands
5.	2493	New from National Band and Tag Company manufactured in 1976
7.	5217	New from National Band and Tag Company manufactured in late 1980

I do not know the exact thickness of the tags when manufactured, but the papers I have from National Band and Tag Company suggest .030-.035".

In late 1980 National Band and Tag provided me with a second special order of Inconel alloy 625 tags. Tag number 5217 (enclosed) is from this shipment. I was interested to see that these more recently produced tags are dull and do not have the silver-surface shine that is present in my first order of 1976. There are also dark spots present on some of the tags. Can you offer any explanations for this change in appearance?

All of the "used"tags that I am sending to you were recovered with varying amounts of fouling organisms (primarily calcareous algae) growing on the surface and in the stamped letters and numbers. I have cleaned most of this material away using a soft brush.

Please feel free to cut or analyze these tags in any way that you feel is necessary. It is not essential that they be returned in their present condition.

I appreciate your continuing interest in this matter, which is of critical importance to our research of Hawaiian sea turtles.

Sincerely,

George H. Balazs
Assistant Marine Biologist

GHB:lb.

Dear Collegue,

In response to your letter of the 28th of Feb. For ♀ Dermochelys coriacea I use the big tags of which you have on the next page an example. These tags are put directly on the flipper (foot) of the turtle with a special pincer like that for the usual model of metal tags.

For Chelonia mydas and other little species where the skin of the foot is stronger, we can use the smaller model (your example échantillon n° 021 (I don't know what this is)) with a message on the 2nd side like the big tags. To put this tag on Chelonia, you have to make a little hole with a special piece furnished by the maker.

The maker is Chevillot identification etc...

The name of the big tag model is Axaflex C.4 yellow
Unit price 1.72 francs
Price of the automatic pincer is 195 francs

It seems to me that the tags made of plastic cut (injure) the turtles less and are better tolerated physiologically. They are better seen than metal tags are at night and you can read the numbers faster. But, [if they are lost,] it is also more easy for them to make the tissue of the foot die (? necrose) + for the tag to be lost with the metal tags, if the hole in the foot (gets worse or bigger), the marker can still hang on. (Illustrated on

2nd page)

On 2nd page it says:

If the hole gets bigger, with plastic tags, the tag can be lost. It is the inconvenience (drawback) of these markers.

If you'd like to try these tags (axaflex) tell me (let me know) as I am employed (or in assoc. with) the makers Chevillot. It will be necessary to ______ (send?) (~ 500 francs) for the name of the laboratory. Sincerely,

LABORATOIRE des REPTILES et AMPHIBIENS
MUSÉUM NATIONAL d'HISTOIRE NATURELLE

25, Rue Cuvier — 75005 PARIS
336-00-21

JACQUES FRETEY

Paris, le 8 avril 1981

à George H. BALAZS
University of Hawaii at Manoa

Cher Collègue,

En réponse à votre lettre du 28 février.

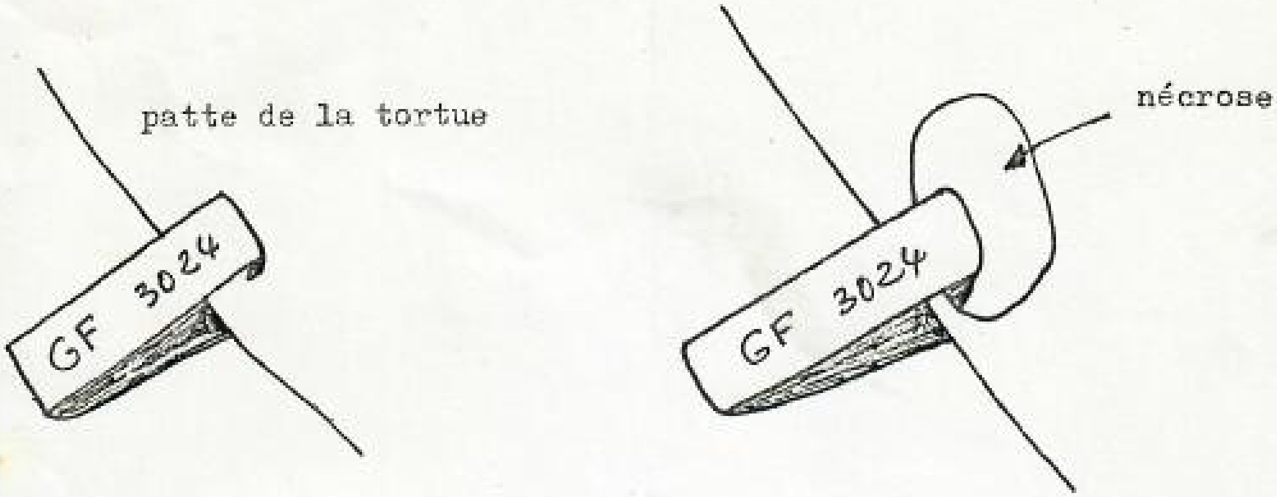
J'utilise pour les femelles Dermochelys coriacea les grandes marques (tags) dont Vous avez ci-joint un exemplaire. Ces marques se mettent directement à la patte de la tortue avec une pince spéciale comme pour les marques métalliques du modèle habituel.

Pour Chelonia mydas et autres petites espèces dont la peau des pattes est plus dure, on peut utiliser le modèle plus petit (voir exemplaire échantillon n° C21) avec un message sur la deuxième face comme les grandes marques. Pour poser cette marque chez Chelonia, il faut faire au préalable un petit trou avec emporte-pièce fourni par le fabricant.

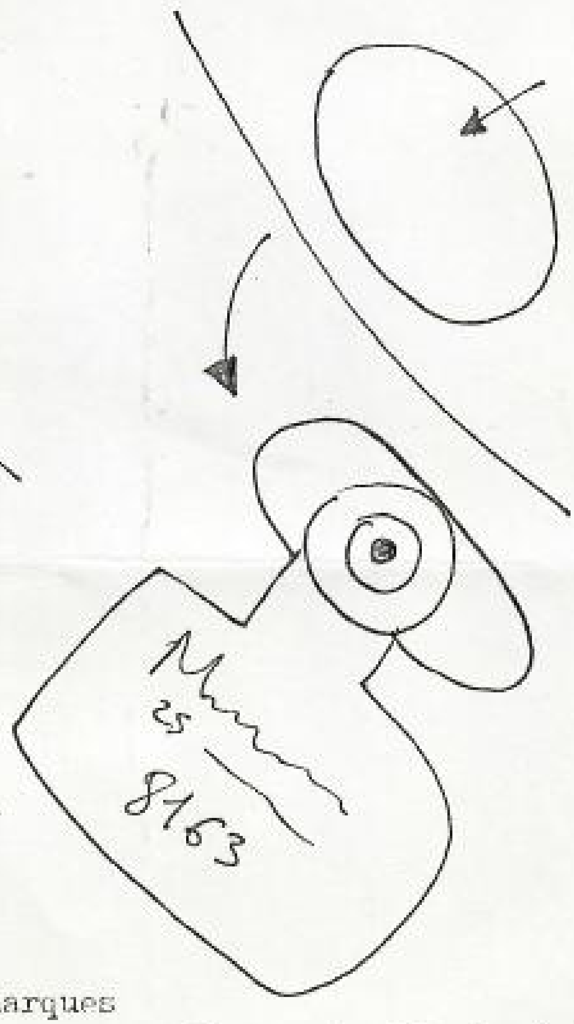
Le fabricant est: CHEVILLOT identification
119, rue Vieille du Temple
75003 Paris FRANCE

Le modèle de grande marque s'appelle: AXAFLEX C.4 jaune
prix à l'unité: 1,72 franc
prix de la pince automatique: 195 francs

Il me semble que ces marques de matière plastique blesse moins les tortues et sont mieux supportées physiologiquement. Elles se voient mieux que les marques métalliques la nuit et le numéro peut se lire plus rapidement. Mais peut-être sont-elles perdues plus facilement aussi par le fait que les tissus de la patte peuvent se nécroser et libérer l'étiquette.



avec les marques métalliques; si le trou dans la patte s'agrandit, la marque peut tenir.



avec les marques plastiques; si le trou s'agrandit, la marque peut partir. C'est l'inconvénient de cette marque.

Si Vous voulez essayer ces marques AXAFLEX, dites-le moi je m'en occuperai avec le fabricant CHEVILLOT. Il faut faire un poinçon (environ 500 francs) pour le nom du laboratoire. Cordialement.

Postscript

Others who have used the Allflex plastic tag with satisfaction are:

James A. Kushlan
South Florida Research Center
Everglades National Park
P.O.Box 279
Homestead, FL 33030

Has applied tags to alligators and crocs through tail scutes and on plastic collars. Haven't calculated tag loss yet. Tags withstand abrasion, but skin sometimes rips.

Jeanette Thomas
Hubbs-Sea World Research Institute
1700 South Shores Road, Mission Bay
San Diego, CA 92109

Has applied 4000 to Weddell seals for 7 years
Not observed corrosion of brass tip.
Tag loss about 3-5% annually, commonly caused by improper application, migration of the whole tag through a tear in the flipper, and freezing of the tag to the ice.
Lettering remains visible although colors may fade.

They may be able to bring you up to date on their experiences with the Allflex tag.

Steve

S.E. Cornelius
RR3, Box 216
Mountain View, MO 65548

31 March 1981

Mr. George H. Balazs
Fishery Biologist
National Marine Fisheries Service
Southwest Fisheries Center
Honolulu Laboratory
P.O. Box 3830
Honolulu, HA 96812

Dear George,

We employed two tag styles in our operation at Ostional and Nancite, Costa Rica during the 1980 season. The metal tag was a standard monel type made by National Band and Tag except that it incorporated the redesigned locking mechanism. That is, the bridge was eliminated and the piercing point locks through a slot in the lower plane. Tom Haas called this design style 4-1005, size 19. The size number designation is somewhat confusing as it is the same size as the #49. In my notes I have the cryptic equation, #49 + #681 = #19. I guess this means when the old size 49 uses the new locking mechanism it becomes #19. We applied approximately 14,000 tags of this style at the two beaches. Tag fouling was initially high until we discovered that that could be eliminated by manually bending the piercing tooth inwards slightly after in was loaded in the applicator. In the end, I believe the fouling rate was approximately 1%.

About 25% of the above marked turtles carried a counter tag made by the Allflex Tag Co. I've enclosed an advertizing flyer which has addresses, phone numbers and price we paid in 1980. I do not believe the price changed this year. We used three colors of this plastic tag, blue, yellow, and orange. We will use only green this year.

Monel tags were always placed on the trailing edge of the right front flipper. The plastic tag was placed primarily on the left front flipper, however a limited number were applied on one or the other rear flippers. Double tagging under arribada conditions is a complex, time consuming operation which requires extra care in application and record keeping. I sincerely hope never to have to do it again! With between 3 and 4 thousand so marked (We haven't received a final printout of the numbers tagged at each beach from the University of Costa Rica computor yet, accounting for the imprecise estimate at this time) I believe we have an adequate sample size to judge the relative staying power, legibility of the printing etc. of the two styles.

At Nancite we recovered 360 turtles tagged earlier in the season. Of these, 308 had been tagged more than 14 days before reobservation. Interestingly, nearly 47% of the latter were double tagged turtles, even though most turtles had been marked with a single monel tag. The large colored plastic countertag is more visible and certainly the reason for the high reobservation rate. Much more time needs to elapse, of course, before an adequate examination of the relative staying power of the two tags can be undertaken.

One obvious advantage of the plastic tag was the very low rate at which it fouled on application. At Nancite, this occurred six times and in all cases, it was due to the tag being incorrectly positioned in the applicator. This resulted in the self-piercing pin forcing the brass cap apart from the male end, rendering it useless. Even when this happeded, the tag was recoverable since all pertinent information is stamped on the unaffected female end. The tag can be reapplied after a new male piece is placed in the applicator.

During 1971, 1972 and 1973, David Hughes and I marked about 4,500 ridleys at Nancite. None were reobserved this past year. Many interpretations of this can be made. One of course, is that after 7-9 years all the monel tags had been lost due to corrosion. In February I visited with A. Carr and was fortuitously present when a tag arrived in the mail that turned out to have been applied by B. Nietschmann at La Boquita, Nicaragua in 1972. The tag (applied to a ridley and recovered on the same beach) was in surprisingly good condition. In fact, it looked absolutely new. I was very impressed and began to wonder whether the absence of 1971-1973 marked ridleys at Nancite in 1980 was due to some other factor. A disturbing alternative would be the Ecuadorean fishery.

I've enclosed a summary of our report of the 1980 field activities. The complete report should be available from J. Woody at the USFWS office in Albuquerque in a couple weeks.

I hope the above information has been useful.

Best regards,

Steve

Stephen E. Cornelius

enclosures (2)

LABORATOIRE des REPTILES et AMPHIBIENS
MUSÉUM NATIONAL d'HISTOIRE NATURELLE

25, Rue Cuvier — 75005 PARIS
336-00-21

Paris, le 8 avril 1981

JACQUES FRETEY

à George H. BALAZS
University of Hawaii at Manoa

Cher Collègue,

En réponse à votre lettre du 28 février.

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Le fabricant est: CHEVILLOT identification
119, rue Vieille du Temple
75003 Paris FRANCE

Le modèle de grande marque s'appelle: AXAFLEX C.4 jaune
prix à l'unité: 1,72 franc
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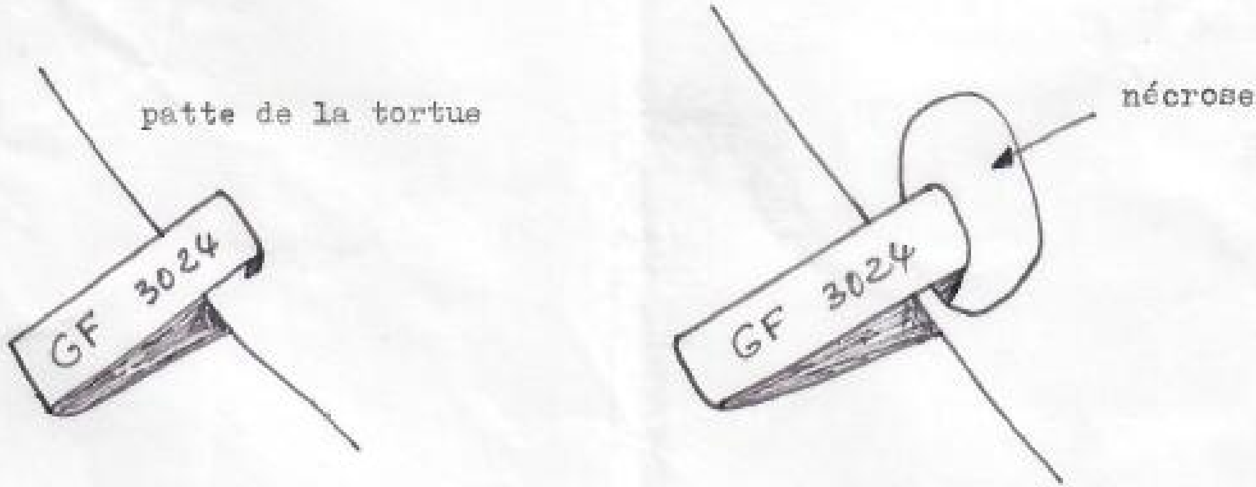
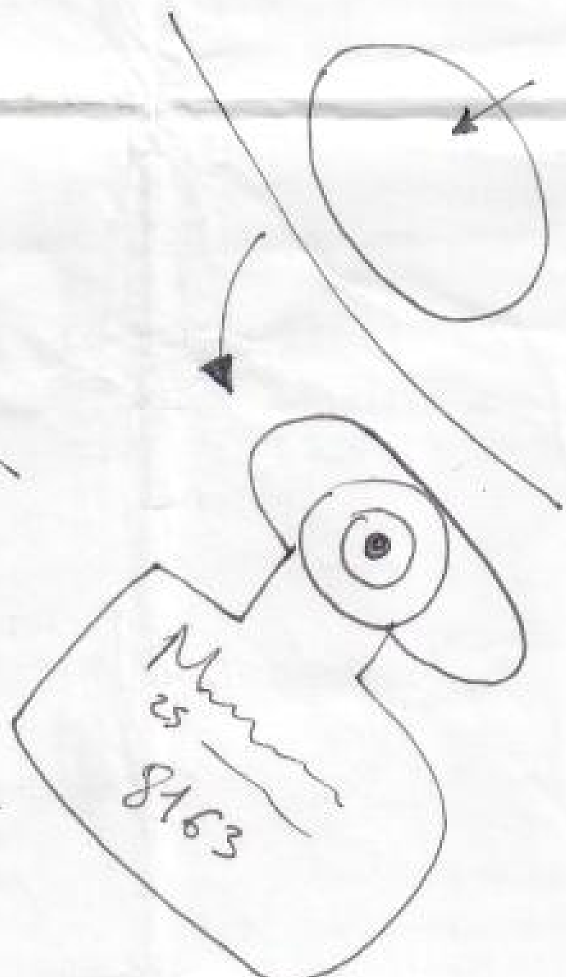


avec les marques métalliques; si le trou dans la patte s'agrandit, la marque peut tenir.



avec les marques plastiques; si le trou s'agrandit, la marque peut partir. C'est l'inconvénient de cette marque.

Si Vous voulez essayer ces marques AXAFLEX, dites-le moi je m'en occuperai avec le fabricant CHEVILLOT. Il faut faire un poinçon (environ 500 francs) pour le nom du laboratoire. Cordiale-

HUNTINGTON ALLOYS
An INCO company

K-2
June 2, 1981

Dr. George H. Balazs
Assistant Marine Biologist
Hawaii Institute of Marine Biology
P. O. Box 1346
Coconut Island
Kaneohe, Hawaii 96744

Dear Dr. Balazs:

I recall the turtle tagging project so very vividly--I suppose because of its unusual character, and the problems you have had with the obliteration of identifications on the MONEL alloy 400 tags due to corrosion. It was this series of record keeping frustrations which prompted me to recommend to Mr. J. Haas of National Band and Tag that he manufacture the turtle tags in INCONEL alloy 625.

It is encouraging to learn that you have recovered several of the INCONEL alloy 625 tags after nearly five years of exposure and that your visual inspection of the tags show no signs of corrosion. While I am sure your assessment of the condition of the tags is correct, we would be very happy to examine the tags and render an opinion on the alloy's performance. To assist in that examination, could you supply the exact thickness of the tags as you received them from the manufacturer.

There will be no charge for the examination we undertake.

Very truly yours,

L. A. Yerkovich

L. A. Yerkovich
Senior Technical Coordinator

LAY/kbz

HUNTINGTON ALLOYS, INC., Huntington, West Virginia 25720

University of Hawaii at Manoa

Hawaii Institute of Marine Biology
P.O.Box 1346 • Coconut Island • Kaneohe, Hawaii 96744
Cable Address: UNIHAW

May 20, 1981

Dr. L.A. Yerkovich
Senior Technical Coordinator
Huntington Alloys, Inc.
Huntington, West Virginia 25720

Dear Dr. Yerkovitch:

Since late 1976 I have been using a tag made of Inconel 625 for marking green sea turtles (Chelonia mydas) throughout the Hawaiian Islands. Prior to that time, my tags were made of Monel 400, the standard alloy still used by most sea turtle researchers around the world. The use of Monel tags on Hawaiian turtles was not satisfactory due to extensive corrosion, sometimes only after a year or two in the wild. Other researchers have also reported corrsion in their Monel tags, but the problem does not appear to be universal.

Several of my Inconel 625 tags have now been recovered from turtles after nearly five years. Visual inspections that I have conducted have not been able to reveal any signs of surface corrosion. However, I am admittedly not an authority on these matters. I would therefore like to ask if you would be willing to look at a few of these tags and render an expert opinion. Perhaps your company undertakes such analyses on a paying basis, and if this is in fact the case I would appreciate being informed of the details.

Thank you for any help that you can provide to this request.

Sincerely,

George H. Balazs
Assistant Marine Biologist

AN EQUAL OPPORTUNITY EMPLOYER

delta plastics ltd
931 Tremaine Avenue, P.O. Box 940, Palmerston North, New Zealand
Telephone 84-136
69-734
71-506
Telegraphic Address 'DELTA'
Telex Delta NZ 3720

Our Ref: JWBW/REH

13th September, 1978.

Hawaii Institute of Marine Biology,
P.O.Box 1346,
Kaneohe,
HAWAII, 96744.

Attention: Mr. George H. Balazs.

Dear Sir,

We have been requested by our Company's Managing Director, Mr. John Burford, to write to you with information and samples of our Allflex Identification Eartags which we understand you require to be used on sea turtles.

Please find enclosed a range of different sizes and colours of tags which will enable you to choose the most suitable combination for your requirements.

Along with the applicator to apply these tags we have also supplied a bottle of our tag marking ink which will enable you to mark the tags yourself if you so wish. We have supplied only black ink for you to experiment with, but you will note from the enclosed brochure that yellow and white ink is also available.

It is hoped that the supplied samples will be of assistance to you. Should you require any further samples for your initial trials please do not hesitate to contact us.

Yours faithfully,

DELTA PLASTICS LTD.

J.B.Wackrow

J.W.B.(Bruce) Wackrow,
Export Manager.

Encl.

UNIVERSITY OF HAWAII REQUISITION

PURCHASE ORDER

DELIVER TO: (INCLUDE DEPARTMENT NAME)
HAWAII INSTITUTE OF MARINE BIOLOGY,
P. O. BOX 1346,
KANEOHE, HI 96744

DATE 1-6-81 NO. 142978

TR CODE | ACCOUNT CODE
21-F-81-237-F-582-B-105

VENDOR
NATIONAL BAND AND TAG CO.,
721 YORK STREET,
NEWPORT, KY 41072

REQ'NER. TEL. NO. 247-6631 | REQUISITION NO. | VENDOR CODE

REQUISITIONER
Balazs/WHITTOW

OTHER VENDORS CONTACTED AND THEIR QUOTATIONS
1. FEARING MANUFACTURING CO. - NOT AVAILABLE .
2. DALTON SUPPLIES LTD. - NOT AVADLABLE.
3. DELTA PLASTICS LTD. - NOT AVAILABLE.
4. HUNTINGTON ALLOYS INC. - NOT AVAILABLE.

DELIVER ON/BEFORE 1-25-81 | DELIVER PREPAID VIA PARCEL POST

F.O.B. POINT IS THE SAME AS DELIVERY POINT UNLESS INDICATED OTHERWISE HEREAFTER

F.O.B.

Contract/Price List/Quotation No. QUOTE ATTACHED | DISCOUNT TERMS

Item No.	QUANTITY	DESCRIPTION—UNIT PRICES ARE E (ESTIMATED) OR F (FIRM)	OBJECT SYMBOL	E/F	UNIT PRICE	AMOUNT
1	5000 (MINIMUM ORDER)	STYLE 1005 MONEL, SIZE 681 INCONEL 625 TAGS. INCLUDES CONSECUTIVE NUMBERS AND STAMPING, "WRITE HIMB UNIVERSITY HAWAII 96744"	3015	F	.56/EA	2,800.00
		DIE ALTERATION CHANGE				120.00
		SHIPPING				31.00
					TOTAL →	2,951.00

JUSTIFICATION FOR PURCHASE AND/OR CHOICE OF VENDOR

TAGS OF THIS STYLE MANUFACTURED FROM THE SPECIAL ALLOY "INCONEL 625" ARETHE ONLY TAGS EVER FOUND TO TOTALY RESIST CORROSION AND CRACKING WHEN AFFIXED TO HAWAIIAN SEA TURTLES. DURABLE AND LONG LASTING TAGS OF THIS NATURE ARE ABSOLUTELY ESSENTIAL TO THE CONDUCTION OF THIS RESEARCH PROJECT. THEY ARE A LINE ITEM IN THE BUDGET.

EQUIPMENT TO BE LOCATED: | OR INCORPORATED INTO EXISTING EQUIPMENT:

BLDG. | RM. | DECAL NO. (OR P.O. NO. IF DECAL NOT ISSUED)

I CERTIFY THAT THIS PURCHASE SUPPORTS THE UNIVERSITY PROGRAM INDICATED IN THE ACCOUNT CODE BLOCK.

G. C. Whittow — G. WHITTOW P.I.
APPROVING AUTHORITY | TYPED NAME | TITLE

I CERTIFY THAT SUFFICIENT FUNDS ARE AVAILABLE IN THIS ACCOUNT FOR THIS PURCHASE.

TELEPHONE NO. 247-6631

[signature] 1-5-81 | F.O. CODE NO. 038
FISCAL OFFICER | DATE

FOR ASSISTANCE IN COMPLETING THIS FORM, PLEASE REFER TO SECTIONS 3410 THRU 3417.1 AND 3420 OF THE PROCUREMENT AND PROPERTY MANAGEMENT VOLUME OF THE BUSINESS MANUAL.

QUOTATION SHEET

National Band & Tag Co., Newport, Ky. - 721 York Street . . Area Code 606
Phone 261-2035

DATE January 2, 1981

Reference Your letter dated December 26, 1980.

University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P.O. Box 1346, Coconut Island
Kaneohe, HI 96744
Attn: George H. Balazs, Asst. Marine Biologist

We Propose to furnish the following subject to the Provisions and Prices Stated Hereon.

On 10 days notice to the buyer, all quotations on contracts are subject to adjustment upon the enactment of any State or Federal legislation imposing a sales tax or limiting hours of labor, or production. In event of such development the buyer reserves the privilege to cancel any unfabricated balance of his contract. All Orders are accepted with the mutual understanding that they are not subject to cancellation after in the process of fabrication—unless we are reimbursed for the material and labor involved. All agreements are contingent upon Strikes, Accidents, Fires or Causes Beyond Our Control.

QUANTITY	DESCRIPTION	PRICE
5000 MINIMUM	Style 1005 Monel size 681 INCONEL 625 tags (@ .56/ea.).. Price includes consecutive numbers. Tags stamped: "WRITE HIMB UNIVERSITY HAWAII 96744"	$2800.00
(1)	Die Alteration Charge	120.00
		$2920.00
	Shipping Charges...........	31.00
	TOTAL........	$2951.00

TERMS Net 30 days.

NUMBERING and STAMPING

PACKING

DELIVERY

REMARKS Due to equipment constraints, this will be the last order we can produce from Inconel material in the forseeable future.

For acceptance within 30 days after which this quotation will be subject to change without notice.

Respectfully submitted,
NATIONAL BAND & TAG CO.,

By Tom V. Haas
Tom V. Haas
MANAGER

TVH:lc/2

QUOTATION SHEET

National Band & Tag Co., Newport, Ky. - 721 York Street . . Area Code 606
Phone 261-2035

DATE January 2, 1981

Reference Your letter dated December 26, 1980.

University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P.O. Box 1346, Coconut Island
Kaneohe, HI 96744
Attn: George H. Balazs, Asst. Marine Biologist

We Propose to furnish the following subject to the Provisions and Prices Stated Hereon.

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Respectfully submitted,
NATIONAL BAND & TAG CO.,

By Tom V. Haas
Tom V. Haas
MANAGER

TVH:lc/2

Manufacturers of IDENTIFICATION TAGS for
AGRICULTURE • HORTICULTURE • BIOLOGICAL AND SCIENTIFIC RESEARCH •
RABIES CONTROL AND ANIMAL LICENSING • ELECTRICAL AND INDUSTRIAL USES
NATIONAL BAND AND TAG COMPANY
Established 1902 • • GENERAL OFFICES: 721 YORK STREET NEWPORT, KENTUCKY 41072, U. S. A. • • Phone: Area (606) 261-2035

G. H. Balazs
992A Awaawaanoa Place
Honolulu, HI 96825

December 29, 1980

"OUR 78th YEAR"

Dear Dr. Balazs:

Receipt is acknowledged with thanks of your letter dated December 20th, and also of your letter dated December 23rd. As you request, we are submitting 3 separate invoices covering the shipment of Inconel tags which we made to you on December 2nd. Enclosed herewith are 2 of the invoices, one for $500.00 and one for $800.00. The invoice for $800.00 has been marked PAID as your account reflected a credit of $800.00.

We are also returning herewith your Invoice copy showing the total amount of the Invoice at $4,250.17. You are correct in your statement that the tags should be numbered 5051 through 12,350, and the tags we shipped to you were numbered through 12,350.

We are holding the final invoice in the amount of $2950.17 until we receive the Purchase Order from the University at which time we will fill in the purchase order number and date and return it to the University at the address you submitted to us.

Thank you.

Yours truly,

NATIONAL BAND AND TAG COMPANY

Tom V. Haas

Tom V. Haas, Manager

TVH:lc/l

THE WORLD'S LARGEST AND OLDEST MANUFACTURERS OF POULTRY BANDS AND LIVESTOCK TAGS
All quotations and orders are entered subject to Federal Regulations, Government Priorities and conditions beyond our control.

CUSTOMERS ORDER NO.	ORDER DATE	TERMS		CLASS	INVOICE/ SHIP. DATE	SHIPMENT	N.B.&T. ORD. NO.
LETTER C	10/30/80		FOB NEWPORT NET 30 DAYS	421	12/03/80	12/03/80	56727

NATIONAL BAND AND TAG CO.

Phone: Area (606) 261-2035
721 YORK ST., NEWPORT, KY. 41072 U.S.A.

94853 GEORGE H. BALAZS

REFER TO THESE NUMBERS WHEN YOU INQUIRE

2

INVOICE COPY
TO ASSURE CREDIT TO YOUR ACCOUNT, PLEASE RETURN THIS COPY WITH YOUR REMITTANCE.

HAWAII AT MANOA, UNIV. OF
HI. INST. OF MARINE BIOL.
BOX 1346-COCONUT ISLAND
KANEOHE HI 96744

SHIPPED TO: UNV. OF HI AT MANOA, GEO. BALAZSA

QUANTITY THIS INVOICE	DESCRIPTION	UNIT PRICE	AMOUNT
7,300	1005-681MONEL TAG INCONEL 625 . NUMBERED: 5051 THRU ~~11,950~~ 12,350 (should be 12,350?) . STAMPING: "WRITE HIMB UNIVERSITY HAWAII 96744" .	553.00 M	4,036.90
1	SETUP CHARGE (DIE ALTERATION CHARGE) . STAMPING: 1//16" TYPE . NUMBERS CENTERED ON FLAT SURFACE OF POINT END, READING LEFT TO RIGHT FROM THE POINT . STAMPING ON FLAT SURFACE OF THE HOLE END READING LEFT TO RIGHT TO HOLE END . SEE F/T 035805 AND SAMPLE ATT. FOR REF. . PLEASE CENTER CONSECUTIVE NUMBERS ON FLAT SURFACE AS BEST POSSIBLE . . .	175.00 E	175.00
	PREPAID FREIGHT		38.27

MANUFACTURERS OF IDENTIFICATION TAGS FOR: AGRICULTURE — HORTICULTURE — BIOLOGICAL AND SCIENTIFIC RESEARCH — RABIES CONTROL AND ANIMAL LICENSING — ELECTRICAL AND INDUSTRIAL USES

PLEASE PAY THIS AMOUNT OR ADVISE IN WRITING: 4,250.17

ON DOMESTIC SHIPMENTS THERE WILL BE A 1½% SERVICE CHARGE (EQUIVALENT TO 18% A YEAR) ON ALL INVOICES WHICH ARE NOT PAID IN FULL BY END OF THE MONTH FOLLOWING MONTH OF PURCHASE.

CUSTOMERS ORDER NO.	ORDER DATE	TERMS		CLASS	INVOICE/ SHIP. DATE	SHIPMENT	N.B. [illegible] NO.
LETTER	10/30/80	FOB NEWPORT NET 30 DAYS		421	12/03/80	12/03/80	56

NATIONAL BAND AND TAG CO.

Phone: Area (606) 261-2035
721 YORK ST., NEWPORT, KY. 41072 U.S.A.

94853 GEORGE H. BALAZS

REFER TO THESE NUMBERS WHEN YOU INQUI

ORIGINAL INVOICE - (COPIES)

THIS IS THE ONLY INVOICE YOU WILL RECIEVE. TO ASSU
CREDIT TO YOUR ACCOUNT:

1. RETURN THE ATTACHED COPY WITH YOUR REMIT
LIST OUR INVOICE NUMBER(S) ON YOUR CHECK.
2. PAY THE COMPLETE AMOUNT INVOICED OR SEND
EXPLANATION OF ANY DEDUCTIONS.
3. PAY FROM THIS INVOICE . . . . NO ST
IS SENT UNLESS ACCOUNT IS PAST DUE.

TH

UNIV. OF HAWAII AT MANOA
HI.INST. OF MARINE BIOL.
BOX 1346-COCONUT ISLAND
KANEOHE, HI 96744

SHIPPED TO: UNV.OF HI. AT MANOA, GEO. BALAZS

QUANTITY THIS INVOICE	DESCRIPTION	UNIT PRICE	AMOUN
1 LOT	1005-681 MONEL TAGS, INCONEL 625 NUMBERED: CONSECUTIVELY STAMPED: "WRITE HIMB UNIVERSITY HAWAII 96744" SETUP CHARGE (DIE ALTERATION CHARGE) (INCLUDED IN ABOVE LOT PRICE). STAMPING: 1/16" TYPE. NUMBERS CENTERED ON FLAT SURFACE OF POINT END, READING LEFT TO RIGHT FROM THE POINT. STAMPING ON FLAT SURFACE OF THE HOLE END READING LEFT TO RIGHT TO HOLE END. PREPAID FREIGHT(INCLUDED IN ABOVE LOT PRICE)	800.00/L	$800.

NATIONAL BAND & TAG CO
Credit on a/c $800.00
THANK YOU –
BY L

MANUFACTURERS OF IDENTIFICATION TAGS FOR: AGRICULTURE — HORTICULTURE — BIOLOGICAL AND SCIENTIFIC RESEARCH — RABIES CONTROL AND ANIMAL LICENSING — ELECTRICAL AND INDUSTRIAL USES

PLEASE PAY THIS AMOUNT OR ADVISE IN WRITING $800.00

ON DOMESTIC SHIPMENTS THERE WILL BE A 1½% **SERVICE CHARGE** (EQUIVALENT TO 18% A YEAR) ON ALL INVOICES WHICH ARE NOT PAID IN FULL BY END OF THE MONTH FOLLOWING MONTH OF PURCHASE.

23 December 1980

Dear Mr. Haas:

Following some discussion with my fiscal officer, I have found that slightly greater difficulties exist with respect to payment than I had originally anticipated. It will now be necessary for me to submit a University Purchase Order for the $2,950.17 prior to recieving the invoice from you for this amount. It is absolutely essential that the date on the invoice be later than the date on my Purchase Order. I would therefore like to ask you to delay sending the invoice for $2,950.17 until I can provide you with a Purchase Order number. This should not take any longer than two weeks.

I am sorry that this problem has come up, but I am sure it can be solved in short order. The invoice for $500 to my home address (see attached) can be sent immediately- hopefully by December 31.

This letter is being sent by air mail special delivery, therefore the original attached letter mailed a few days ago may not have reached you yet.

Sincerely,

George H. Balazs

University of Hawaii at Manoa

Hawaii Institute of Marine Biology
P.O.Box 1346 • Coconut Island • Kaneohe, Hawaii 96744
Cable Address: UNIHAW

December 20, 1980

Mr. J.R. Haas
National Band & Tag Company
721 York Street
Newport, Kentucky 41072

Dear Mr. Haas:

Thank you for your letter of December 8th, which I received yesterday upon my return from field studies at French Frigate Shoals. It was indeed welcome news to learn that my Inconel 625 tags have been manufactured and are now in shipment to Hawaii. I look forward to receiving the order within the next few weeks.

The production of 7300 tags, instead of the originally projected 5000-6000, presents me with some financial problems, but I believe that this can be resolved without causing delay in payment. I should emphasize, however, that I am pleased that you were able to make this larger number of tags. The invoice that I have received (copy attached) lists a total charge of $4,250.17. In place of this invoice, I would like you to prepare and mail three separate invoices. The number of tags and die alteration charge should be divided proportionately to each of the three. The invoices should be prepared for the following amounts:

1. $2,950.17- to G.H. Balazs, Univ. Hawaii at Manoa, Hawaii Institute of Marine Biology, Box 1346, Kaneohe, HI 96744
2. $500.00- to G.H. Balazs, 992A Awaawaanoa Place, Honolulu, HI 96825
3. $800.00- to G.H. Balazs, 992A Awaawaanoa Place, Honolulu, HI 96825 (invoice marked PAID, as the result of $800 check which I sent to National Band & Tag Co. during late 1979)

Once again, I want to sincerely thank you and the other members of your family business for the excellent service and assistance that you have rendered to my research project. I wish all of you a healthy and prosperous New Year.

Sincerely,

George H. Balazs
Assistant Marine Biologist

GHB:lb

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Larry H. Ogren
SEFC, Panama City Laboratory
3500 Delwood Beach Road
Panama City, FL 32407

COPY

January 10, 1980

"OUR 78th YEAR"

Mr. Ogren:

Confirming the telephone conversations you had with my brother, Tom, on January 8th and 9th.

In a recent communication with International Nickel, the use of the Inconel 625 for the turtle tags is unconditionally recommended over use of monel regardless of the thickness (heavier) of the monel. Therefore, we believe it wise to go with the Inconel 625 in an .036" to .038" thickness. Note, we are beefing the thickness up slightly from that mentioned in my 1/2/80 letter to Dr. Balazs. We are going for a first class tag and the heavier stock should make it that much more so.

Tag width would be 11/32", rolled edge flattened wire.

Tag sizes would be those as represented by our sample size 681 and size 49 enclosed. I am not suggesting dimensions for tag sizes, should you choose to include dimensional tag sizes in your specifications, please feel free to do so; we will give unrestricted authorization to use samples in preparation of specifications for obtaining bids, but what we will propose to supply are tags in the sizes per the samples. Quite frequently, when a bid is solicited from us on a particular item such size and design information is not mentioned in the request specifications and in their place it is stated that "samples of each style and size are of record and in file for public inspection at our central purchasing office during working hours".

The tag's closing procedure could also be described or explained in the same fashion with the exception of the small oblong shaped second hole to accommodate the point of the curl.

It would not be possible to accommodate the making of a still smaller tag size (than size 681) for newly hatched turtles utilizing the new die modification equipment.

Should further information be needed, please advise.

Yours truly,
NATIONAL BAND AND TAG COMPANY

J. R. Haas

CC: Dr. Balazs

JRH:lc/3

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University of Hawaii at Manoa
P.O. Box 1346 Coconut Island
Kaneohe, Hawaii 96744

January 8, 1980

"OUR 78th YEAR"

Attn: Dr. George H. Balazs, Deputy Chairman,
IUCN/SSC Marine Turtle Group

Dear Dr. Balazs:

With reference to your December 3rd letter as well as your letter and check of December 27th, I am sure by now you have received the January 2nd correspondence from my brother, Jim.

We are presently trying to reach Mr. Ogren to finalize the possibility of obtaining a grant to be used to purchase a press to manufacture turtle tags. When this is finalized, we will once again contact you as well as the many others now on our list of prospective turtle tag users with more concrete information.

In the meantime, we have deposited the $800.00 check in your account and will hold it for future use.

I hope my brother's letter is self-explanatory to you as he is anxiously awaiting your thoughts on the matter.

As new developments occur, I will be in touch. Thanks for your help.

Yours truly,
NATIONAL BAND AND TAG COMPANY

Tom V. Haas

Tom V. Haas

TVH:lc/2

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January 2, 1980

"OUR 77th YEAR"

University of Hawaii at Manoa
Hawaii Institute of Marine Biology
P.O. Box 1346 Coconut Island
Kaneohe, Hawaii 96744

Attn: George H. Balazs, Deputy Chairman
IUCN/SSC Marine Turtle Group

Dear Dr. Balazs:

I have reviewed recent exchanges of correspondence between you and my brother, Tom, concerning the Inconel 625 tags, your latest letter dated 12/3/79.

I am pleased to learn that the Inconel 625 tags which we supplied to you a few years back have proved to be satisfactory. But, our (NB&T) approach on future Inconel 625 production is conservative.

What we have done is to utilize a product that manufacturing facilities as well as (tag) design were engineered for domestic animals and adapt this same product as well as the manufacturing equipment for other purposes -- and rather extreme purposes at that. I believe logic dictates that continuance in this direction will result in problems in the areas of production and product failures, deliveries, etc. We run these risks at the expense of the research work involved, -- lost data, time and no doubt hundreds of thousands of dollars in preparation, etc., all because we won't take the time or go to the expense of designing a proper tag and building the equipment to make that tag.

The research work is important, funds should be available to support engineering and making the needed equipment and designing the tag.

On several occasions in the past year, we have conversed with Mr. Larry Ogren, SEFC Panama City Laboratory, Panama City, Florida along these lines and if we are reading Mr. Ogren correctly, he is in agreement.

We would propose a tag designed along the lines of the enclosed sketch, basically utilizing the same closing procedure now incorporated into our size 681 tag with the exception that there be a small oblong shape second hole to accommodate admitting the point of the curl; (hole) as shown in the sketch, top view, thus eliminating the possibility of tag snagging.

January 2, 1980

Univ. of Hawaii at Manoa
Attn: George H. Balazs
Kaneohe, Hawaii

To relieve the hassle and expense of material procurement, we should standardize tag width to 11/32". By so doing, we can use one material to manufacture both size 49 and size 681 tags simply by making modifications and adjustments in the dies made practicable with the new equipment. It is our belief that these tags manufactured from a heavier .050" Monel material would perform just as well as tags made from the Inconel 625 in lighter .030" to .035" thickness. The advantage of monel would be availability and cost. Monel cost at about $6.00 per pound while Inconel 625 is about $14.00 per pound. At this point, material is incidental but once the material is decided upon, no change could be made as the dies and equipment would be engineered accordingly. Monel tags in .050" thickness we would project cost at $100.00 to $200.00 per thousand; -- Inconel 625 tags in a material thickness of say .033" would cost at least double. We would estimate the equipment and die modification expense to be in the area of $15,000.00.

After the initial production run of each tag size, orders for anywhere from a few hundred to several thousand tags could be manufactured and shipped on relatively short notice.

In our conversations with Mr. Ogren, we understand the funding is available for such a project, but competitive bidding would be a necessity, -- therein lies the problem -- how to write specifications for intelligent, accurate bidding, assuring the desired end results.

Mr. Ogren is presently on a turtle tagging work trip and we have a call in for him upon his return. We will keep you informed, but in the meanwhile, please let me have your thoughts on the subject.

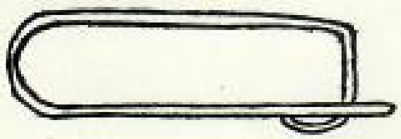
Sincerely,

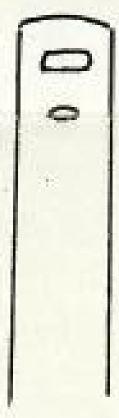
NATIONAL BAND AND TAG COMPANY

J. R. Haas

JRH:lc/3

CC: Larry Ogren
SEFC Panama City Laboratory
Panama City, FL





NATIONAL BAND & TAG COMPANY
721 YORK STREET
NEWPORT, KENTUCKY 41072