EXPERIMENTS IN THE WESTERN ATLANTIC NORTHEAST DISTANT WATERS TO EVALUATE SEA TURTLE MITIGATION MEASURES IN THE PELAGIC LONGLINE FISHERY

REPORT ON EXPERIMENTS CONDUCTED IN 2001-2003

February 4, 2004

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National Oceanic and Atmospheric Administration
NOAA Fisheries

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2003 Western Atlantic Pelagic Longline Sea Turtle Mitigation Research Report
Executive Summary

Five potential mitigation techniques were evaluated during 539 research sets in 2003. Data were collected to evaluate the effectiveness of the mitigation measures and to investigate variables that effect sea turtle interaction rates with pelagic longline gear. The results of 2003 research confirmed 2002 research results that found 18/0 circle hooks with both mackerel and squid bait significantly reduce both loggerhead and leatherback sea turtle interactions when compared with industry standard J hooks and squid bait. Also, circle hooks significantly reduced the rate of hook ingestion by the loggerheads, reducing the post-hooking mortality associated with the interactions. 2003 research found that 20/0 circle hooks were also effective in reducing both loggerhead and leatherback interactions but did not increase swordfish catch rates over 18/0 circle hooks. Mackerel bait was found to be more efficient for swordfish than squid bait but the increase in swordfish catch with mackerel bait only occurred in waters cooler than 64° F. Circle hooks with squid bait were more efficient for tuna than J hooks, but mackerel bait was less efficient for tuna than squid bait.
(Reports available online at http://www.mslabs.noaa.gov/mslabs/docs/pubs.html)

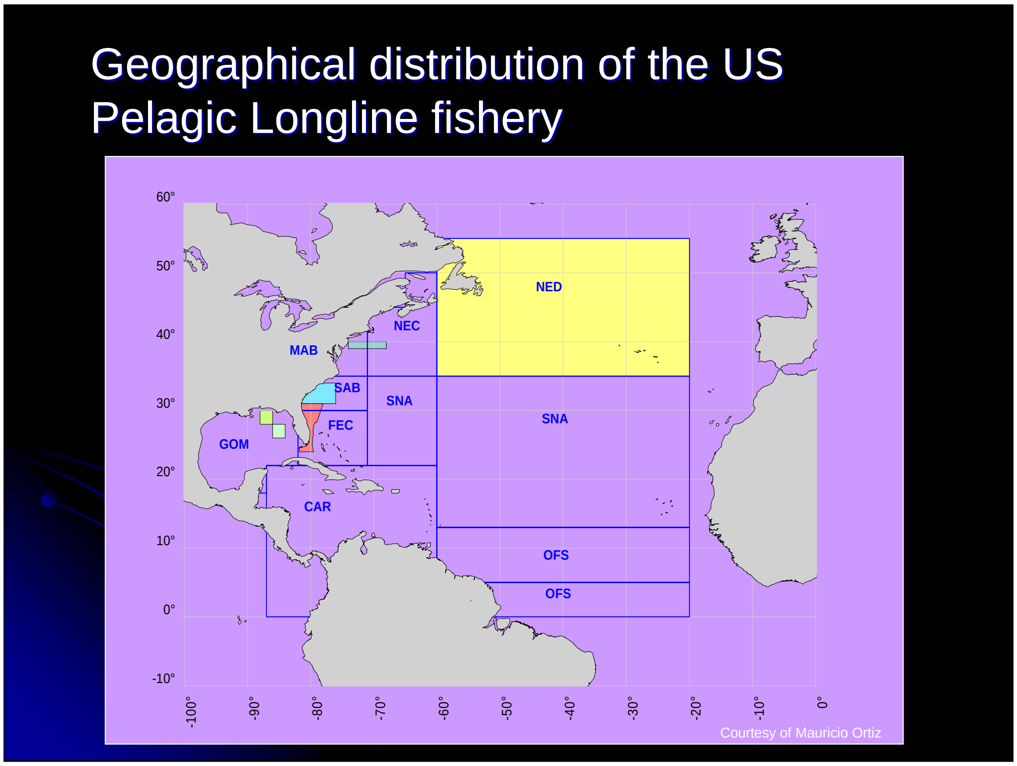
Permit #1429 Sea Turtle Takes Feb. 4, 2004

Year	# individuals	species	population	life stage	sex	origin	take activity category	125 KHz PIT tag	Inconel flipper tag	other tag	Biopsy sample	location	Details capture is by longlines unless otherwis
2003	65	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	yes	no	yes	Grand Banks, N. Atlantic	
2003	1	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	yes	no	no	Grand Banks, N. Atlantic	
2003	6	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	no	yes	no	yes	Grand Banks, N. Atlantic	
2003	3	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	no	no	yes	Grand Banks, N. Atlantic	
2003	3	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	no	no	no	yes	Grand Banks, N. Atlantic	
2003	10	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	yes	yes	yes	Grand Banks, N. Atlantic	4 PAT and 6 SAT tags
2003	10	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	yes	yes	yes	Grand Banks, N. Atlantic	Dipnet control, 10 PAT tags
2003	4	*Caretta caretta*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	yes	no	yes	Grand Banks, N. Atlantic	Dipnet control, no PAT tags
2003	4	*Caretta caretta*	unknown	juvenile	unknown	wild	capture, handle, release	no	no	no	no	Grand Banks, N. Atlantic	
2003	56	*Dermochelys coriacea*	unknown	unknown	unknown	wild	capture, handle, release	no	no	no	yes	Grand Banks, N. Atlantic	
2003	5	*Dermochelys coriacea*	unknown	unknown	unknown	wild	Capture, handle, measure, release	yes	yes	no	yes	Grand Banks, N. Atlantic	
2003	13	*Dermochelys coriacea*	unknown	unknown	unknown	wild	capture, handle, release	no	no	no	no	Grand Banks, N. Atlantic	
2003	5	*Dermochelys coriacea*	unknown	unknown	unknown	wild	capture, handle, release	no	no	no	unsuccessful	Grand Banks, N. Atlantic	
2003	1	*Lepidochelys olivacea*	unknown	unknown	unknown	wild	Capture, handle, measure, release	yes	yes	no	yes	Grand Banks, N. Atlantic	
2003	1	*Lepidochelys kempii*	unknown	juvenile	unknown	wild	Capture, handle, measure, release	yes	yes	no	yes	Grand Banks, N. Atlantic	dipnet

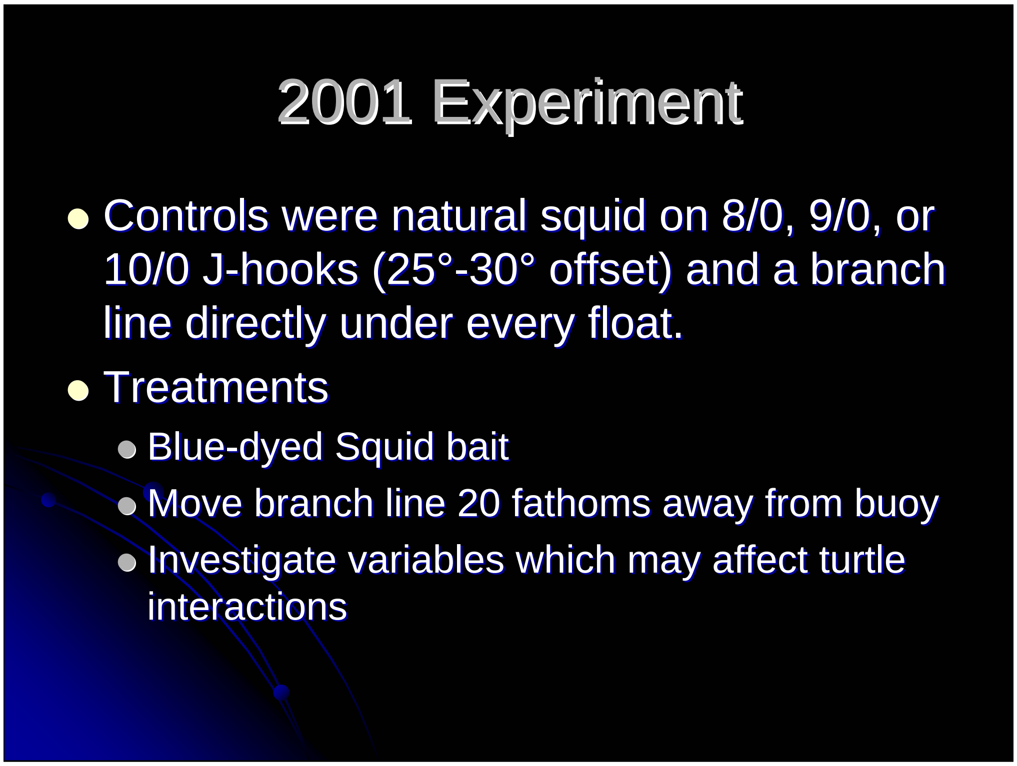
Permit # 1429 Marine Mammal & Sea Bird Takes Feb. 4, 2004

AREA	SPECIES	.IFE STAGI	SEX	ORIGIN	COUNT	TAKE ACTIVITY CATEGORY	DATE	DETAILS
NED	Risso's Dolphin	unknown	unknown	unknown	4	capture, released alive	Aug-Oct, 2003	estimated measurement, no biopsy taken
NED	Risso's Dolphin	unknown	unknown	unknown	1	capture, released dead	Sept., 2003	estimated measurement, no biopsy taken
NED	Striped Dolphin	unknown	unknown	unknown	1	capture, released alive	Aug., 2003	estimated measurement, no biopsy taken
NED	Unidentified baleen whale	unknown	unknown	unknown	1	capture, released alive	Sept., 2003	estimated measurement, no biopsy taken
NED	sea bird	juvenile	unknown	unknown	1	capture, released dead	Sept. 2003	estimated measurement, no biopsy taken

NOAA Fisheries in cooperation with the Blue Water Fishermen's Association conducted research in the Western Atlantic Ocean to develop and evaluate fishing gear modifications and tactics to reduce the incidental capture of endangered and threatened sea turtle species by pelagic longline fishing gears. A three year project was initiated in 2001 and was completed in 2003. The following presentation is a summary of the results of this research.

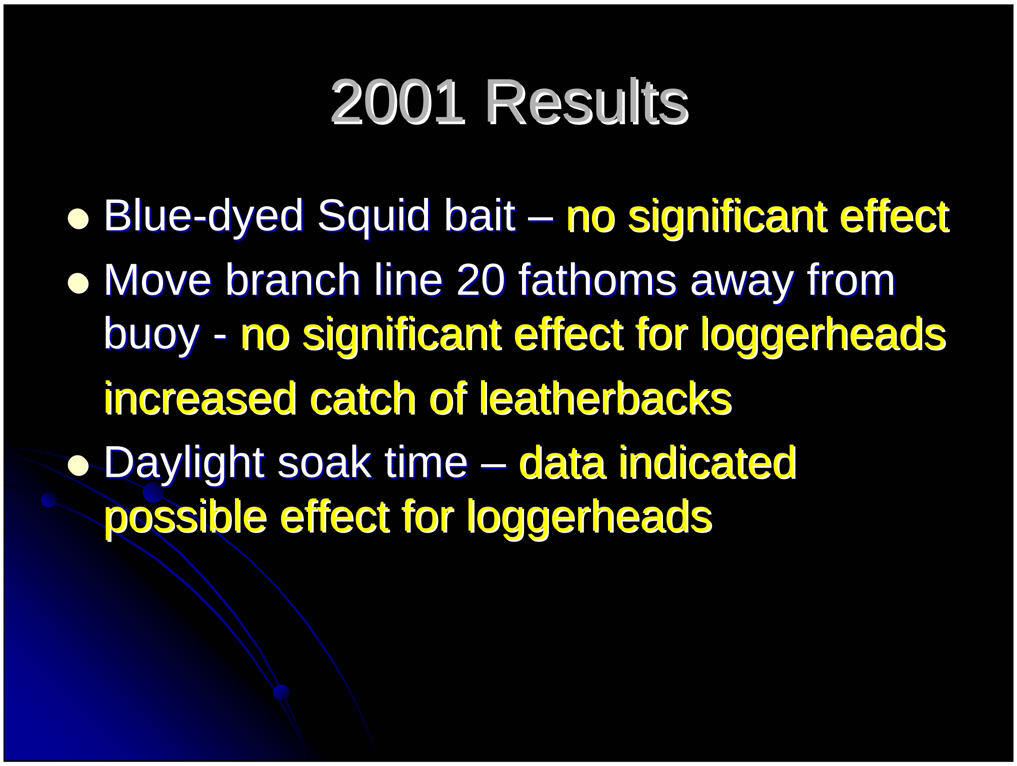


The area of operation was the Northeast Distant Waters (NED) statistical reporting zone in the Western Atlantic Ocean. The NED area is closed to pelagic longline fishing by U.S. flag vessels by regulation with the exception of the experimental fishery.

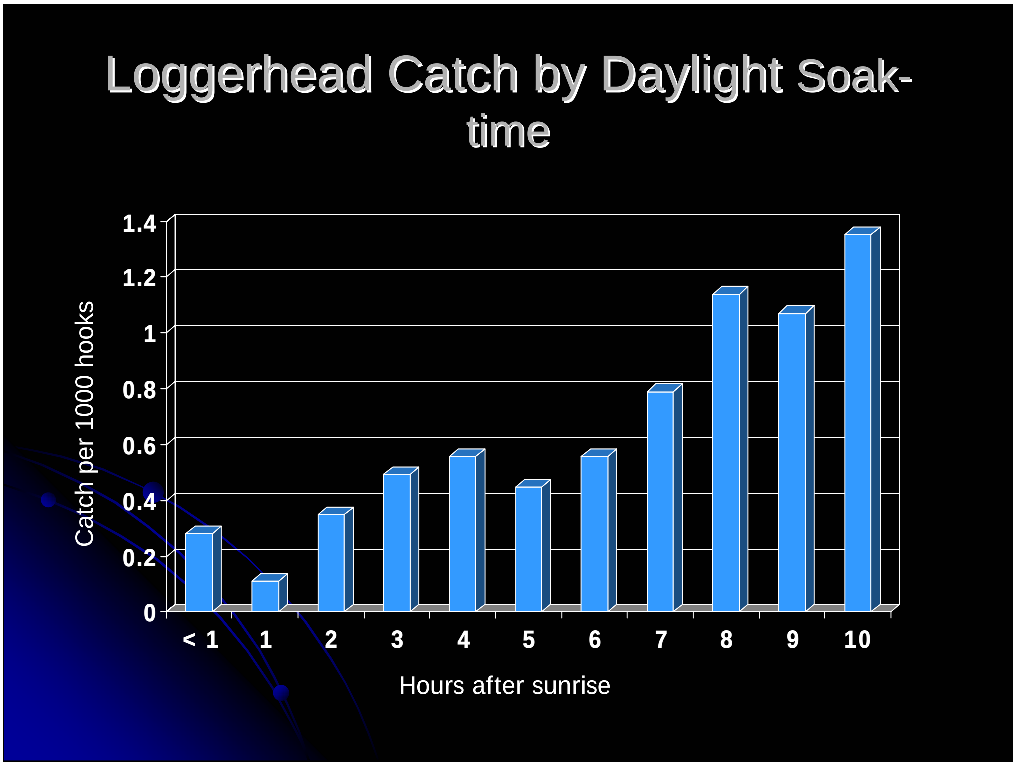


In 2001 the research experimental design was to test the effect of moving hooks that are normally deployed very near floats to 20 fathoms away from floats as historical data indicates a higher turtle take proportion on the hooks nearest floats. The design also tested the effect of using blue dyed squid rather than the standard squid as bait. Data on eighteen other variables were also collected to determine their effect on turtle capture rates.

In 2001 eight commercial pelagic longline vessels made 186 sets fishing 164,429 hooks.



Analysis of the data collected in 2001 indicated that there was no significant effect of blue dyed squid on turtle capture rates and that there was an increase capture rate for leatherback turtles on the hooks placed 20 fathoms from floats. A general linear model indicated that daylight hook soak time (the amount of time the hooks are in the water during daylight hours) was the only variable which effected loggerhead turtle capture rates, but there was no effect of daylight soak time for leatherback turtle captures.

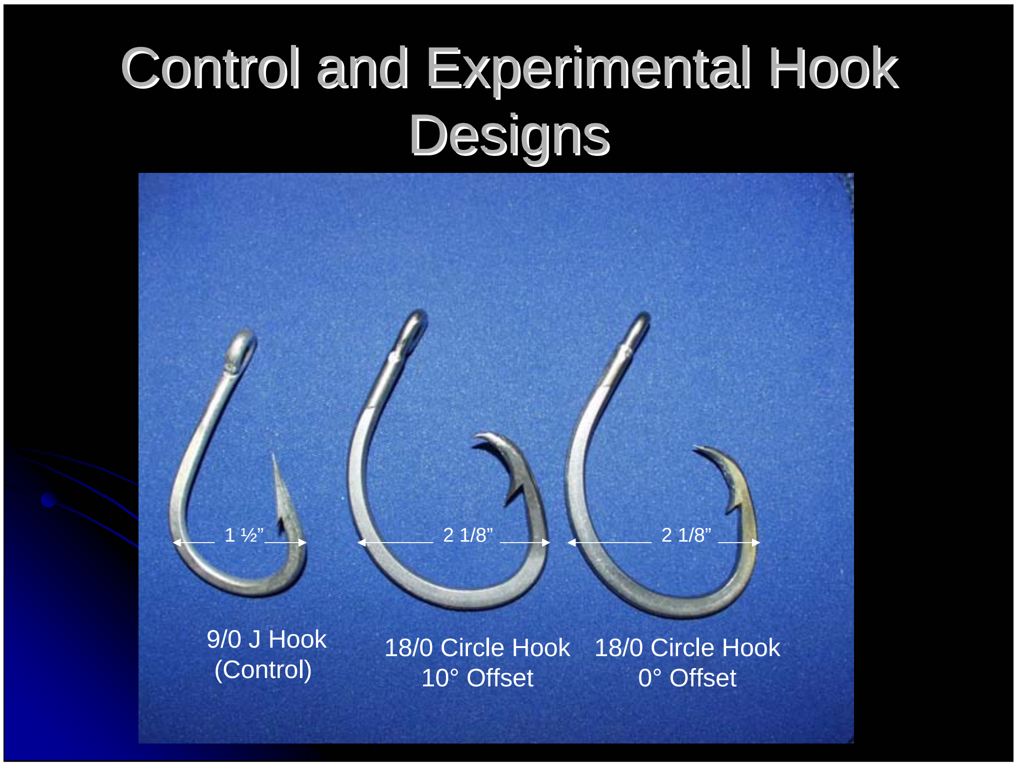


Loggerhead cpue increases with increased daylight hook soak time indicating that loggerhead interaction with longline gear in the NED is a daytime interaction.

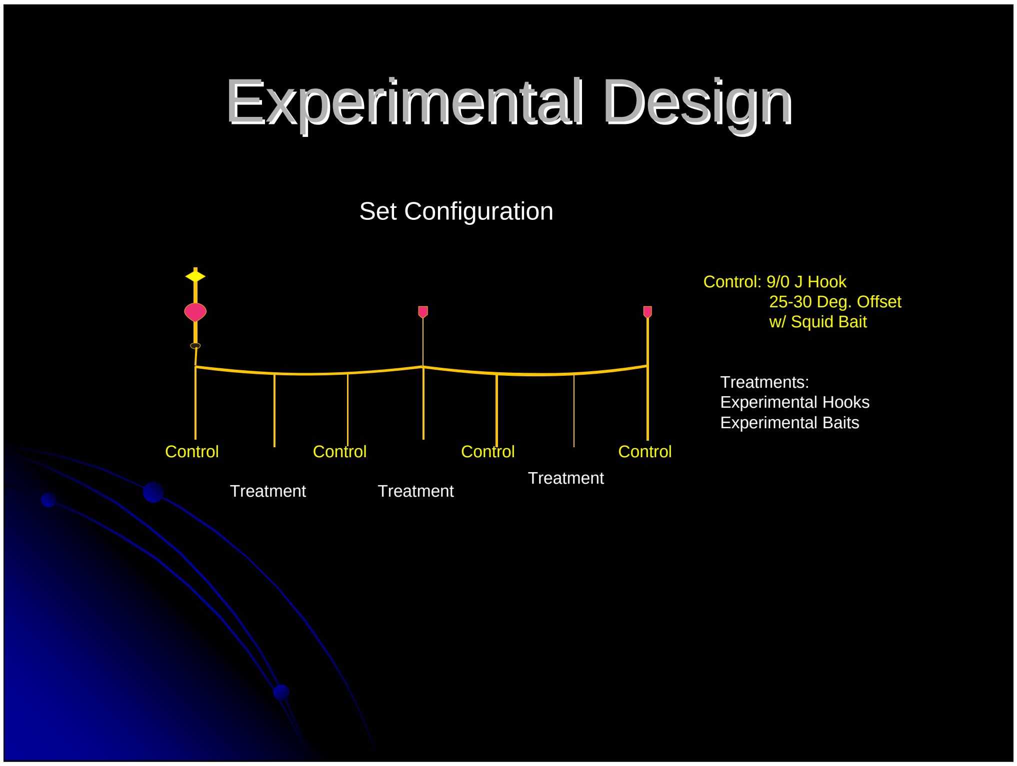
2002 Experiments

- Controls were natural squid on 25°-30° offset 9/0 J-hooks.
- Treatments
  - Reduce daylight hook soak time
  - 0° offset 18/0 circle hooks
  - 10° offset 18/0 circle hooks
  - Mackerel bait

In 2002 the experimental design evaluated the effect of reducing daylight hook soak time, the use of 18/0 circle hooks both offset and non offset with squid bait, and the use of mackerel bait on both J hooks (control) and 18/0 circle hooks in reducing sea turtle interactions with pelagic longline gear.

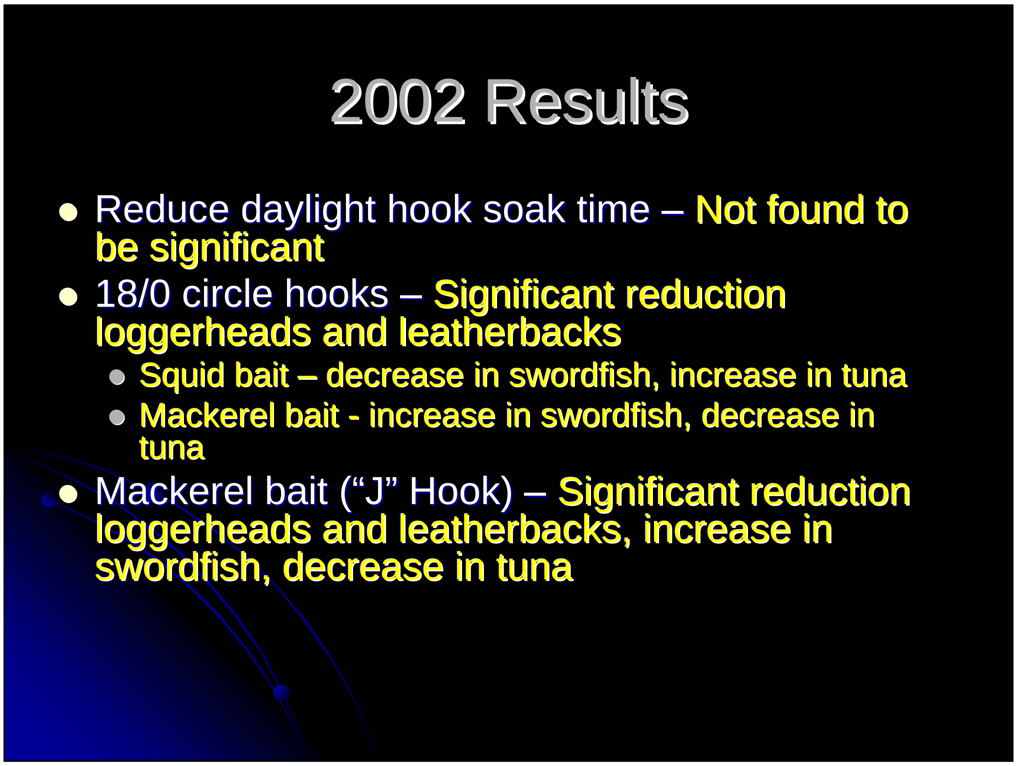


The control hook used in the experiments was the standard 9/0 J type typically used in this fishery with an offset of 25-30 degrees. The experimental hook was an 18/0 circle hook specially designed by the fishers and a fishing gear manufacturer for this experiment. The 18/0 circle hooks were tested with no offset and a 10 degree offset. The 18/0 size circle hook was chosen because research in the Azores by the University of Florida has shown significantly less deep ingestion of hooks by turtles with 16/0 circle hooks and feeding behavior studies by NOAA Fisheries indicates that loggerhead turtles of the size encountered by the pelagic longline fishery have difficulty swallowing objects larger than 2 inches in diameter.

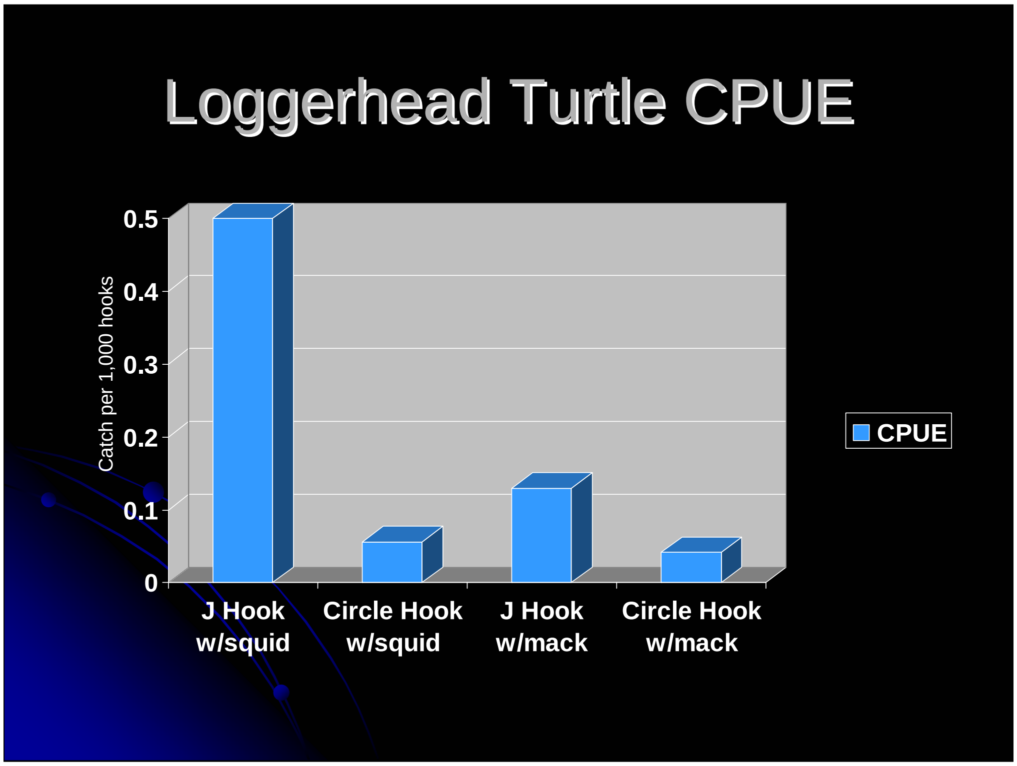


The experimental design was to evaluate the treatment hooks and baits using a randomized block design alternating control hooks and experimental hooks and bait along the entire set. Bait types (ie squid or mackerel) were not mixed on a set.

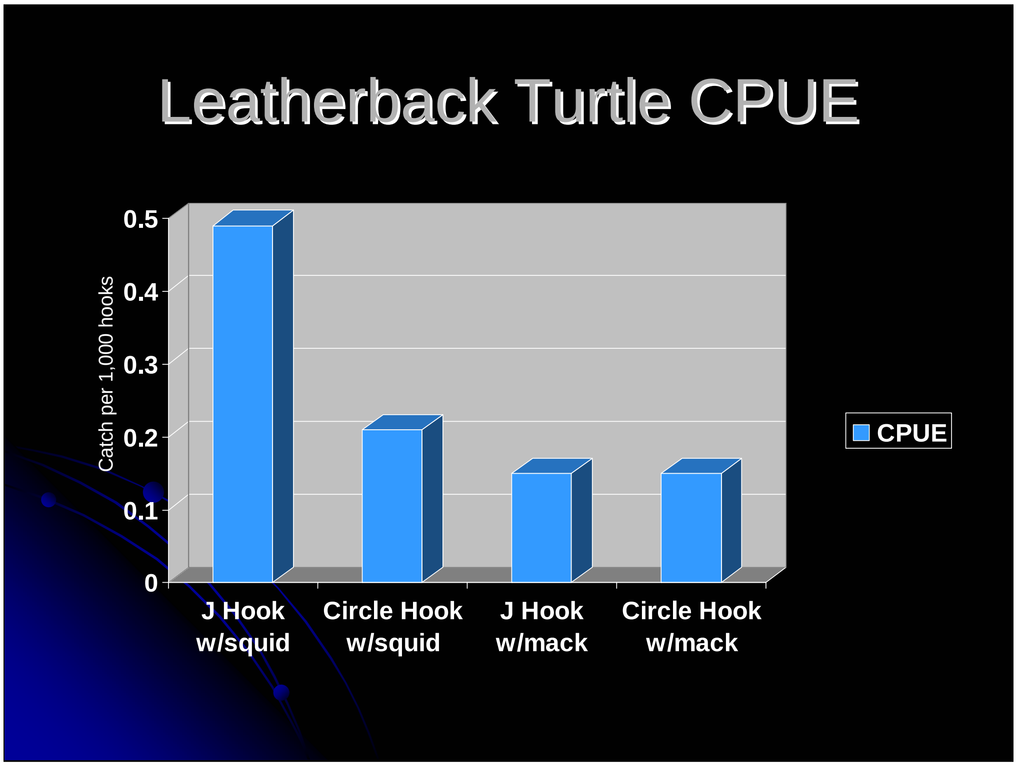
In 2002 thirteen commercial pelagic longline vessels made 489 research sets fishing 427,38 hooks.



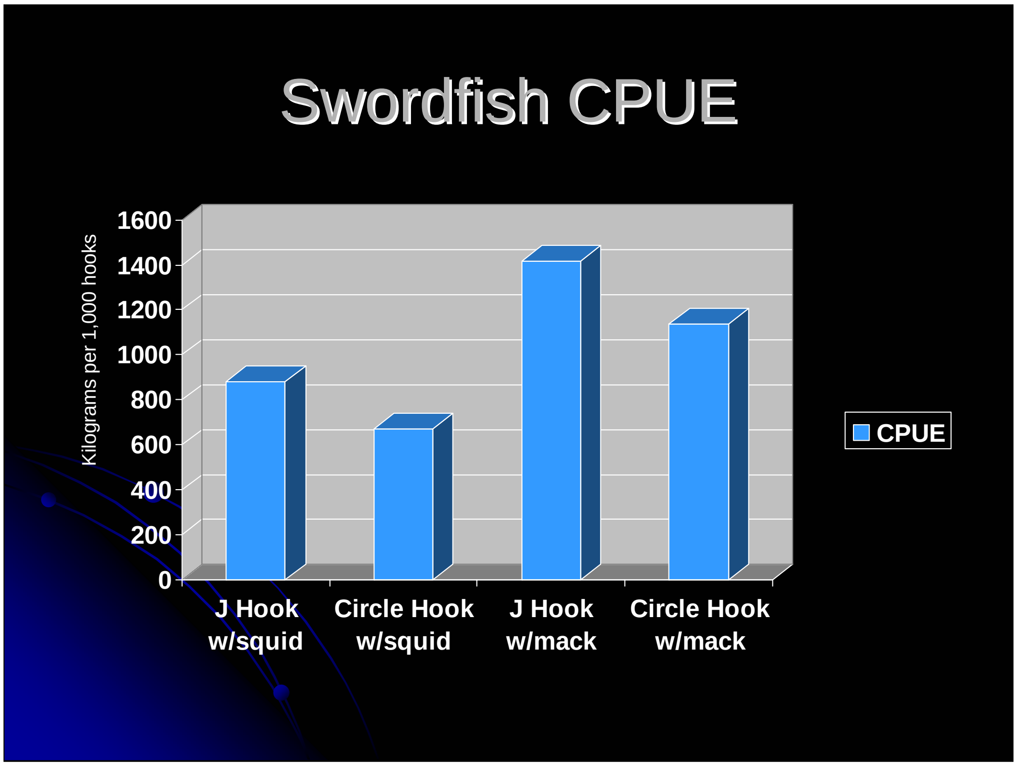
Logistic regression models indicated that daylight soak time was not a significant variable in determining turtle interactions with longline gear. 18/0 circle hooks were found to significantly reduce both loggerhead and leatherback interactions when compared to J hooks. 18/0 circle hooks with squid bait reduced swordfish catch, but increased tuna catch. 18/0 circle hooks with mackerel bait had the highest reduction in loggerhead turtle interactions and increased swordfish catch, but decreased tuna catch. J hooks with mackerel bait significantly reduced both loggerhead and leatherback interactions, increased swordfish catch, and reduced tuna catch.



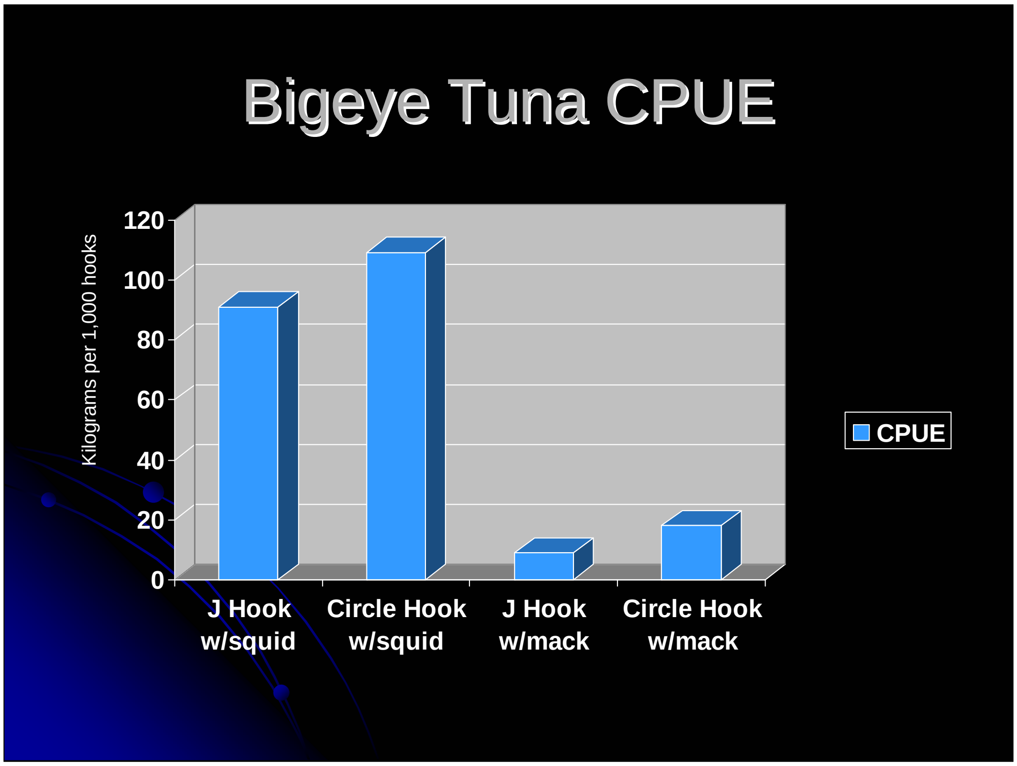
Circle hooks with squid bait reduced loggerhead catch by 86% (CI= 73%-93% p<0.0001), mackerel bait with “J” hooks reduced loggerhead catch by 71% (CI = 42%-86%, p=0.0005), and circle hooks with mackerel bait reduced loggerhead catch by 90% (CI= 70%-97%, p<0.0001).



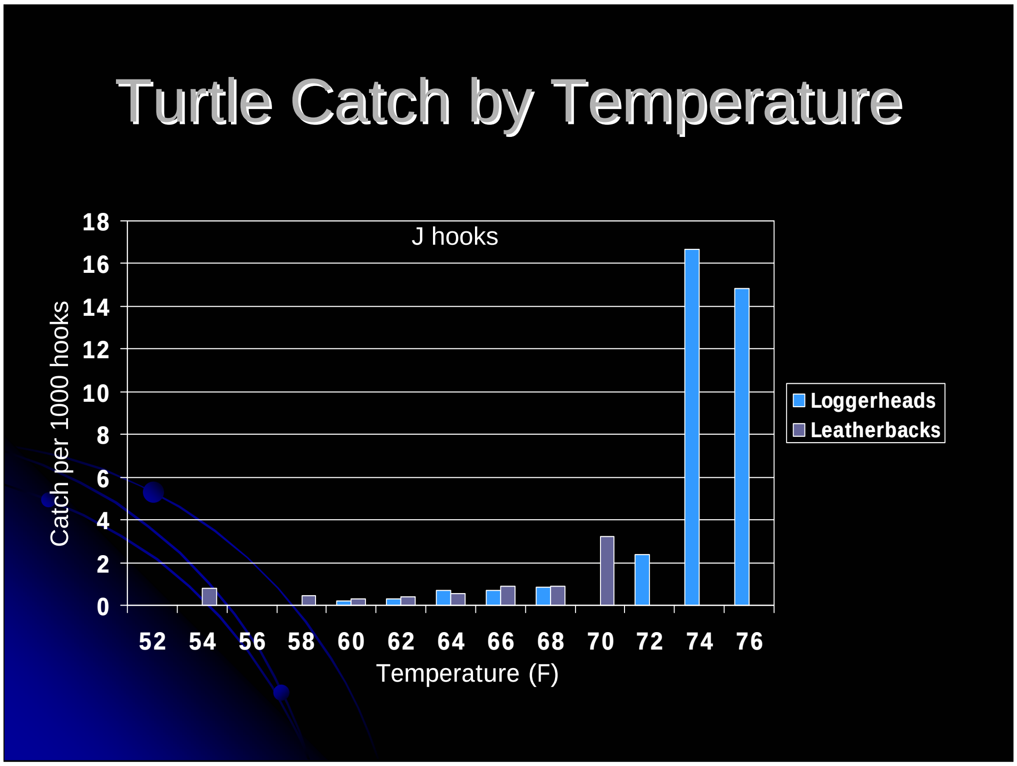
Circle hooks with squid bait reduced leatherback catch by 57% (CI=34%-72%,P<0.0001), “J” hooks with mackerel bait reduced leatherback catch by 66% (CI=37%-81%, p = 0.0006), and circle hooks with mackerel bait reduced leatherback catch by 65% (CI=36%-81%, p=0.0006).



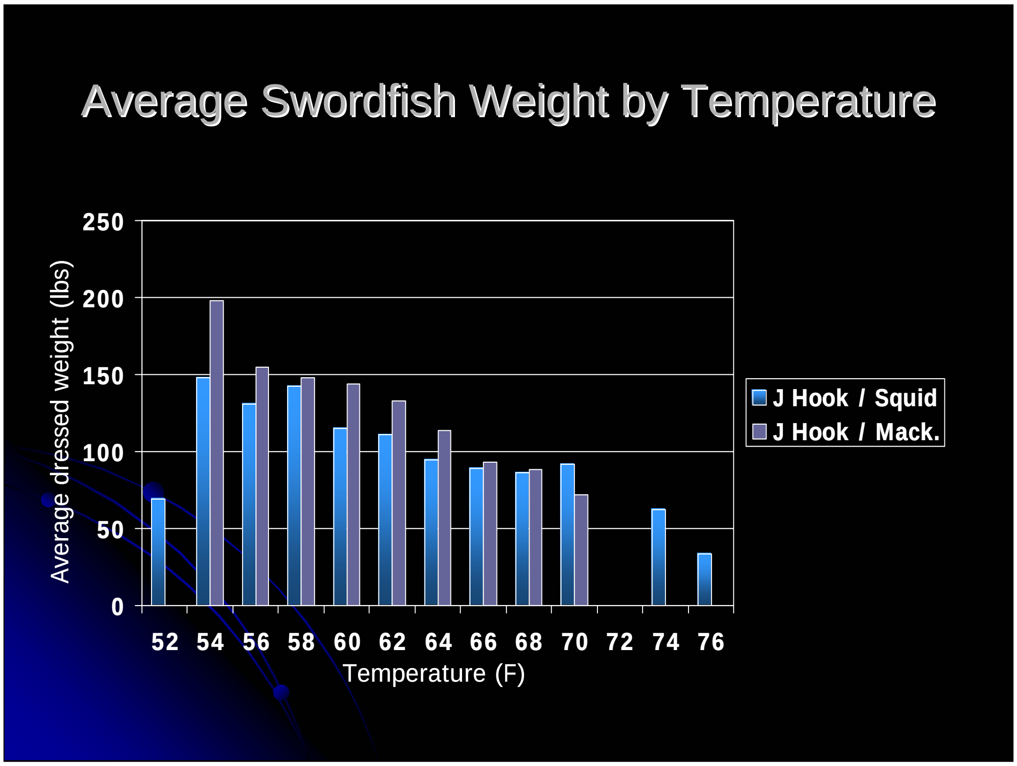
Circle hooks with squid bait reduced swordfish catch by 29% (10° offset) and 33% (non offset) (CI=14%-44%, p=0.0002 and 19%-46%, p<0.0001), “J” hooks with mackerel bait increased swordfish catch by 63% (CI= 46-81%, p<0.0001), and circle hooks with mackerel bait increased swordfish catch by 30% (CI = 14%-46%, p =0.0002).



Circle hooks with squid bait had a nominal increase in tuna catch of 26%. Mackerel bait reduced tuna catch by 81% (CI = 49% - 100%, $p<0.0001$) on circle hooks and 90%, CI = 58%-100%, $p<0.0001$) on “J” hooks.



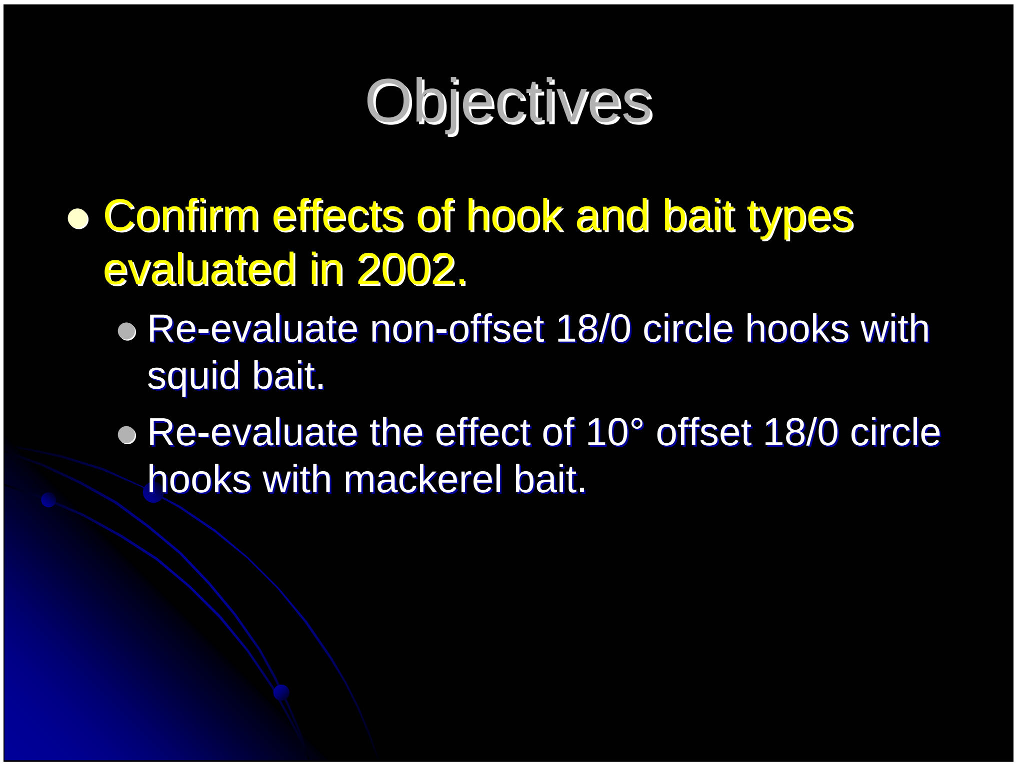
Both loggerhead and leatherback turtle catch rates varied with the surface water temperature. There was a dramatic increase in loggerhead catch rates for water temperature over 72 degrees (F). There was also an increase in leatherback turtle catch rates for water temperatures over 68 degrees (F). This data indicates that turtle interaction rates can be reduced by fishing in cooler water temperatures.



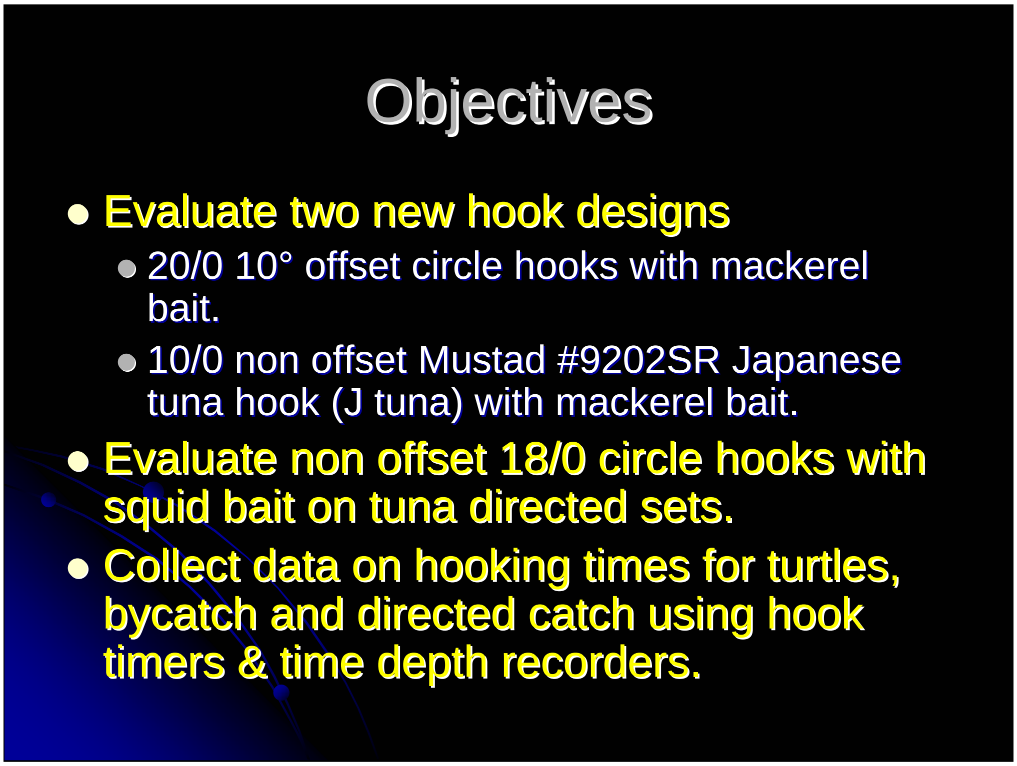
The effect of surface water temperatures was the reverse for swordfish catch by weight. The average dressed weight increased with cooler water temperatures (below 68 degrees (F).

This data indicates that a fishing water temperatures below 68 degrees (F) can significantly reduce loggerhead turtle interactions while increasing target catch rates.

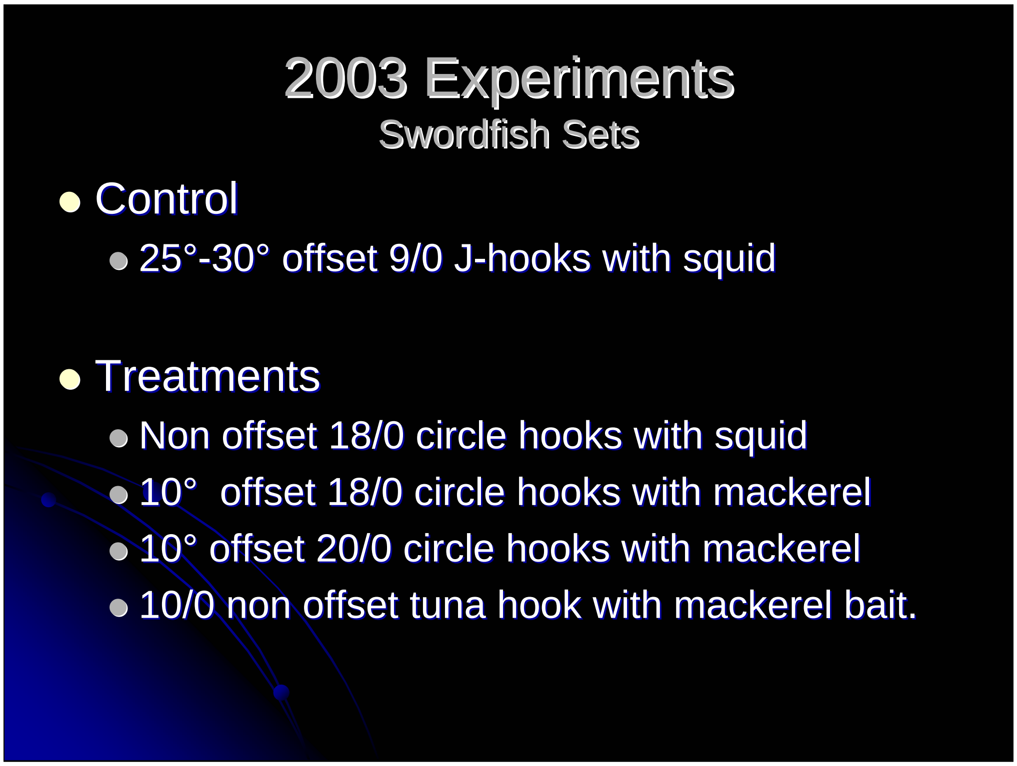
The longline sea turtle mitigation research project was completed in November 2003. The following slides present the preliminary results of analysis of the data collected in 2003.



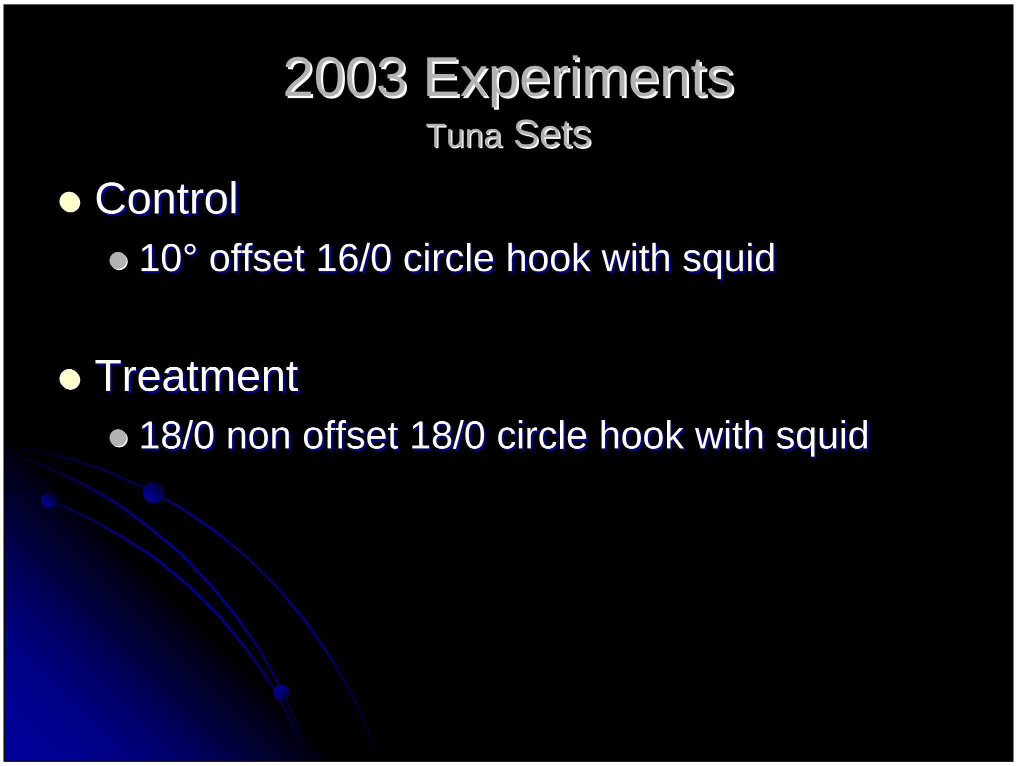
The objectives of the 2003 research were to duplicate the 2002 experiments with the 18/0 non-offset circle hooks with squid bait and the 18/0 10° offset circle hook with mackerel bait to collect additional data over two fishing seasons.



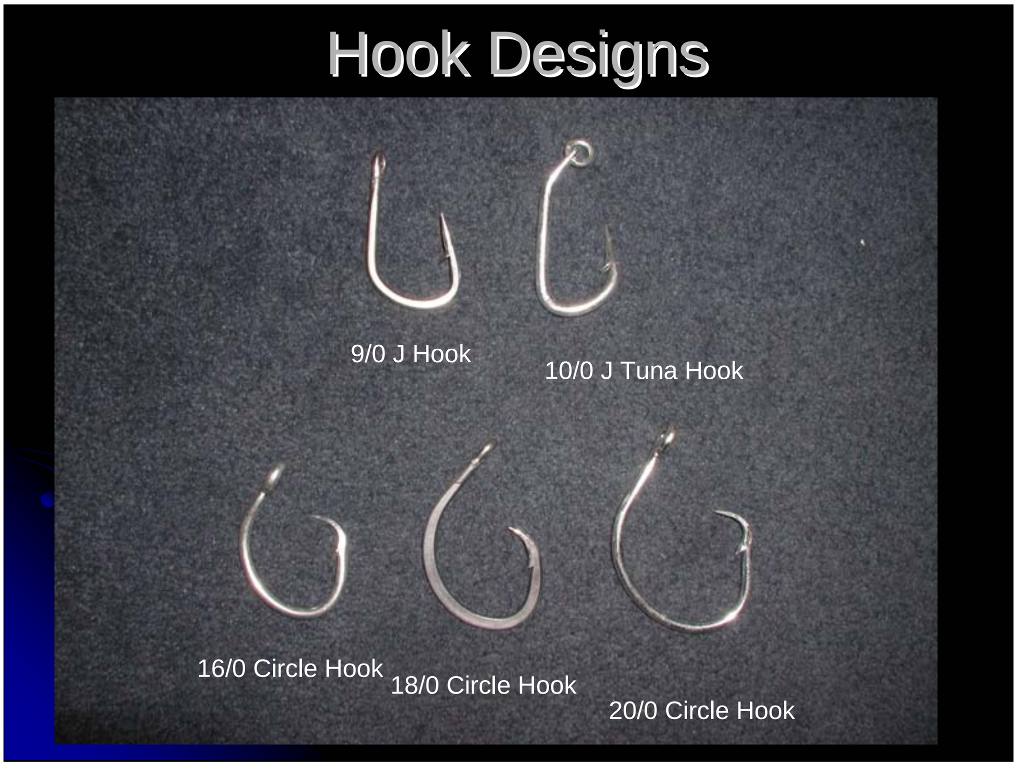
The experimental design also included evaluation of two additional hook designs. These designs included a 20/0 10° offset circle hook with mackerel bait and an 11/0 modified "J" hook. The modified "J" could not be obtained in time for the experiments and a 10/0 non offset Japanese tuna hook was substituted for the 11/0 modified "J" hook. Evaluation of the Japanese tuna hooks was terminated early in order to maximize the sample size on the other treatments and there was insufficient data collected to evaluate the effectiveness of this hook design. Preliminary evaluations were also conducted on the efficiency of 18/0 non offset circle hooks with squid bait on tuna directed sets, but the sample size collected is too small to determine the effectiveness of the 18/0 circle hook for tuna. Data was also collected on hooking times for target and bycatch species using hook timers and time depth recorders.



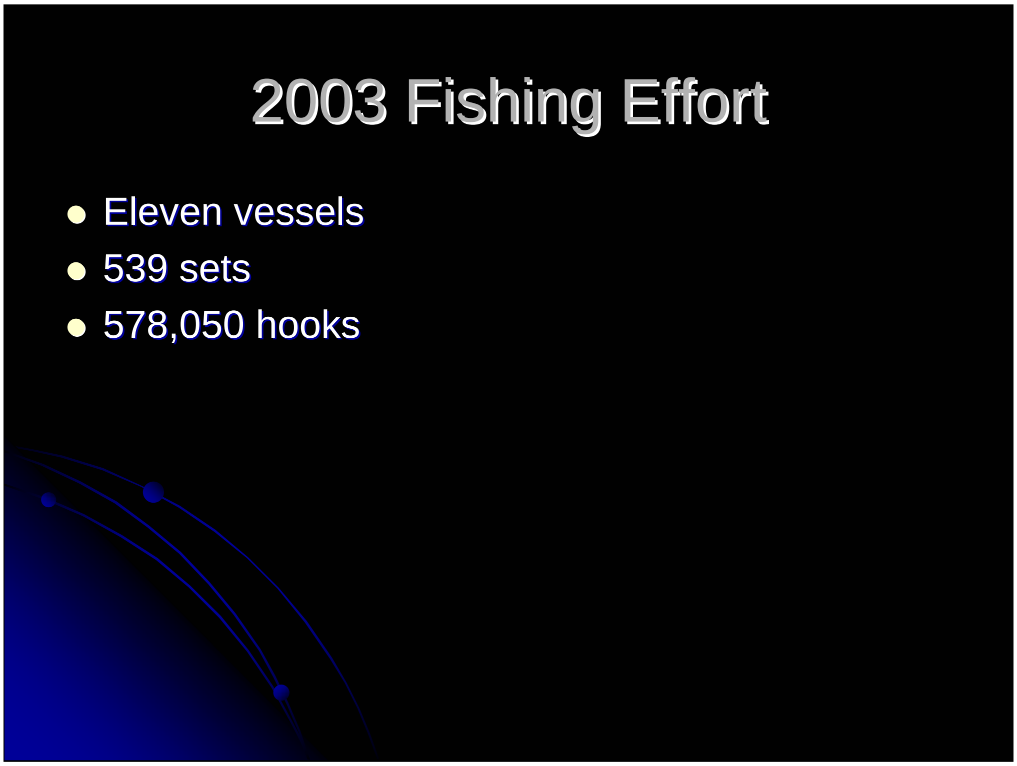
The control hook was a 25° - 30° offset "J" hook and the control bait was squid. Treatments were non offset 18/0 circle hook with squid bait, 10° offset 18/0 circle hook with mackerel bait, 10° offset 20/0 circle hook with mackerel bait, and non offset 10/0 Japanese tuna hook with mackerel bait.



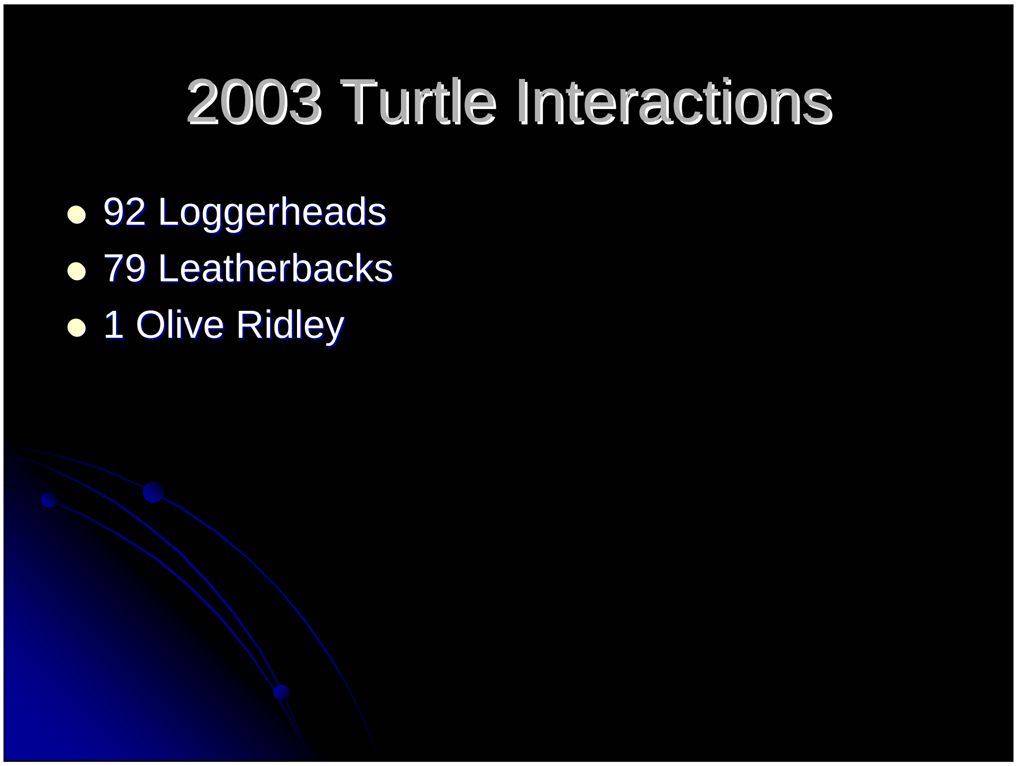
The control hook for tuna directed fishing sets was a 10° offset 16/0 circle hook and the control bait was squid and the treatment hook was a non offset 18/0 circle hook and the treatment bait was squid.



These are the control and treatment hooks designs tested.



In 2003 eleven commercial pelagic longline vessels made 539 research sets fishing 578,050 hooks.

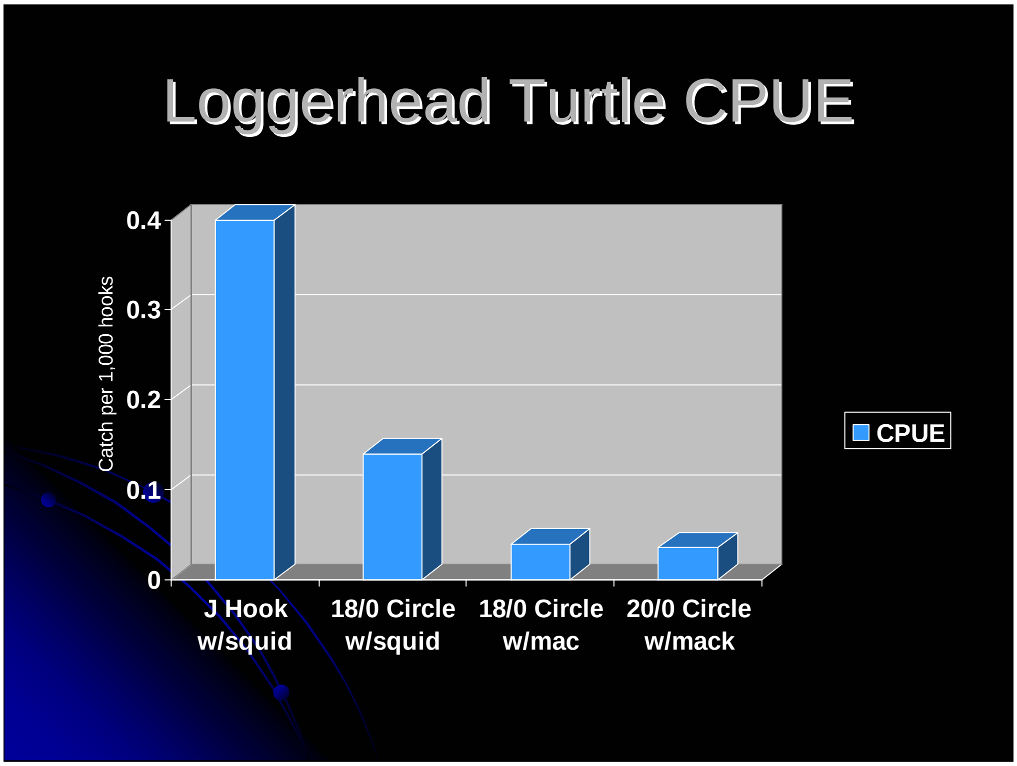


There were 92 loggerhead and 79 leatherback turtle interactions with longline gear during the 2003 experiments.

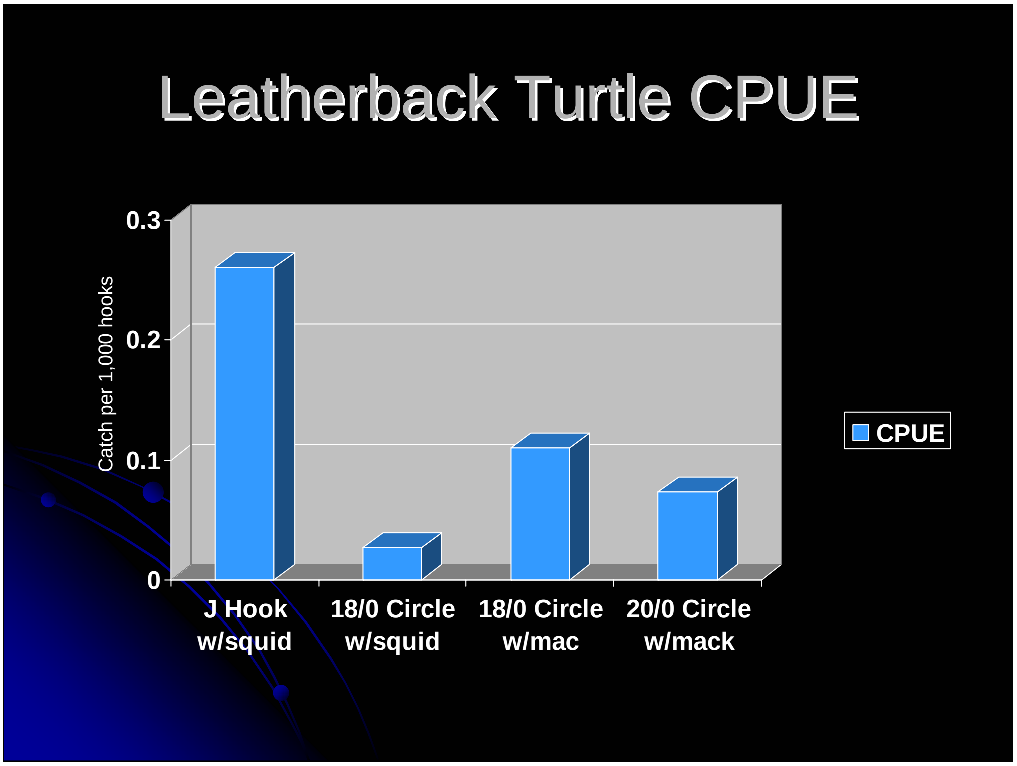
2003 Results

- 18/0 (non offset) circle hooks with squid bait
  Significant reduction loggerheads and leatherbacks, decreased swordfish catch, increased tuna catch
- 18/0 (10° offset) circle hooks with mackerel bait
  Significant reduction loggerheads and leatherbacks, increased swordfish catch, decreased tuna catch
- 20/0 (10° offset) circle hooks with mackerel bait
  Significant reduction loggerheads and leatherbacks, increased swordfish catch, decreased tuna catch

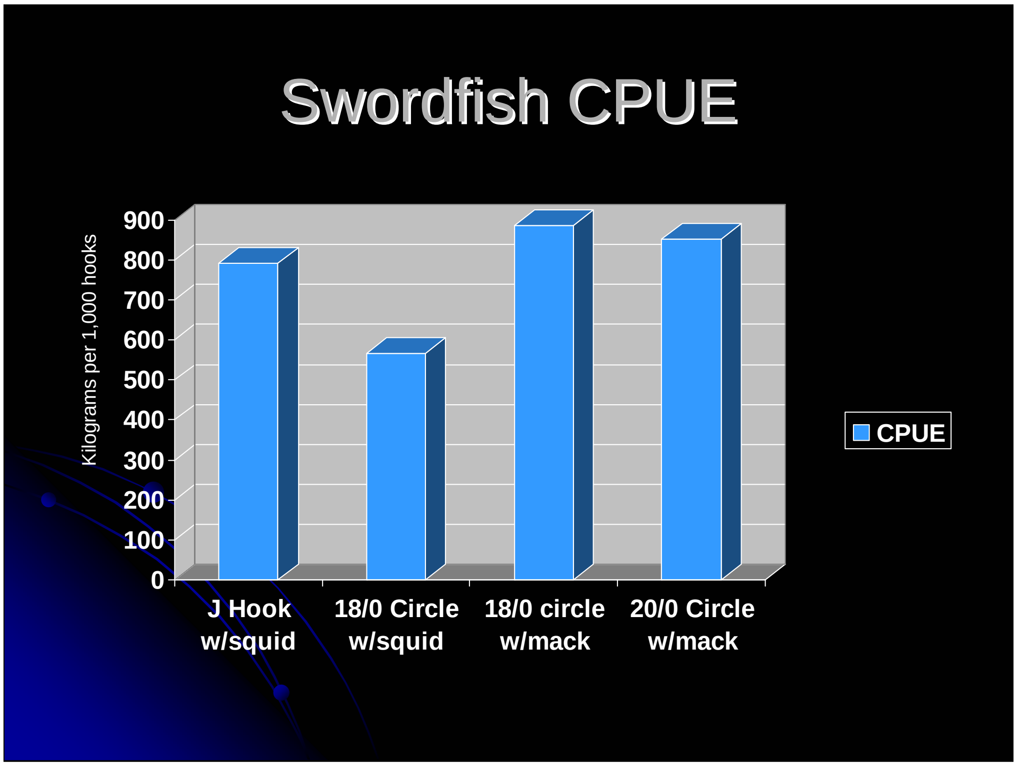
The 18/0 non offset circle hooks with squid bait had significant reductions in loggerhead and leatherback catch when compared to the control “J” hook and squid bait, and an increased tuna catch, but had a significant reduction in swordfish catch. The 18/0 10° offset circle hook with mackerel bait also had a significant reduction in catch of loggerhead and leatherback turtles compared to the control hook and bait and an increase in swordfish catch, but a significant decrease in tuna catch. The 20/0 10° offset circle hook also had a significant reduction in loggerhead and leatherback catch, a slight increase in swordfish catch and a significant decrease in tuna catch.



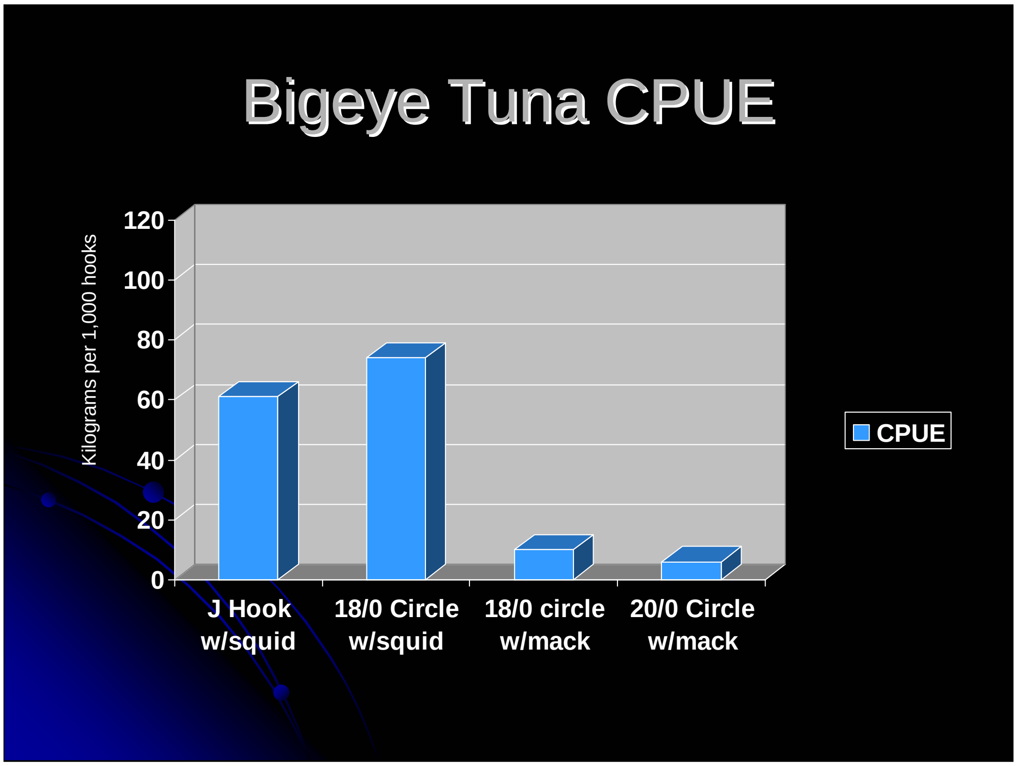
18/0 (non offset) circle hooks with squid bait reduced loggerhead catch by 64% (CI = 37% - 80% p = 0.0002), 18/0 (10° offset) circle hooks with mackerel bait reduced loggerhead catch by 89% (CI = 76%-95% p <0.0001) and 20/0 (10° offset) circle hooks with mackerel bait reduced loggerhead catch by 91% CI = 77%-96% p=<0.001).



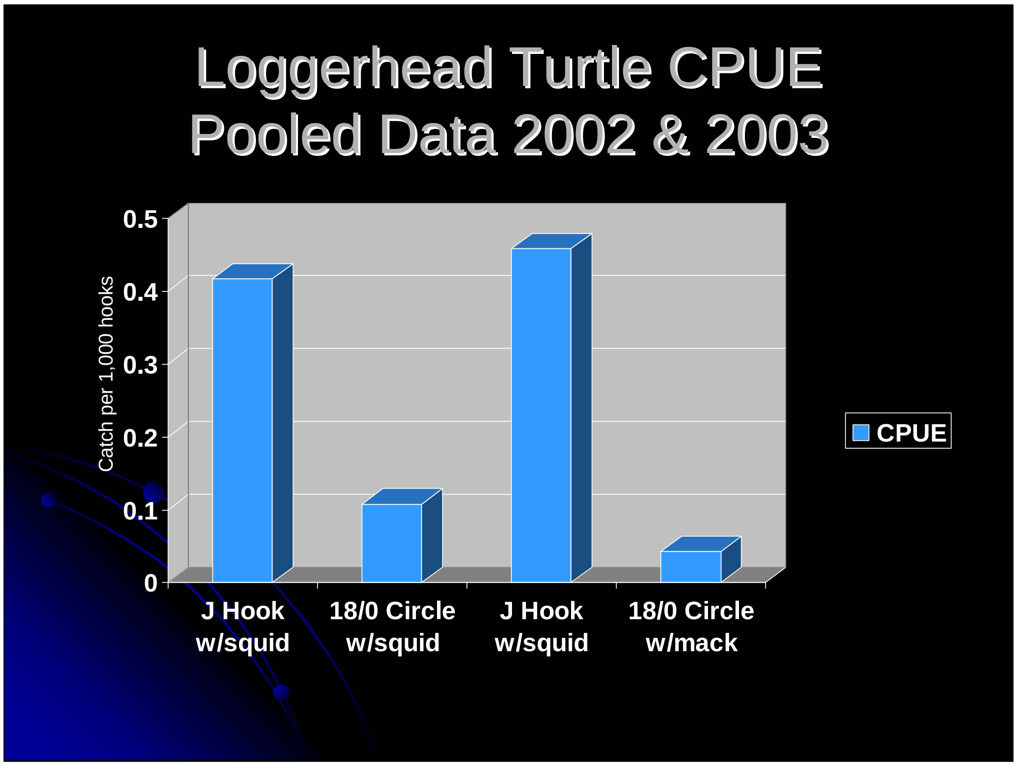
18/0 (non offset) circle hooks with squid bait reduced leatherback catch by 90% (CI = 66%-97% $p<0.0001$), 18/0 (10° offset) circle hooks with mackerel bait reduced leatherback catch by 56% (CI = 22%-76% $p=0.0043$), and 20/0 (10° offset) circle hooks reduced leatherback catch by 72% (CI = 42%-86% $p=0.0002$).



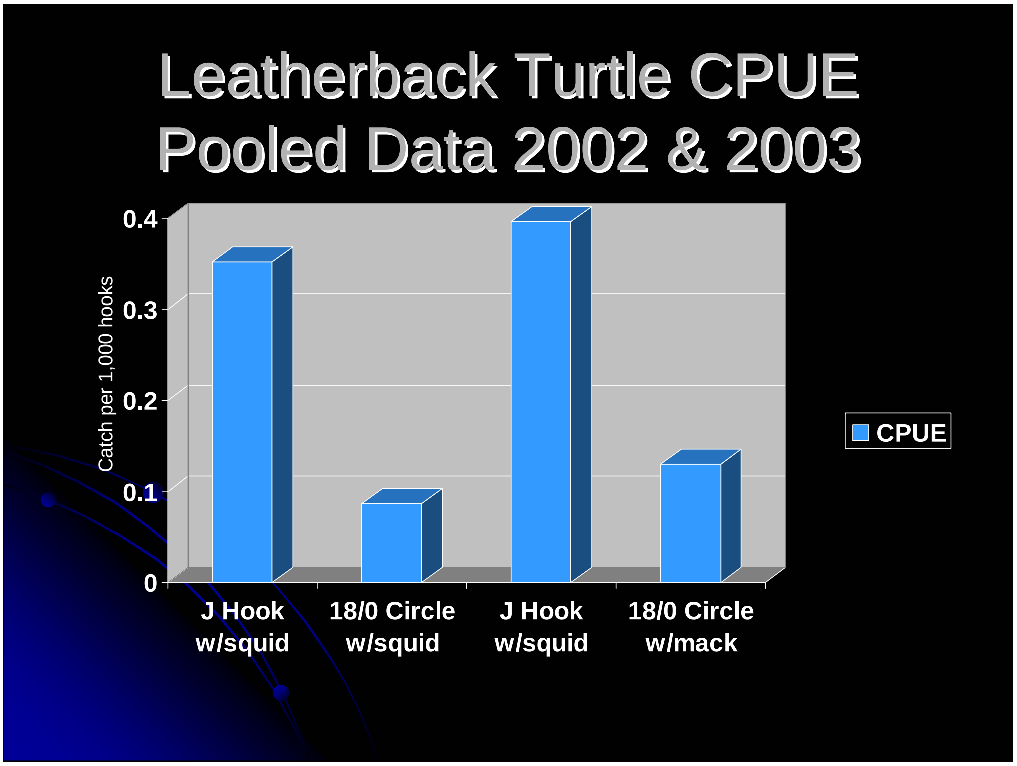
18/0 (non offset) circle hooks with squid bait reduced swordfish catch by 29% (CI = 21%-36%). 18/0 (10° offset) circle hooks with mackerel bait increased swordfish catch by 12% and 20/0 (10° offset) circle hooks increased swordfish catch by 8%.



18/0 (non offset) circle hooks with squid bait increased bigeye tuna catch by 20%, 18/0 (10° offset) circle hooks with mackerel bait decreased bigeye tuna catch by 83% and 20/0 (10° offset) circle hooks with mackerel bait decreased bigeye tuna catch by 90%.



18/0 circle hooks with squid bait reduced loggerhead CPUE by 74% (CI = 58%-84%), and 18/0 circle hooks with mackerel bait reduced loggerhead CPUE by 91% (CI = 82%-95%) for pooled data from 2002 and 2003.



The 18/0 circle hook with squid bait reduced leatherback CPUE by 75% (CI = 57%-86%) and the 18/0 circle hook with mackerel bait reduced leatherback CPUE by 67% (CI = 51%-78%) for 2002 and 2003 pooled data.

Tuna Directed Research Results

- Sample size is too small to determine effect, but preliminary numbers indicate reductions in both loggerhead and leatherback turtles with 18/0 circle hooks compared to 16/0 circle hooks. Bigeye tuna catches were similar and there was a slight increase in yellowfin tuna catch with 18/0 circle hooks versus 16/0 circle hooks

2003 NED Experiment

Data Analysis

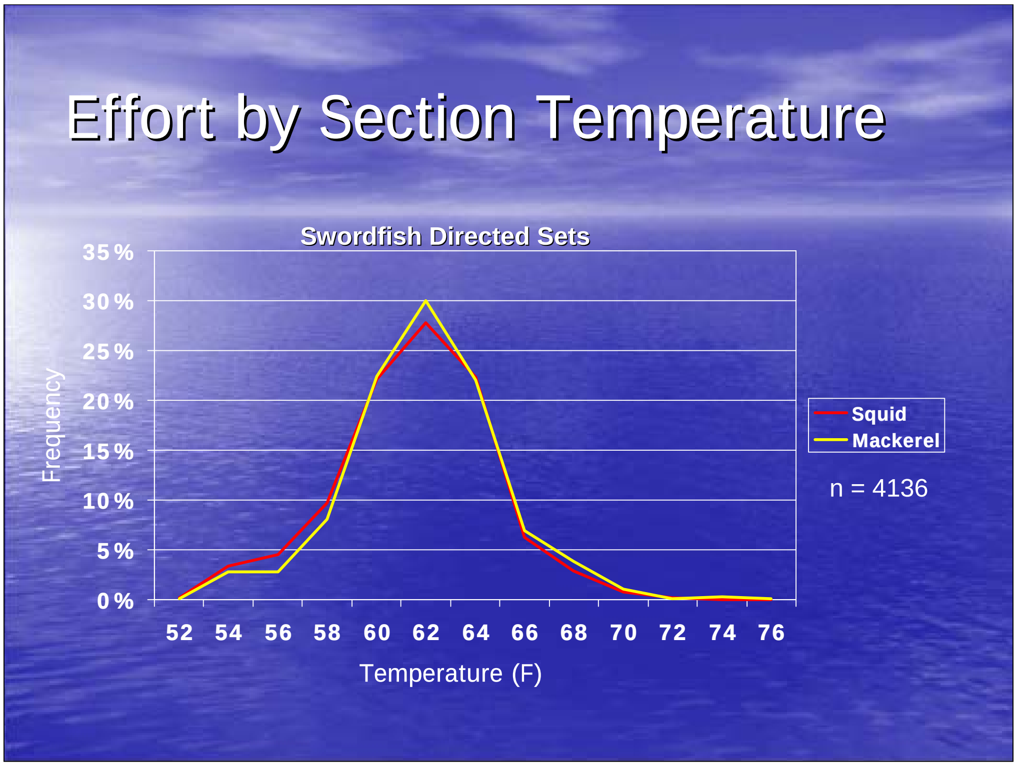
Dan Foster
John Watson
Dr. Arvind Shah

Analysis

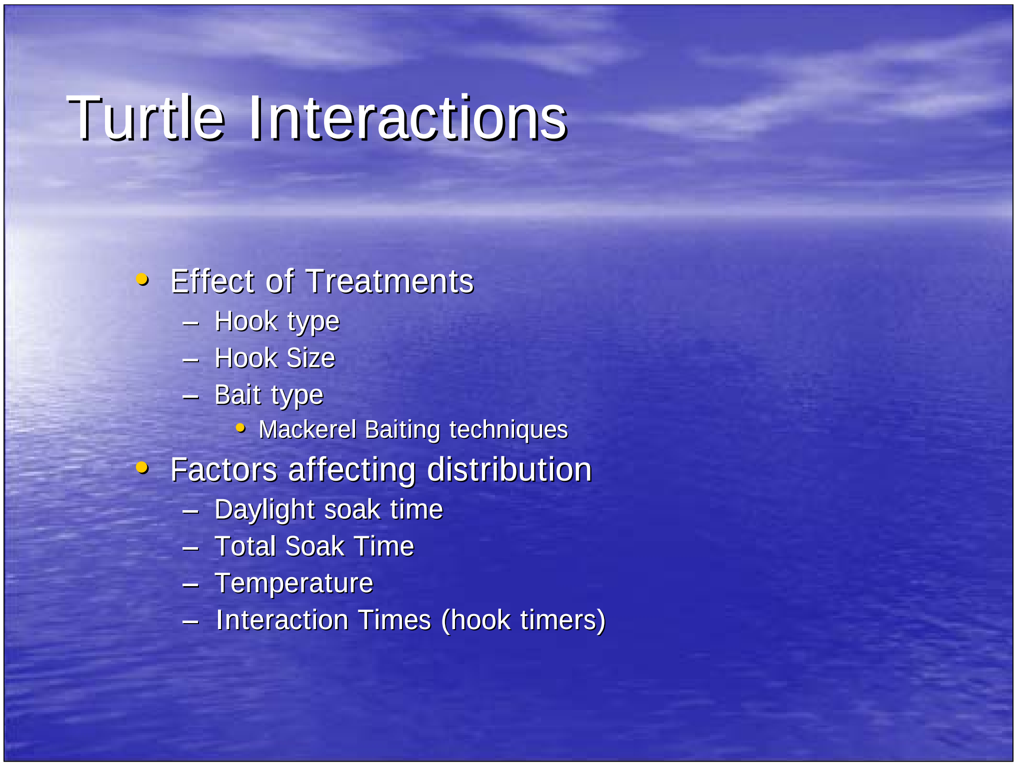
- Provide treatment data for statistical analysis (Dr. Arvind Shah)
- Conduct cursory analysis of data for other factors affecting the catch rate and distribution of swordfish, Leatherback and Loggerhead turtles.
- Provide trend information for further statistical analysis

Of the 539 hauls made in 2003, 510 were swordfish directed hauls and 29 were tuna directed. Of the 92 Loggerheads caught, treatments could be determined for 90. Of the 79 Leatherbacks caught during the experiment, treatments could be determined for 64.

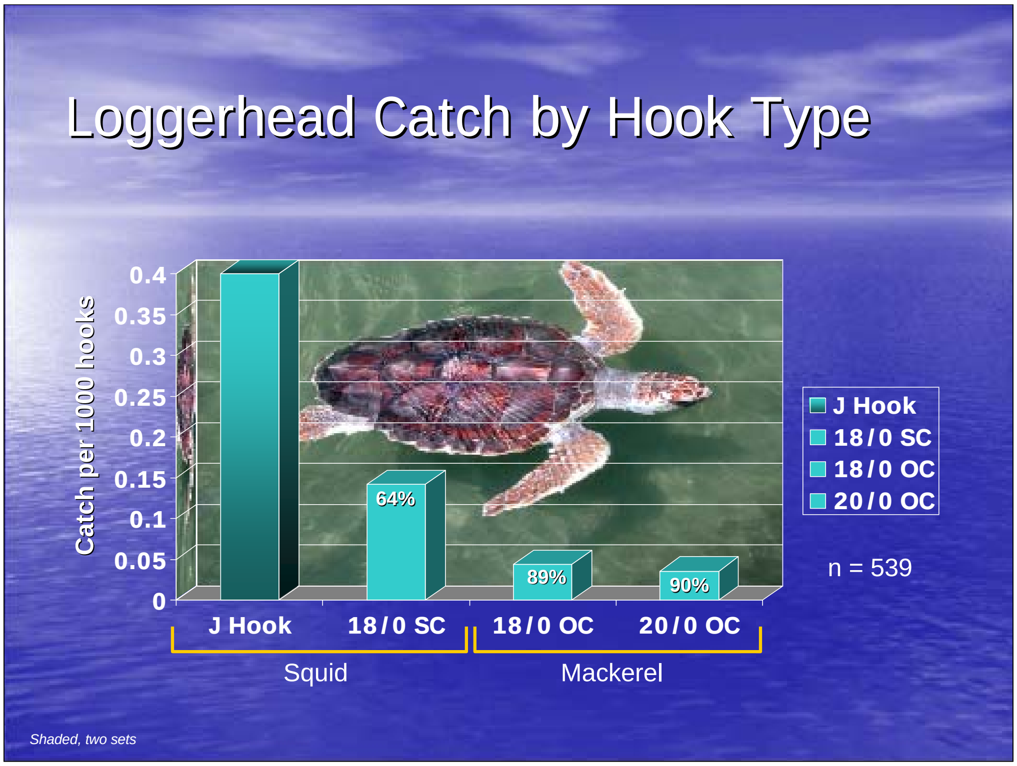
Two hook types were placed on each set in an alternating configuration. The swordfish directed sets were 9/0 J hook with squid and 18/0 straight circle with squid, a mackerel set with 18/0 offset circle hook and 20/0 offset circle, and a mackerel set alternating 18/0 offset circle with a J Tuna hook. The tuna directed sets alternated a 16/0 straight circle and a 18/0 straight circle on each set. The control hook in the swordfish directed sets was the 9/0 J hook with squid. Being that the 18/0 straight circle with squid was on the same sets as the control, this was a paired comparison. All other comparisons in the swordfish directed sets were non-paired.



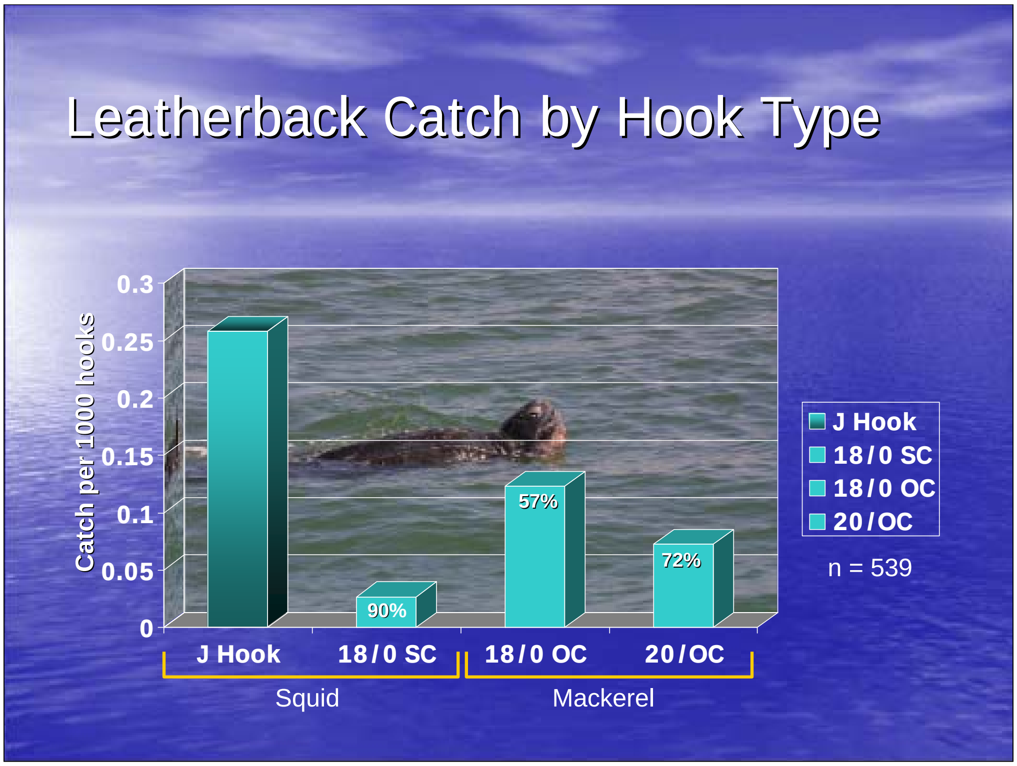
Because non-paired comparison are being made, it is important to ensure that a bias was not introduced into the experiment as a result of different fishing practices when fishing the two bait types. A comparison of fishing effort by the average section temperatures as the gear is being set shows basically the same distribution of effort for the two bait types used.



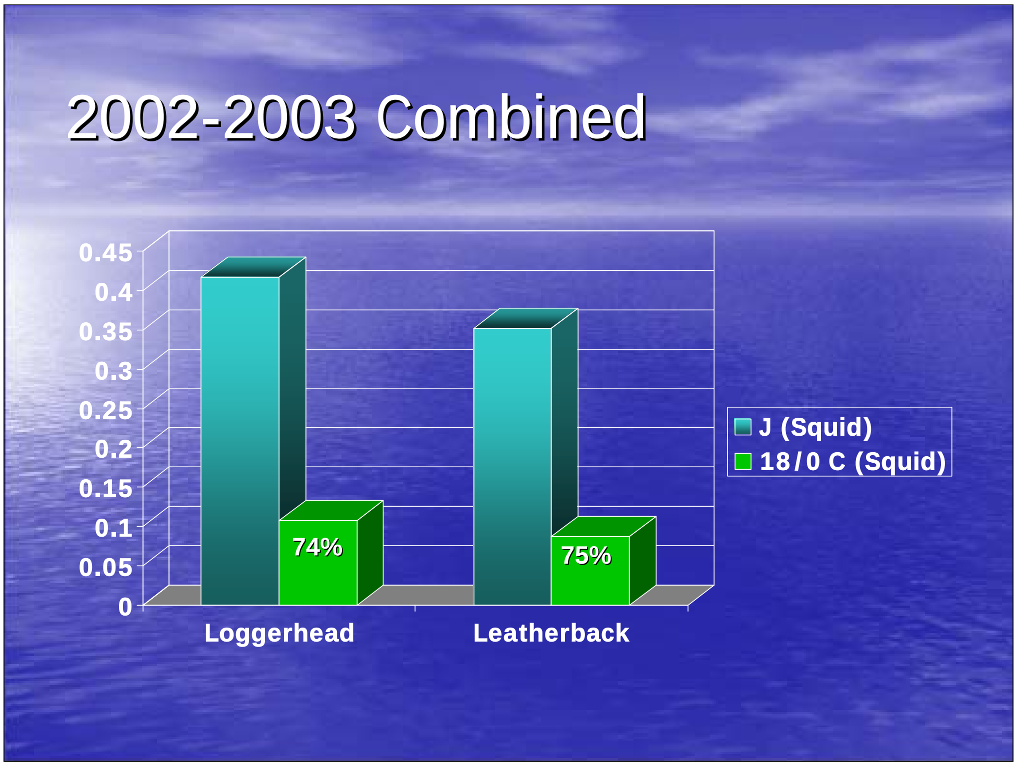
The treatments evaluated were hook type, hook size, bait type, and baiting technique. Other parameters evaluated were daylight soak time, total soak time, temperature, and interaction time as recorded by hook timers.



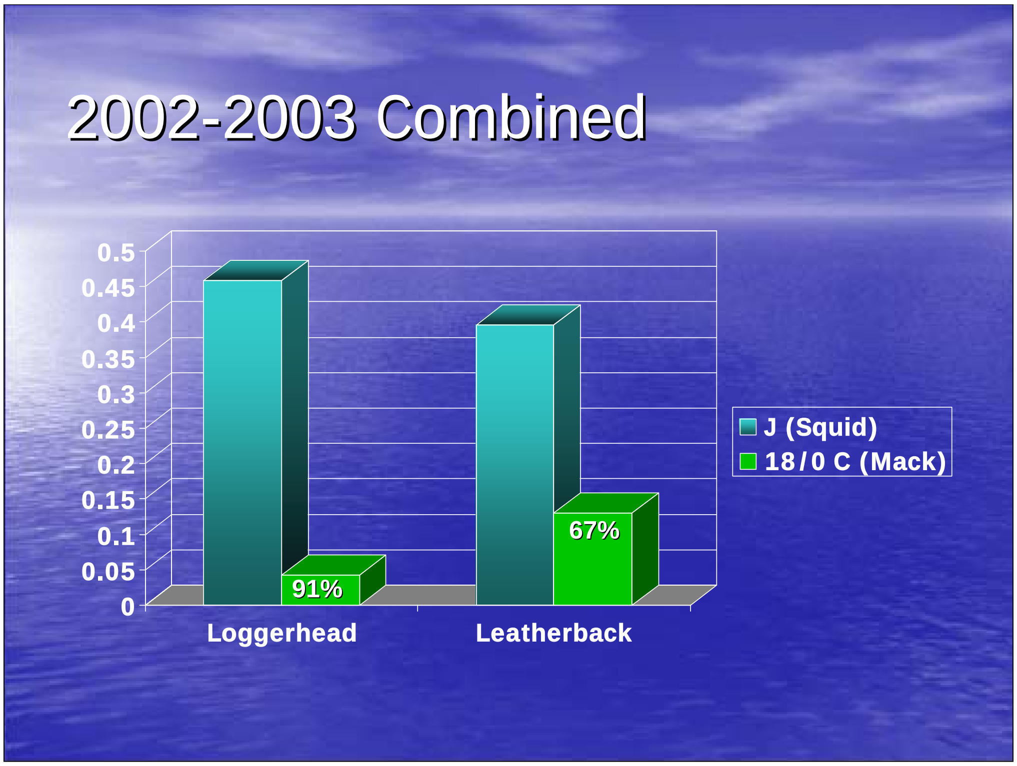
Of the four hook/bait combinations evaluated in the experiment, the 9/0 J hook with squid had the highest CPUE of loggerhead turtles with a catch rate of .399 loggerhead turtles per 1000 hooks. The 18/0 straight circle hook with squid had a 64 % reduction in the mean CPUE of loggerhead turtles as compared to the J hook with Squid. The 18/0 offset circle and 20/0 offset circle with mackerel showed an 89% and 90% reduction in the mean CPUE of loggerheads as compared to the J hook with squid.



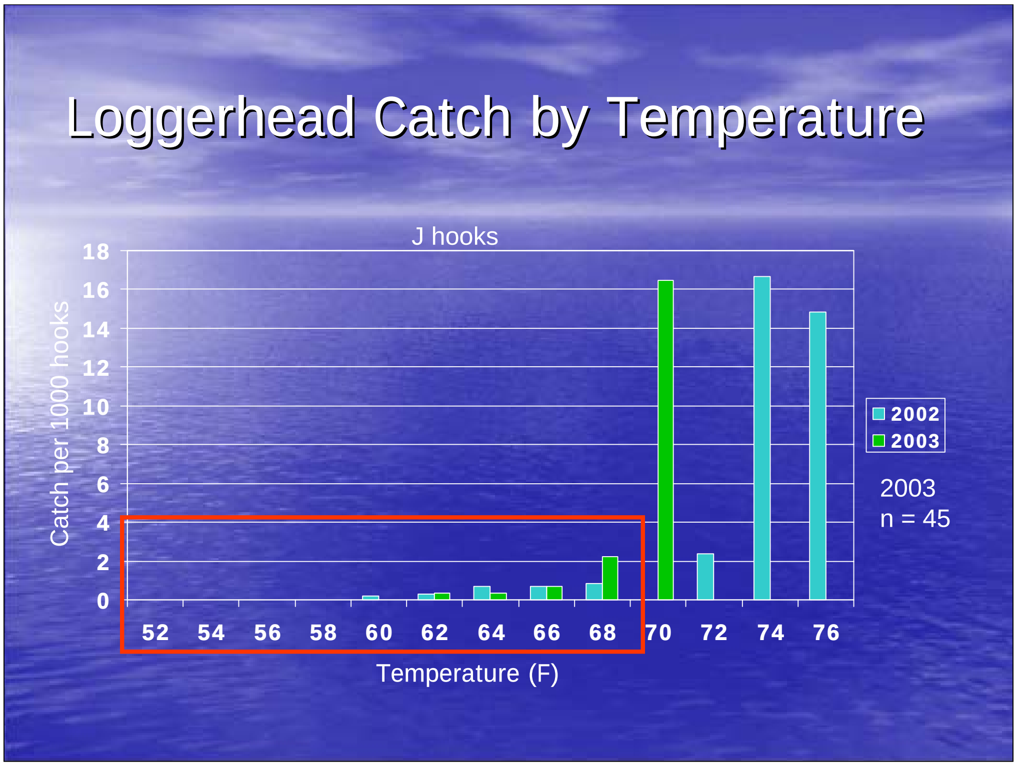
As with the loggerheads, the 9/0 J hook with squid had the highest CPUE of leatherback turtles with a catch rate of .258 leatherback turtles per 1000 hooks. The 18/0 straight circle hook with squid had a 90% reduction in the mean CPUE of leatherback turtles as compared to the J hook with Squid. The 18/0 offset circle and 20/0 offset circle with mackerel showed an 57% and 72% reduction in the mean CPUE of leatherbacks as compared to the J hook with squid.



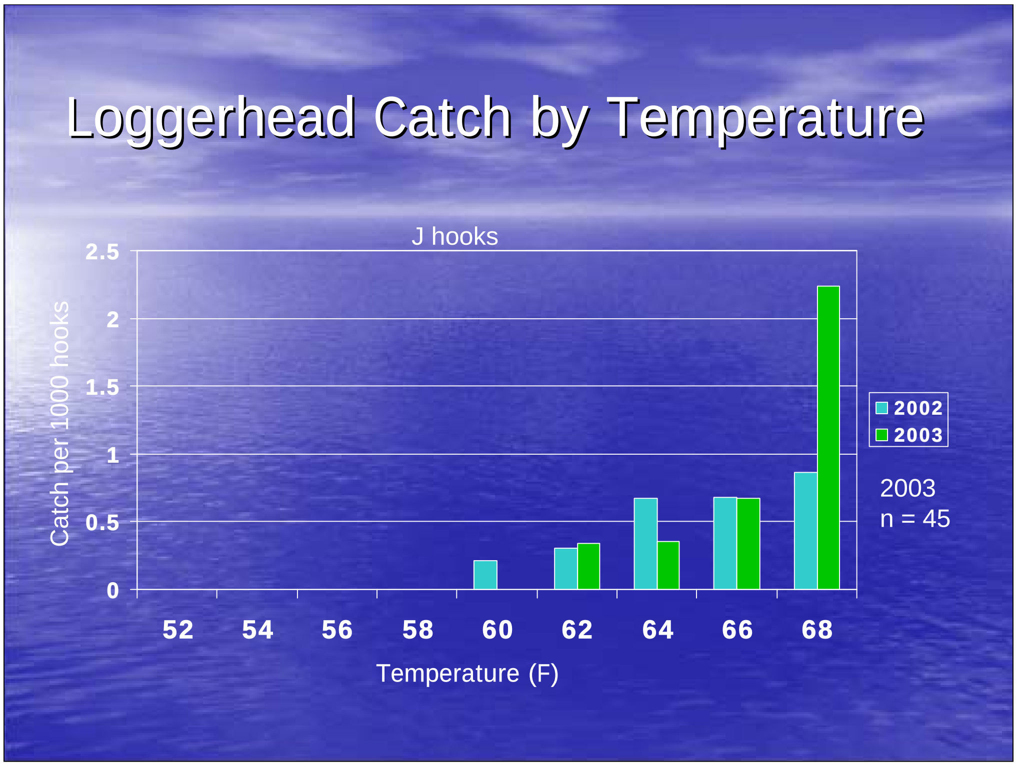
Combining the data from the 2002 and the 2003 experiment, the reduction in the mean CPUE for the 18/0 straight circle with squid was 74% for loggerhead turtles and 75% for leatherbacks.



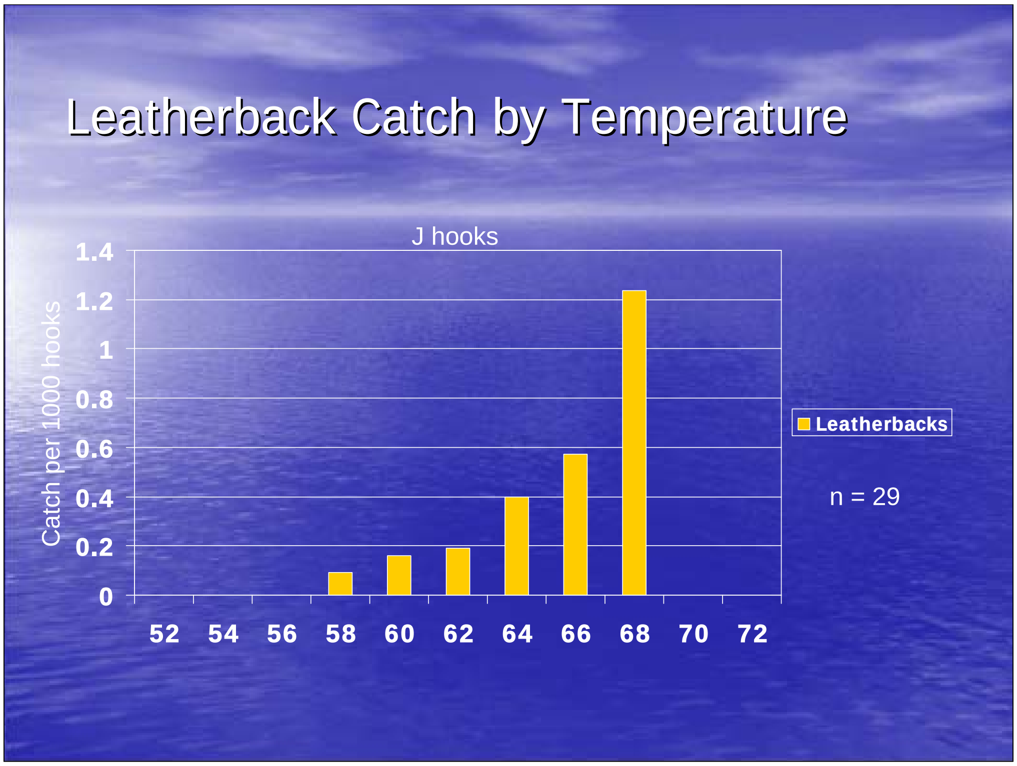
With the combined data, the reduction in the mean CPUE for the 18/0 offset circle with mackerel was 91% for loggerhead turtles and 67% for leatherbacks.



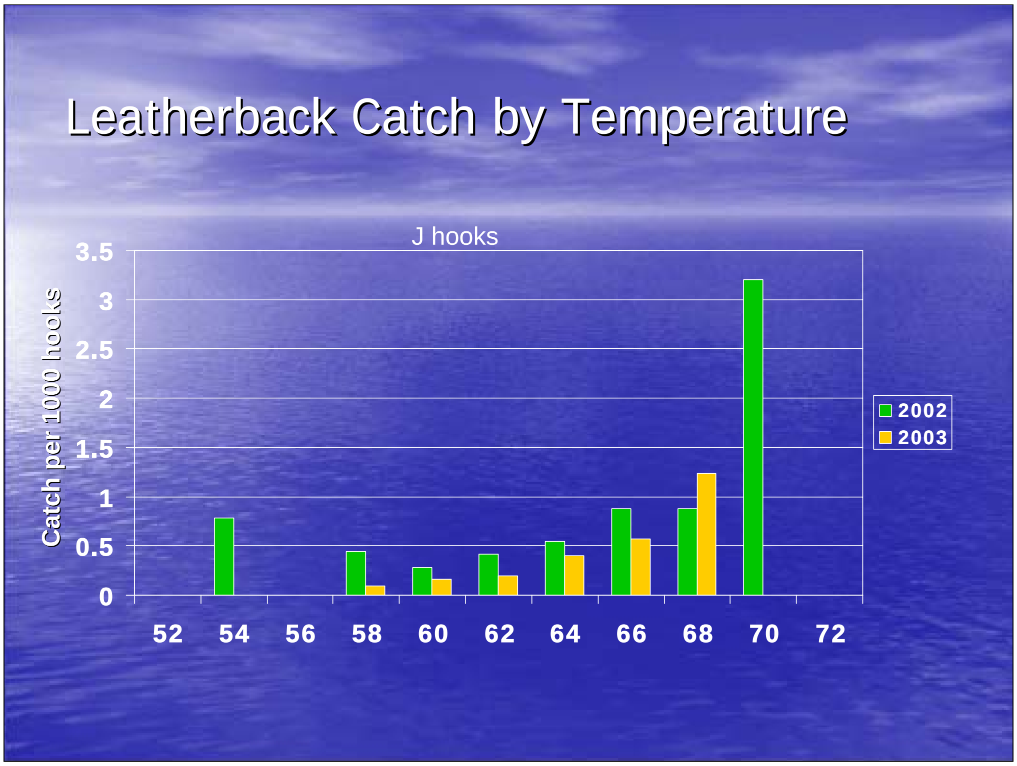
A comparison of the 2002 and 2003 results loggerhead CPUE by mean section temperature were very similar with no loggerhead turtles coming form water with a mean section temperature less than 59.65 degrees.



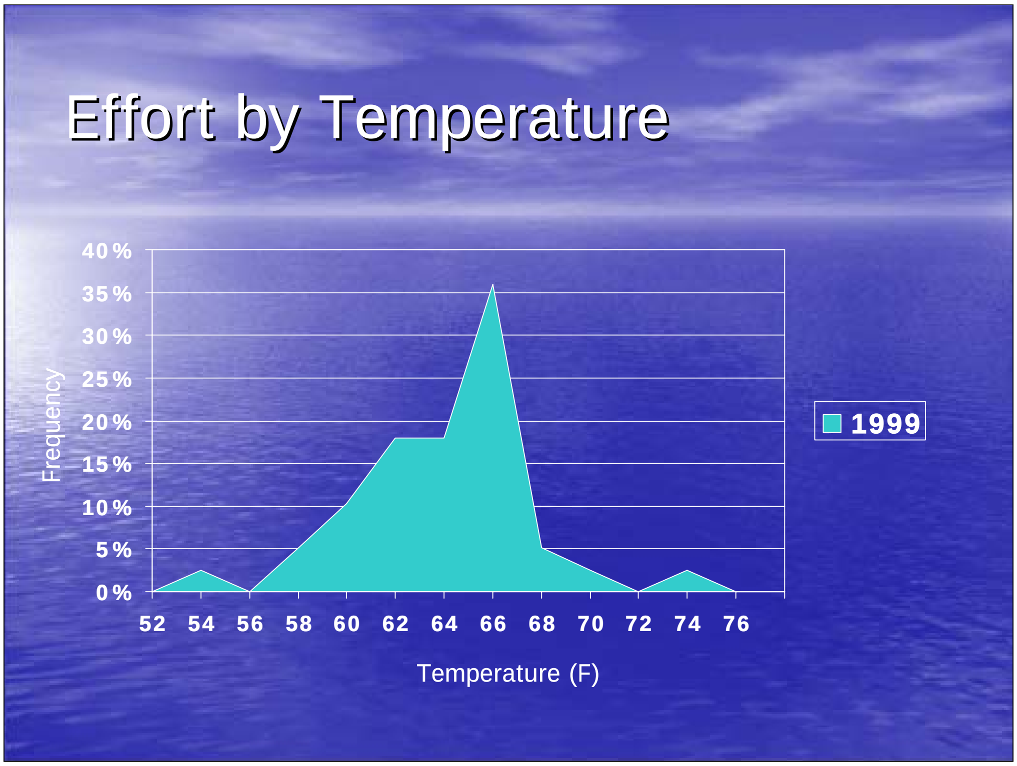
Focusing on the temperature range of 52 to 68, the 2002 and 2003 both show a direct relationship with loggerhead CPUE and temperature. The analysis has been completed for 2002 and this relationship was found to be statistically significant.



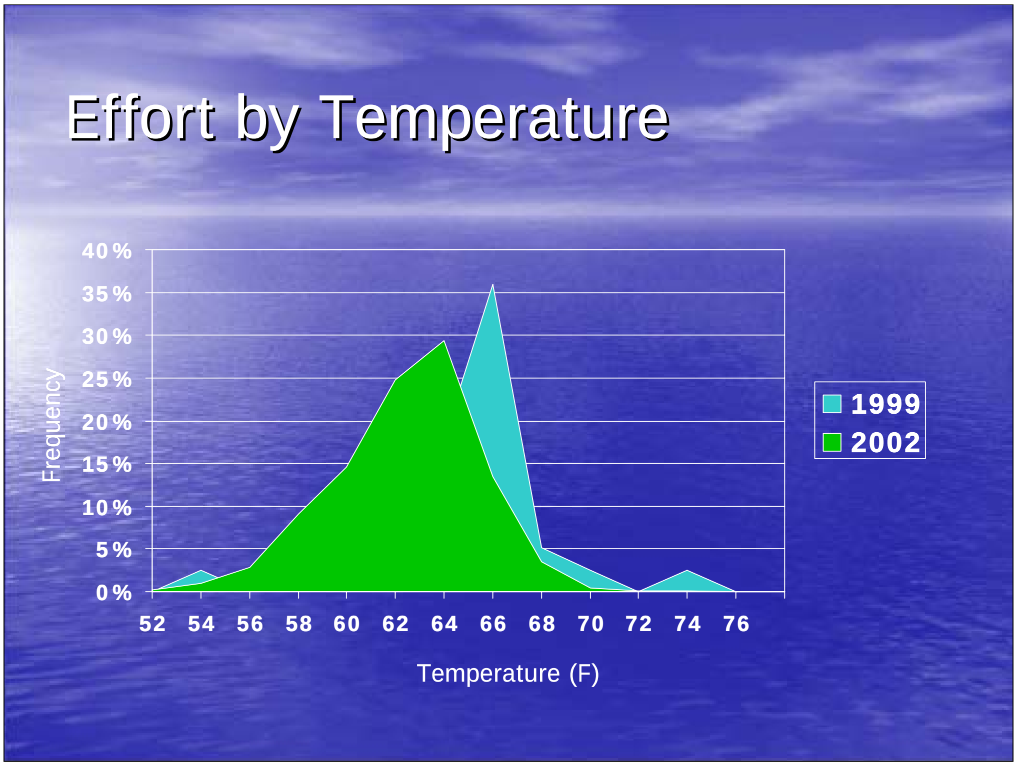
A comparison of CPUE of leatherback turtles by temperature shows that there is a relationship similar to that of loggerheads.



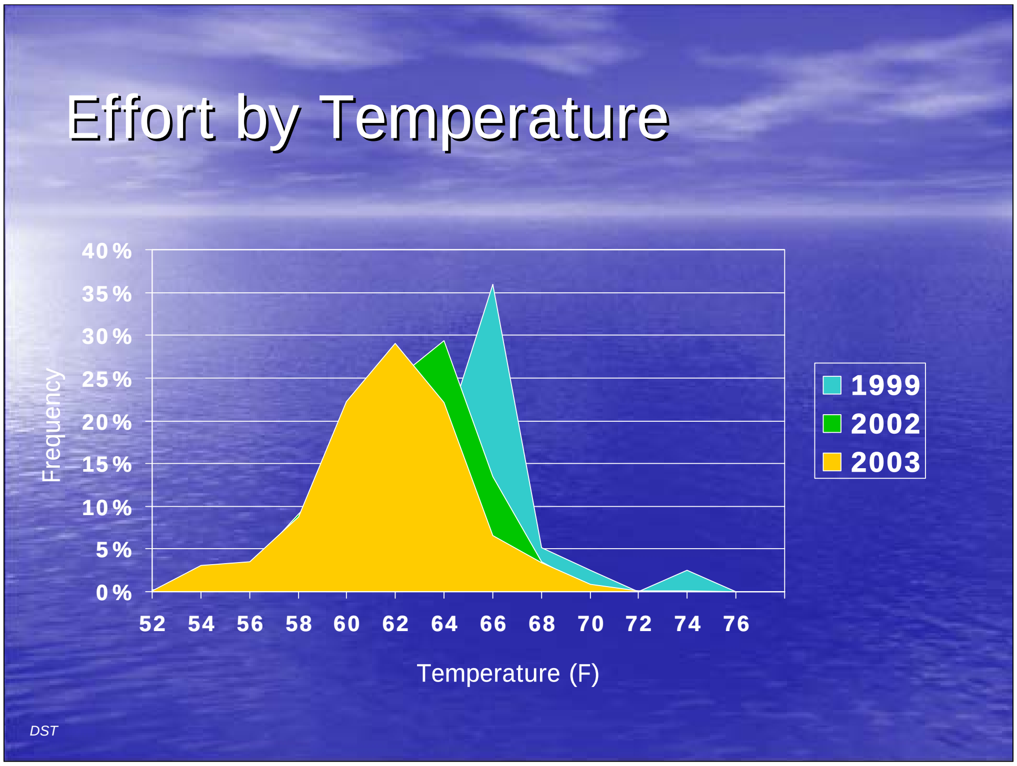
A comparison of 2002 and 2003 data show that this relationship was evident in both years. However, in 2002 that was one turtle caught in the 53 to 55 degree range.



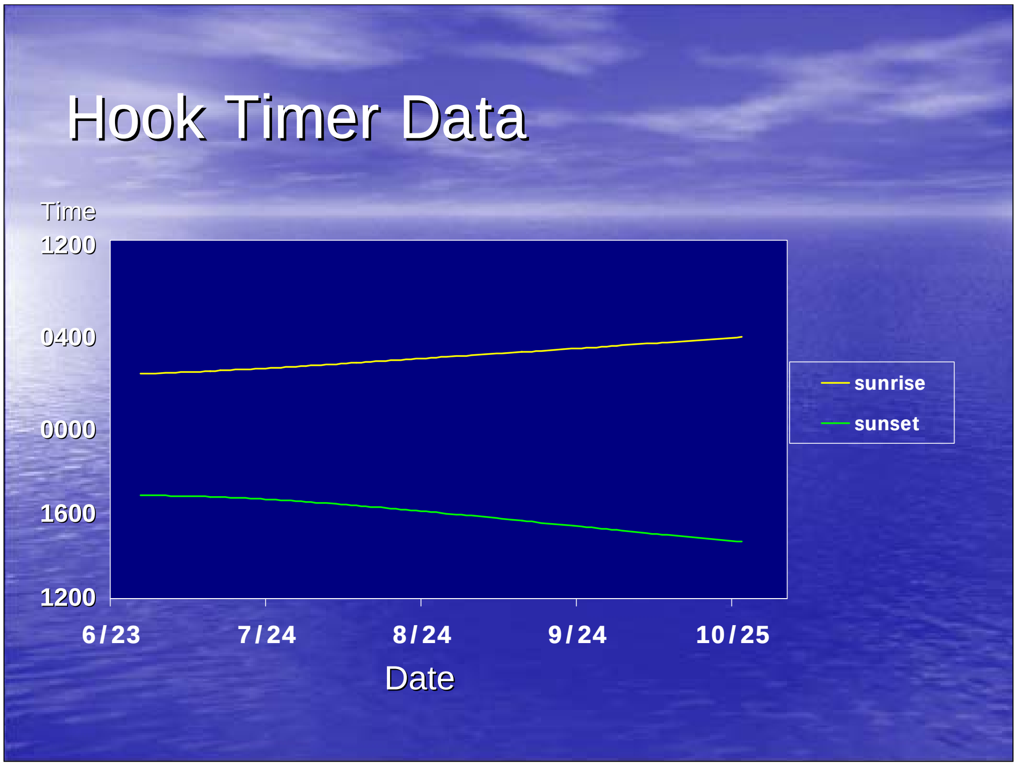
The frequency distribution of effort by average set temperature for 1999 observer data shows that the peak effort was between 65 and 67 degrees. The average set temperature is calculated as an average of temperatures taken at the beginning and end of each set.



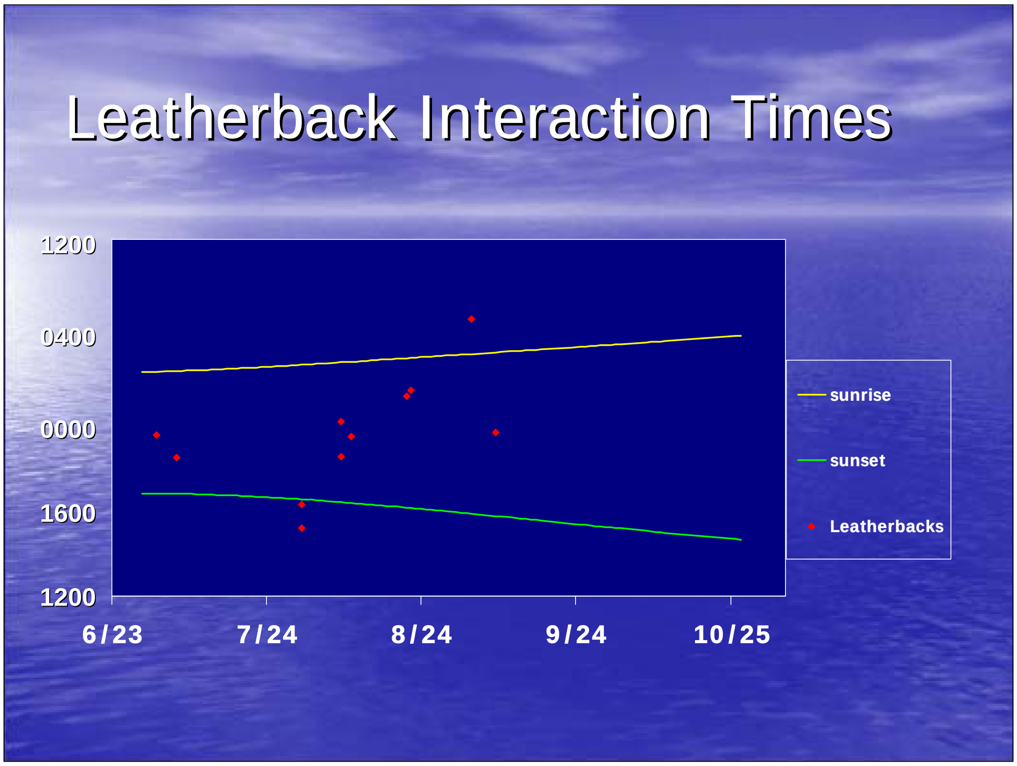
The 2002 effort by temperature was calculated as an average of the temperatures at the beginning and end of each section of gear. The 2002 data indicates that effort shifted toward fishing in cooler water.



The 2003 data indicates that effort again shifted toward fishing in cooler water as compared to 1999 and 2002.

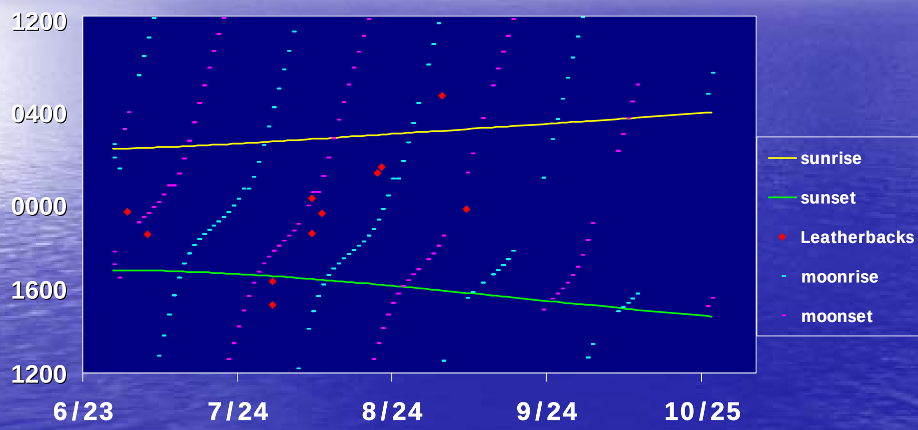


The plot for Interaction time for hook timer data has project date on the *X* axis and time of day on the *Y* axis. The starting time on the *Y* is noon with midnight occurring in the middle of the plot. The time between the sunset and sunrise lines is the night period. As shown in plot, the night period increased during the experiment.

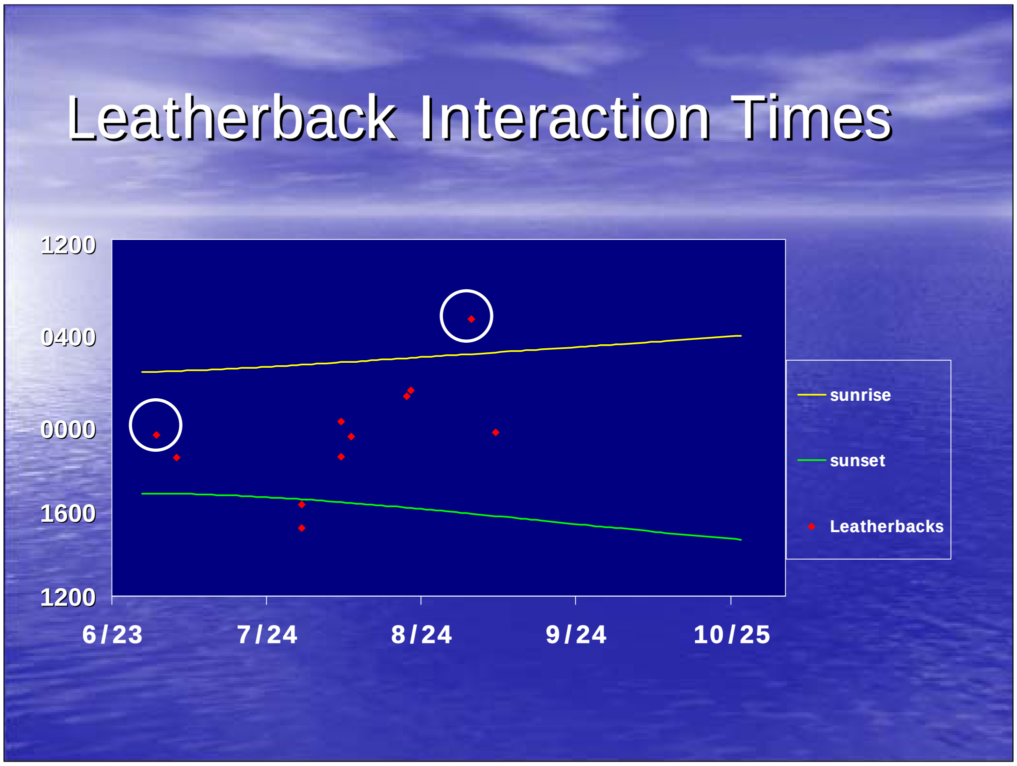


A plot of the leatherback interactions shows that 8 of the 11 leatherback interaction recorded occurred during the night period. Two of the three day interactions occurred in the evening with one occurring in the mourning period.

Leatherback Interaction Times



Adding moonrise and moonset times to the plot shows that the majority of the leatherback interaction occurred when the moon was in the sky.



Only two of the 11 leatherbacks interacted with the gear when the moon was below the horizon.

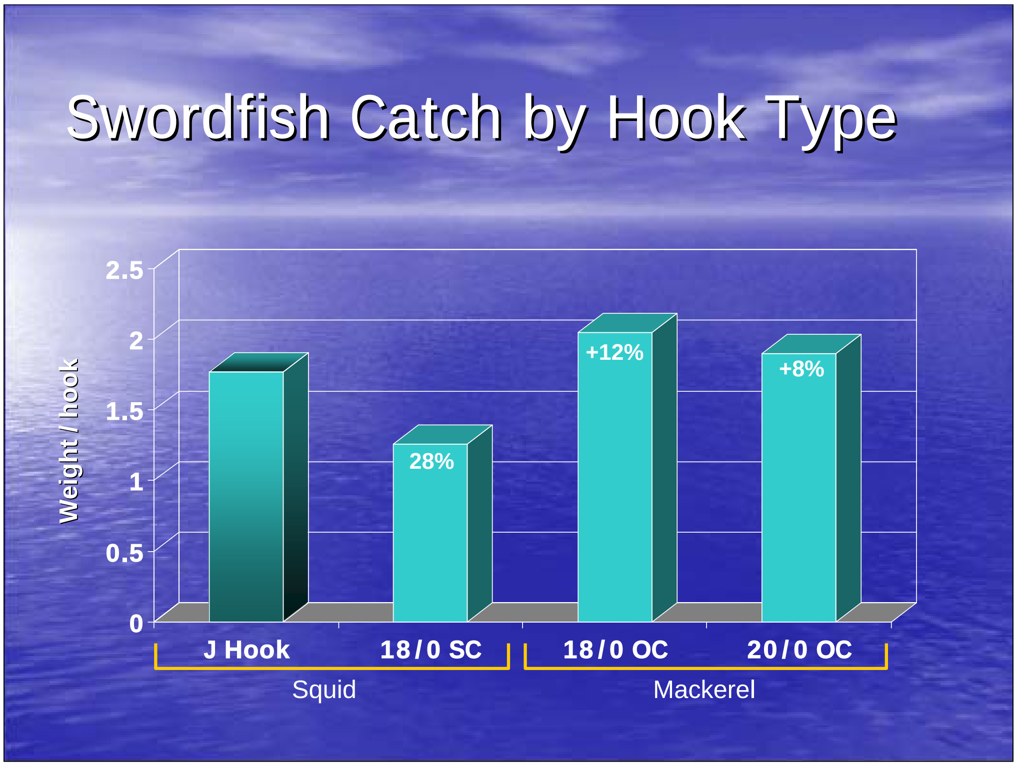
Summary

Effect of treatments on Turtle catch

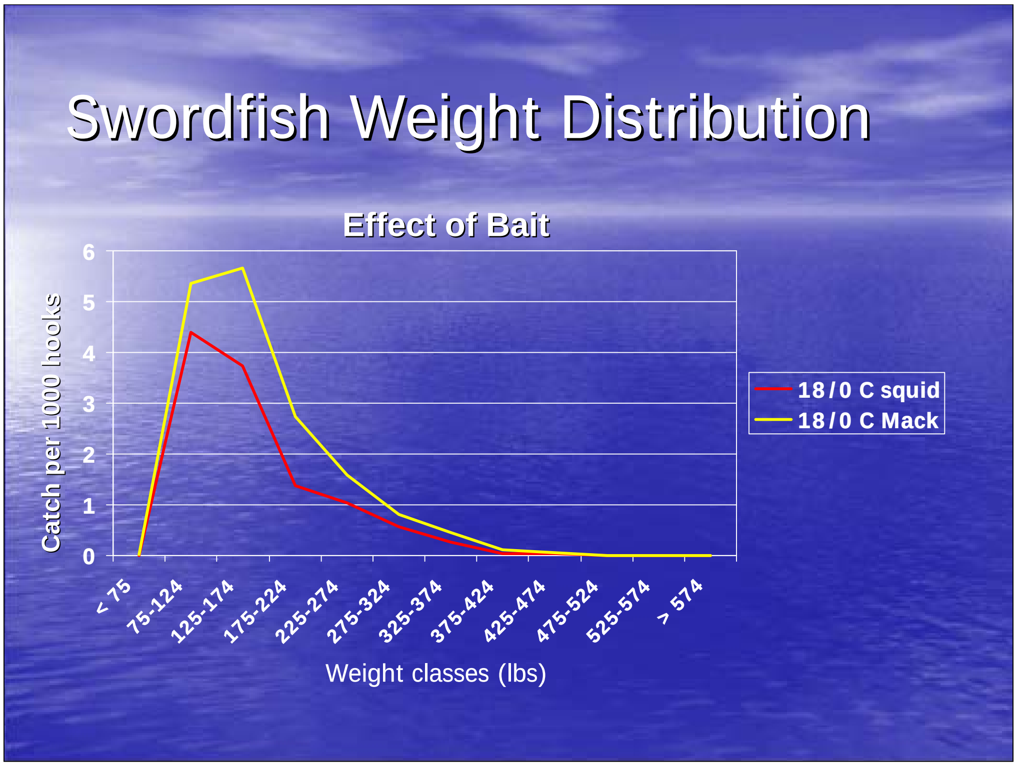
- Squid (J vs. Circle)
  - Circle hooks reduce Loggerhead and leatherback interactions
- Mackerel vs. Squid
  - Compared to squid on J hooks, mackerel on offset circle hooks reduce takes of leatherbacks and loggerheads
- Temperature appears to have an effect on loggerhead and leatherback distribution on the gear
- Leatherback interaction occur primarily at night when the moon is in the sky

Swordfish

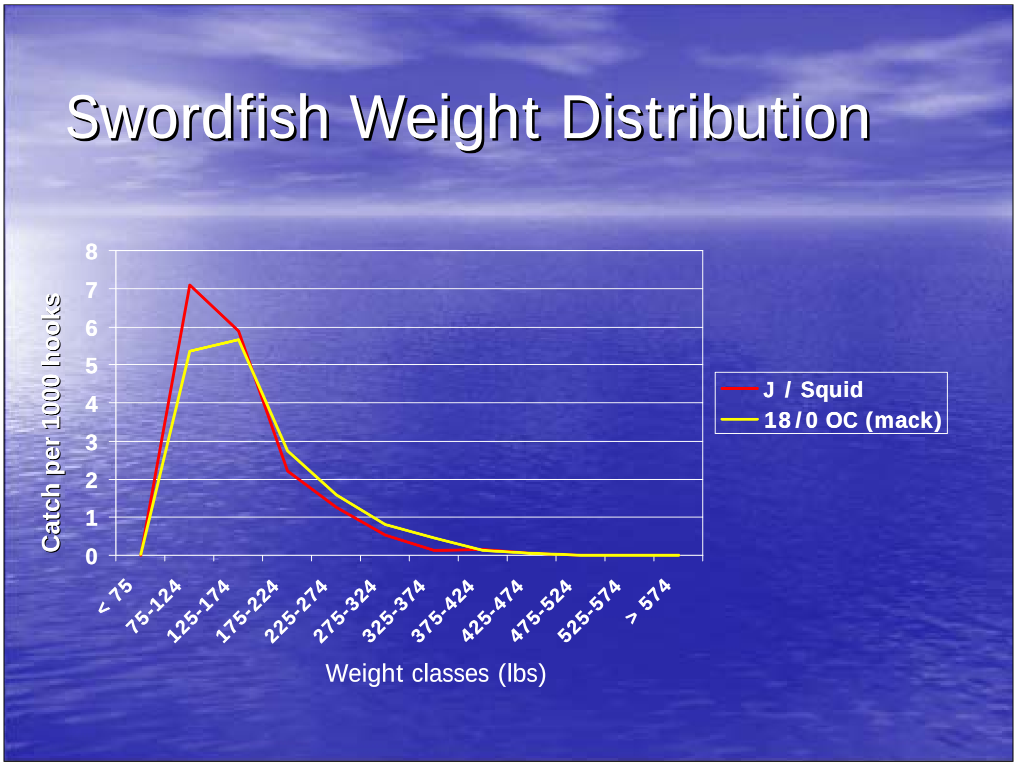
- Effect of Treatments
  - Hook type
  - Bait type
- Factors affecting distribution
  - Temperature
    - Size Distribution
    - Catch rate
  - Interaction time
    - Solar and lunar periods



Three hook and bait configurations were compared to the control J Hook with squid. The straight 18/0 Circle with squid resulted in a 28% mean CPUE weight reduction in swordfish catch. Both hook types tested with mackerel bait resulted in an increased swordfish catch. The offset 18/0 and offset 20/0 with mackerel resulted in an increase of 12% and 8% respectively.



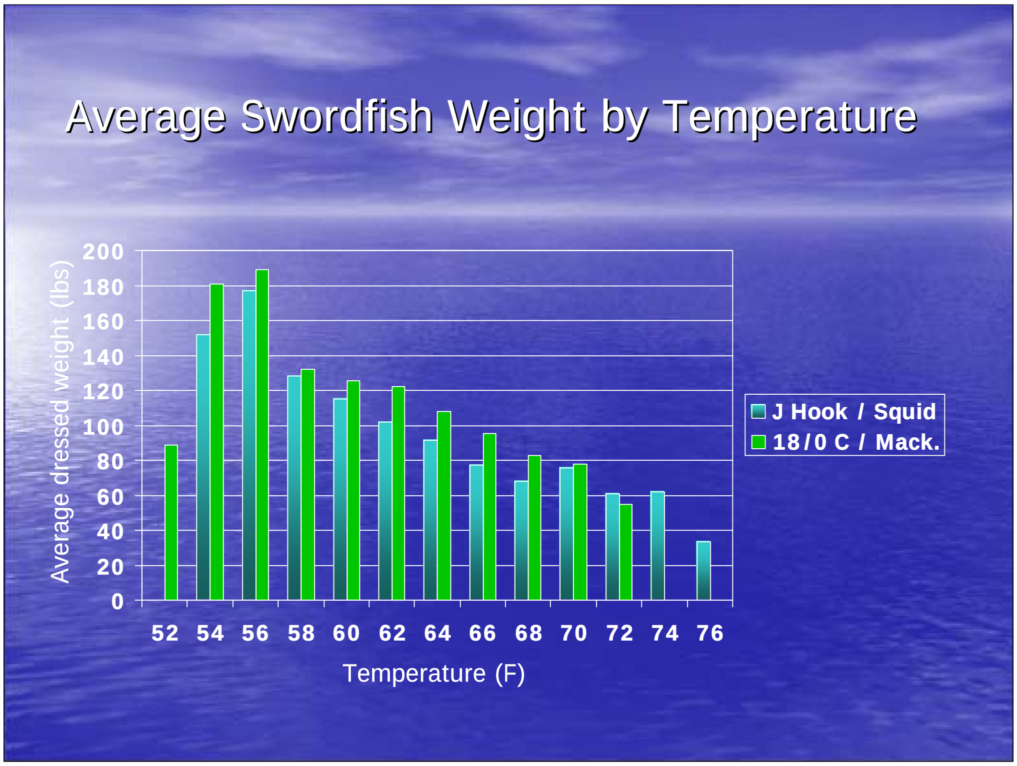
Comparing the count CPUE by dressed weight for squid and mackerel with 18/0 hooks, mackerel had a higher CPUE for all weight classes of swordfish. The two bait types also differed in that the peak CPUE for squid occurred in the 75 to 174 weight class while the peak for mackerel was in the 175 to 224 weight class.



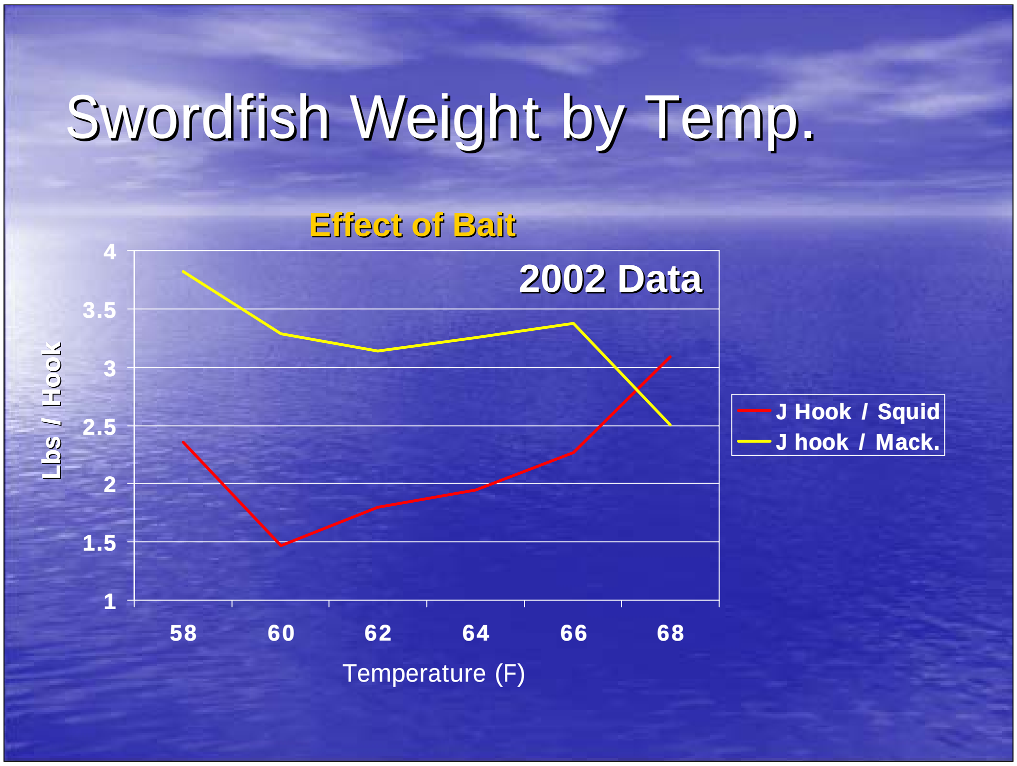
A comparison of CPUE by weight class for the J hook with squid and 18/0 offset circle with mackerel shows that swordfish CPUE mackerel exceeds that of the J Hook with squid in the size classes greater than 174 pounds.

Effect of Temperature

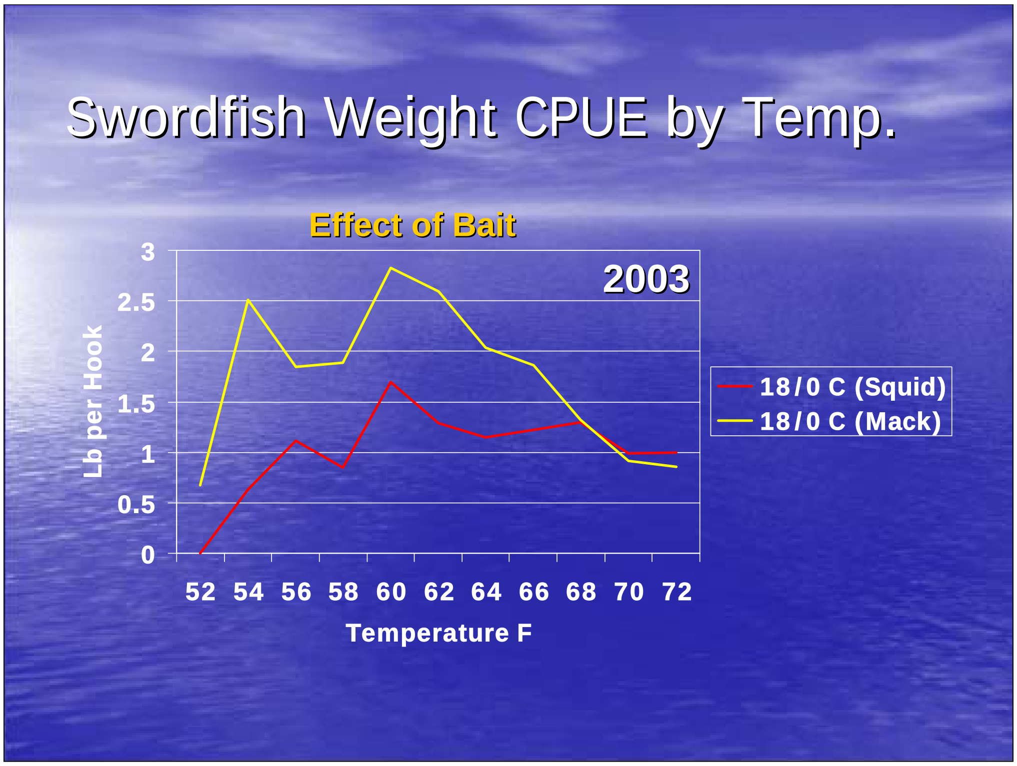
on Swordfish Catch



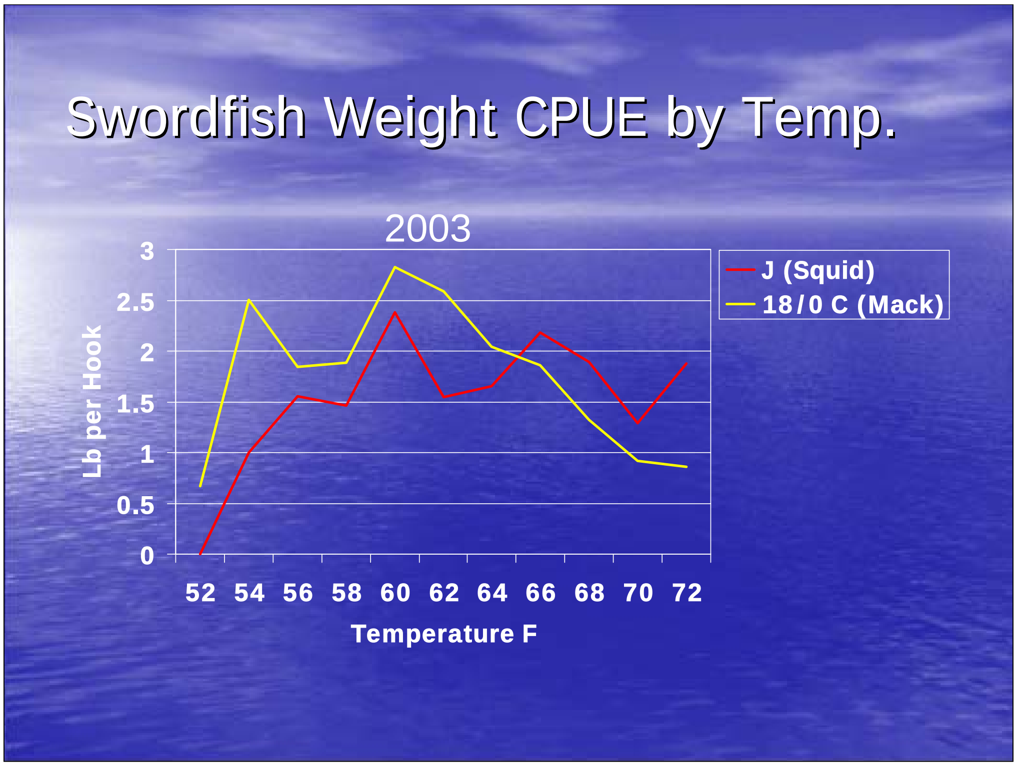
A comparison of average dressed weight of swordfish by temperature shows an inverse relationship. The average weight of swordfish caught between 59 and 61 degrees were approximately twice the weight of swordfish caught in 71 to 73 degree water. For the fish caught in the temperature ranges less than 69 degrees, the 18/0 Circle with mackerel had a higher average weight than did the J Hook with squid.



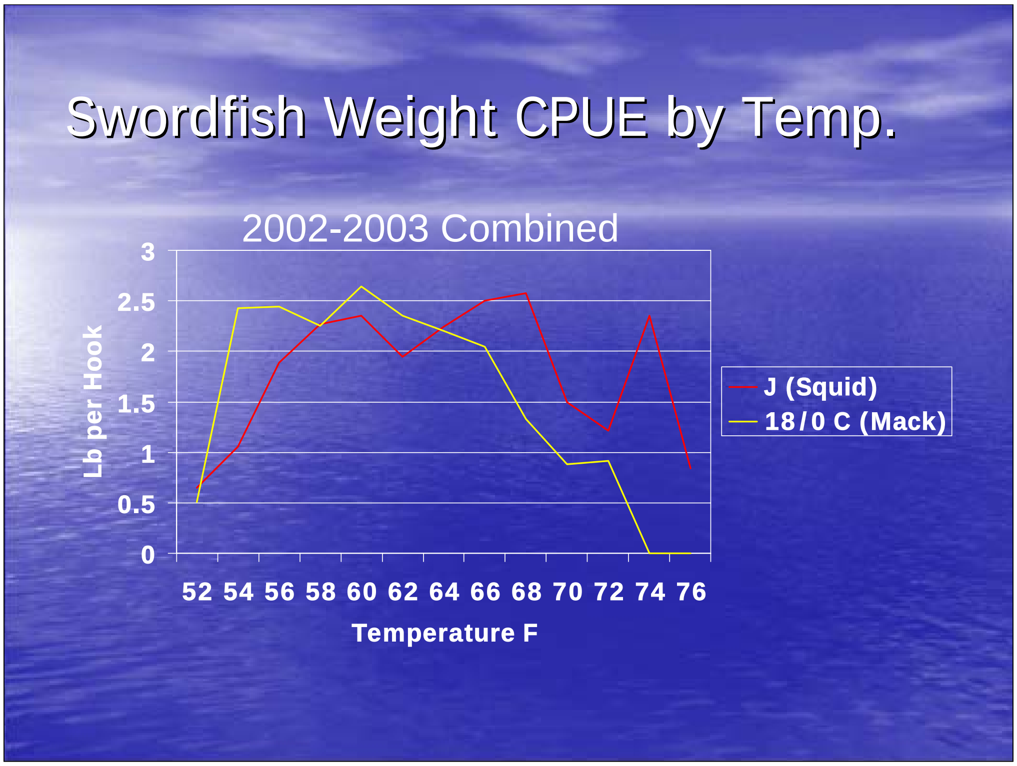
The 2002 results show that the effect of temperature on the mean J hook CPUE of swordfish by weight was dependant on bait type. The swordfish catch was greatest with mackerel when the gear was fished in cooler water. However, the difference between squid and mackerel diminished with and increase in temperature. From 67 to 69 degrees squid had a higher catch rate than did mackerel.



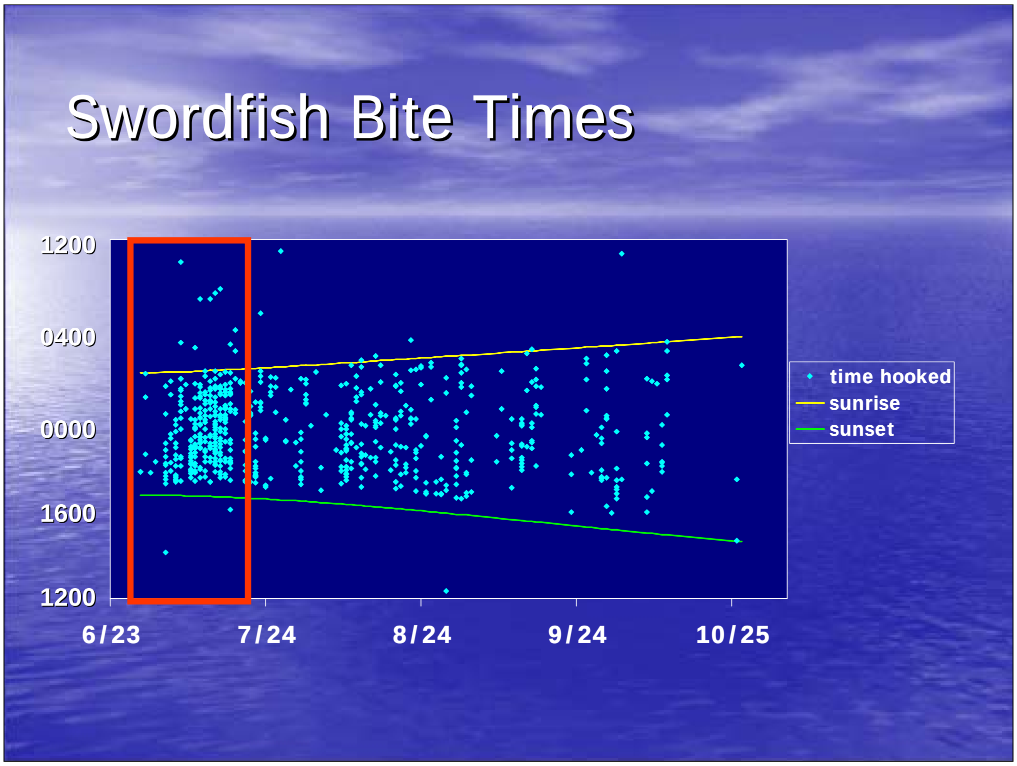
The 2003 results of the effect of temperature on the mean 18/0 Circle hook CPUE of swordfish by weight are similar to the 2002 results. The highest CPUE of swordfish was observed when mackerel was fished in cooler water. However, the benefit of using mackerel diminished as the temperature increased. At temperatures greater than 67 degrees, squid bait had a slightly higher catch rate than did mackerel.



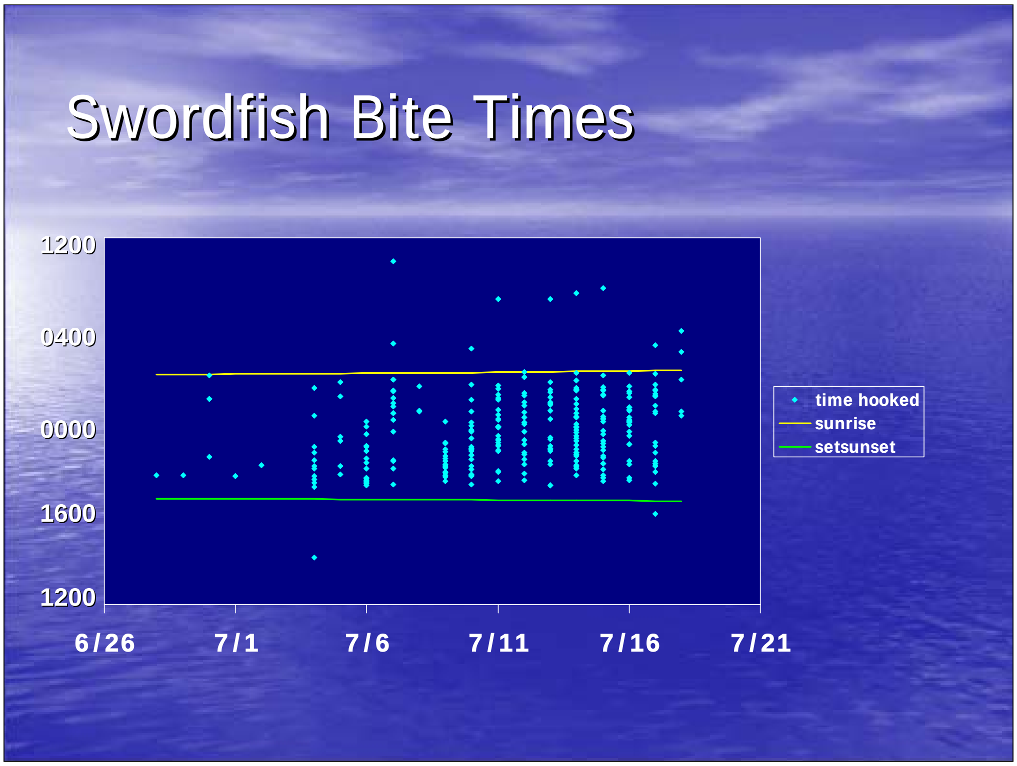
As previously presented, the 2003 results show a reduction in swordfish catch of 28% with 18/0 circle hooks (J hook w/squid vs. 18/0 C w/squid). However, the use of mackerel more than compensates for the loss by circle hooks resulting in an increase in swordfish CPUE by 16% (J Hook w/ squid vs. 18/0 C w/ mackerel). A comparison of this offsetting effect with the use of mackerel shows that the CPUE with mackerel bait on the 18/0 circle exceeds that of the J Hook with squid in water less than 65 degrees. At temperatures greater than 65, the mackerel bait fails to make up for the loss occurring from the use of circle hooks. It is not clear what factors, such as the temperature distribution of pray species or size distribution of swordfish may be affecting these results. Without a better understanding of the influencing factors, it is difficult to speculate whether or not similar results would be expected in other areas.



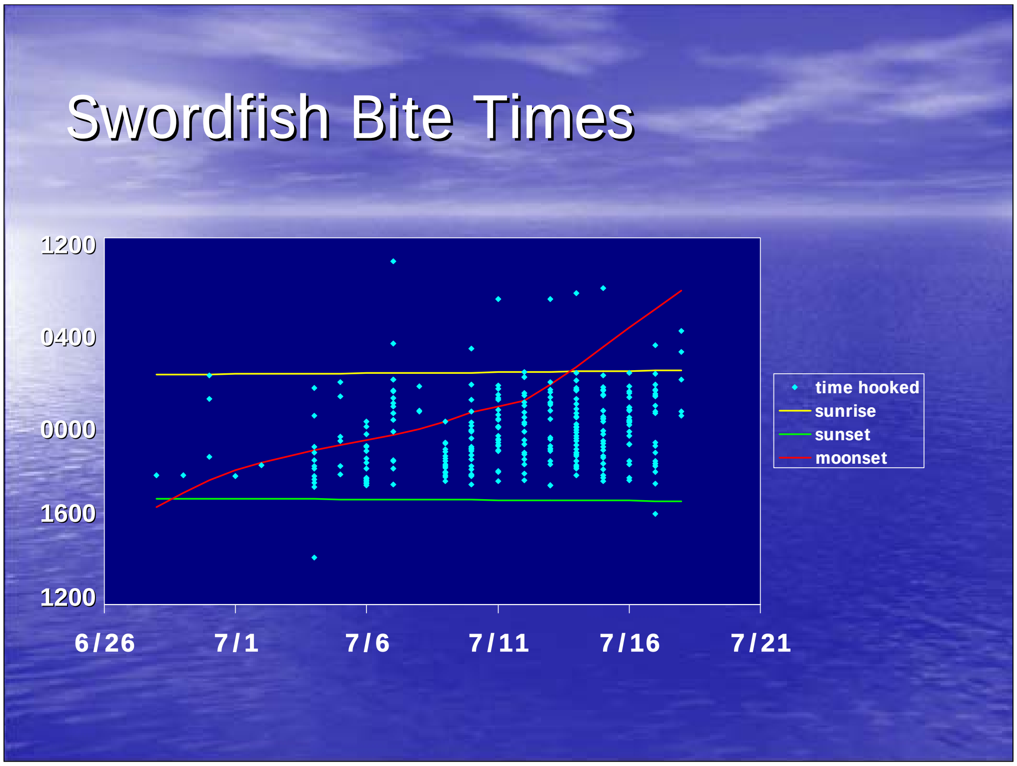
The combined 2002 and 2003 data show a similar trend to the 2002 data with the CPUE of the 18/0 Circle w/mackerel falling below that of the J Hook w/squid at between 63 and 65 degrees.



The interaction times were plotted for 631 swordfish during the experiment. 97% of the interactions occurred between sunrise and sunset. The space in the plot between the sunset line and the first interactions of the night indicates that swordfish wait until dark to become active near the surface. The unevenness of the data across the experimental period is representative of uneven distribution of effort and use of timers.



Focusing on time period between June 28th and July 18th, the plot indicates that the feeding pattern at the beginning of the period was primarily before midnight. However, toward the end of the period feeding activity occurred equally across the entire night.

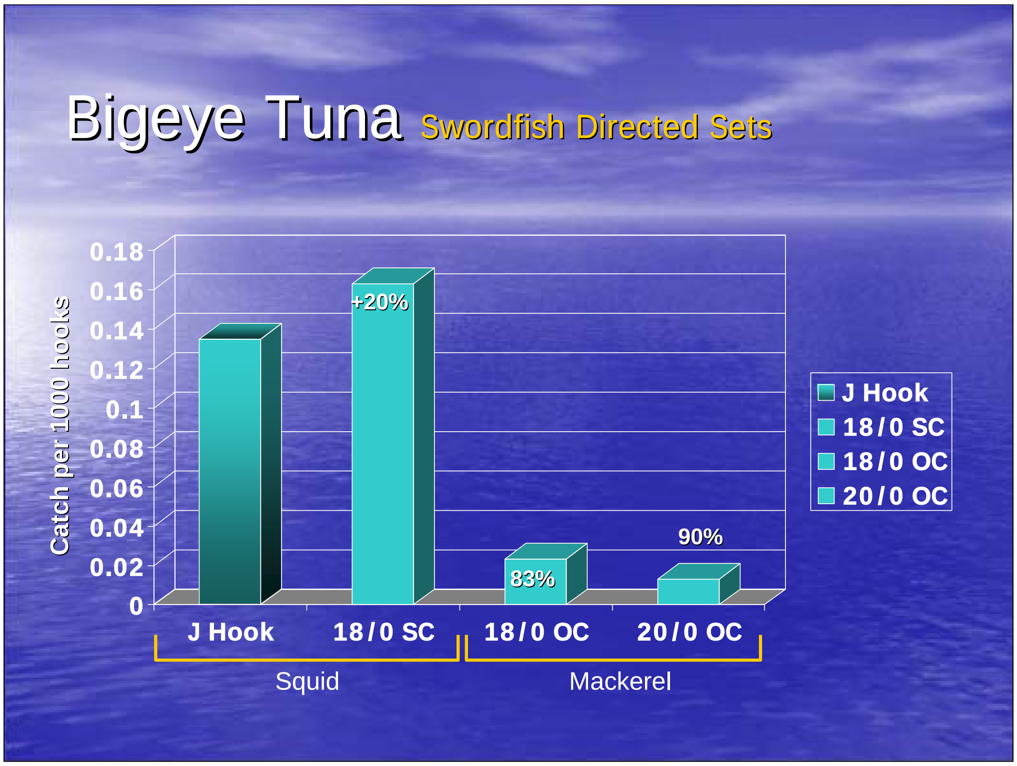


Overlaying the moonset line on the plot shows that feeding activity was at the highest below the moonset line, indicating that the feeding activity was highest during the night period when the moon was in the sky.

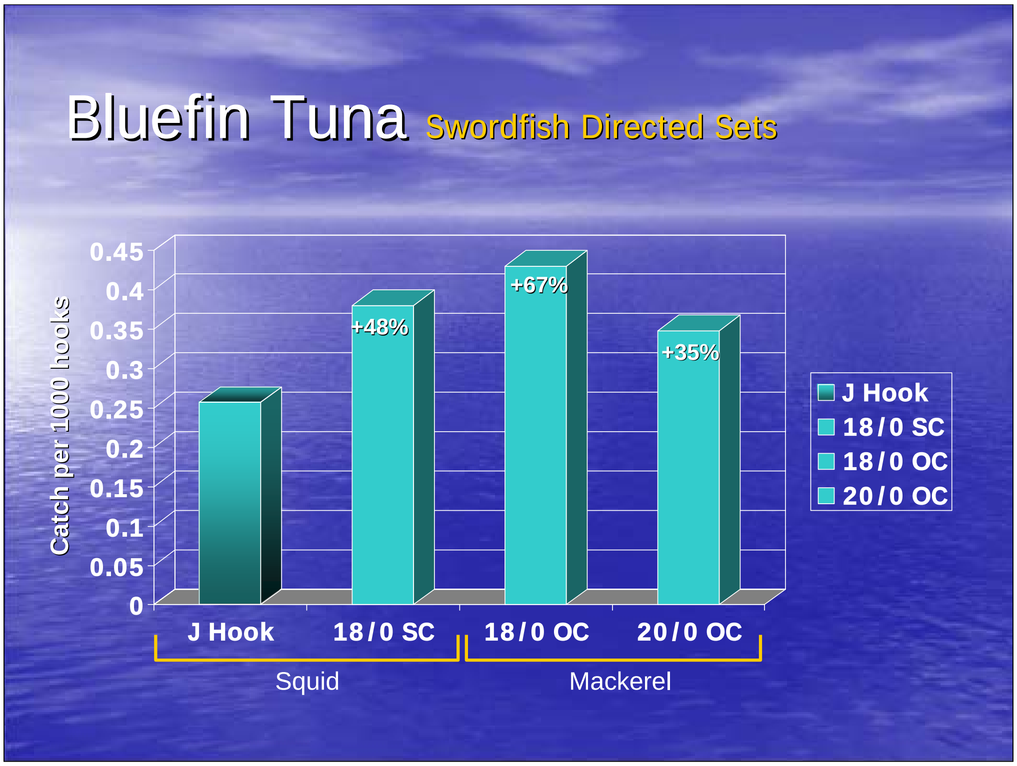
Summary

Effect of treatments on Swordfish Catch

- J Hook vs. Circle
  - Circle hooks reduced swordfish take
- Mackerel vs. Squid
  - Mackerel on offset circle hooks had a higher CPUE than did the Standard J Hook with squid
  - Difference between mackerel and squid is more dramatic in cooler water (away from turtles)
  - An overwhelming majority of swordfish interaction occurs at night and appears to be higher when the moon is in the sky

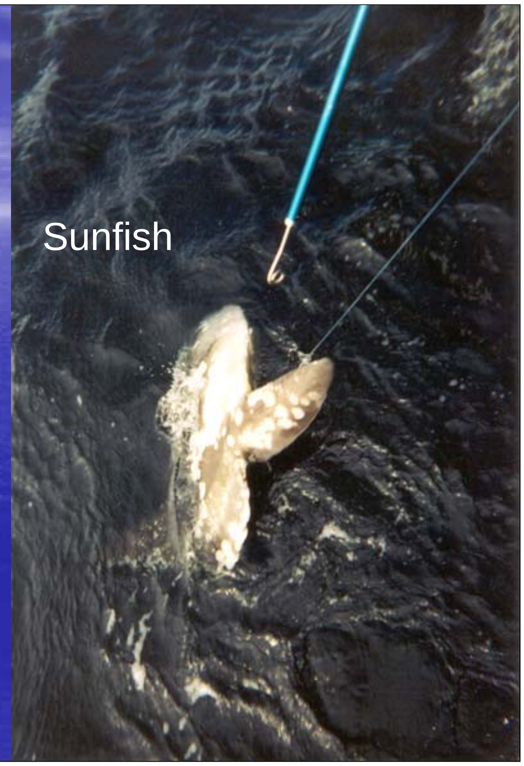


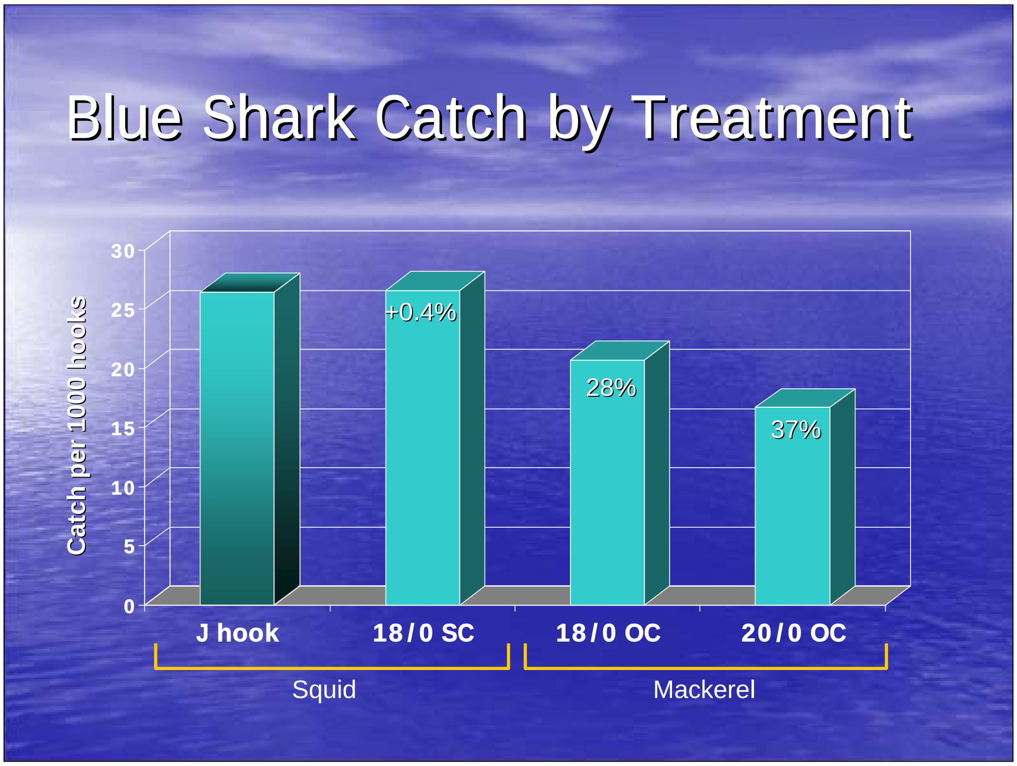
During the swordfish directed sets, bigeye tuna were caught as a byproduct. Compared to the J hook with squid, the 18/0 straight circle with squid resulted in an increase CPUE by weight of 20%. The 18/0 offset circle and 20/0 offset circle with mackerel resulted in an 83% and 90% decrease in bigeye catch respectively.



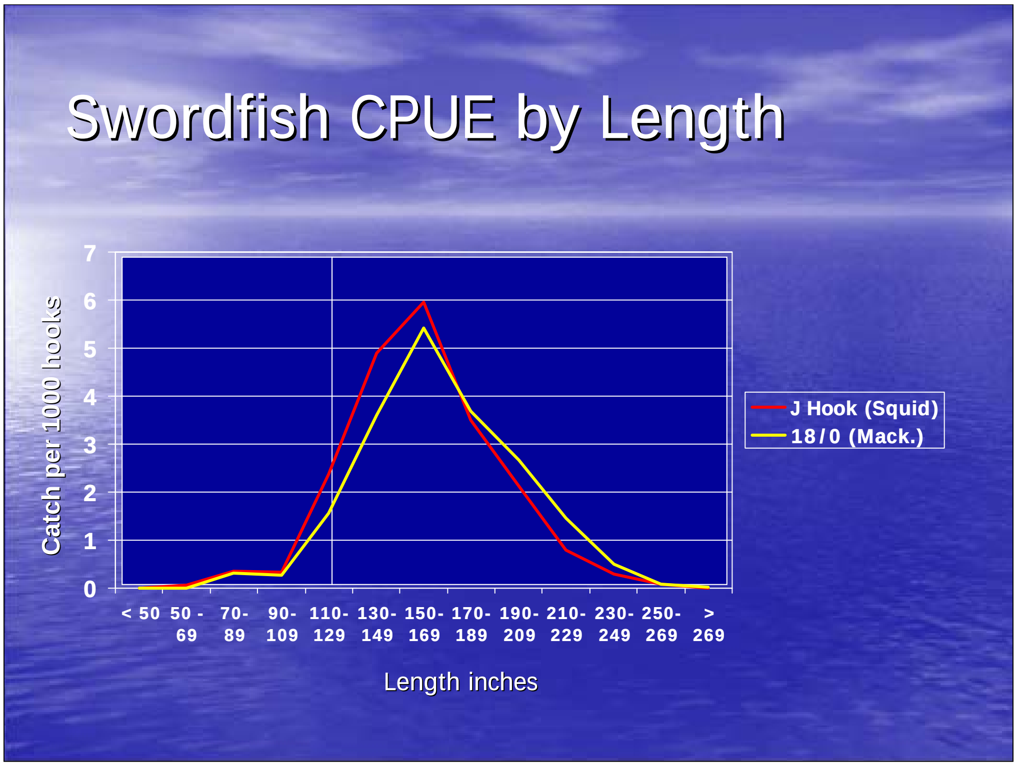
All experimental hook and bait combinations resulted in an increased catch of bluefin tuna. The 18/0 straight circles with squid, the 18/0 offset circle with mackerel and the 20/0 offset circle with mackerel resulted in an increase CPUE by weight of 48%, 67%, and 35% respectively.

Bycatch

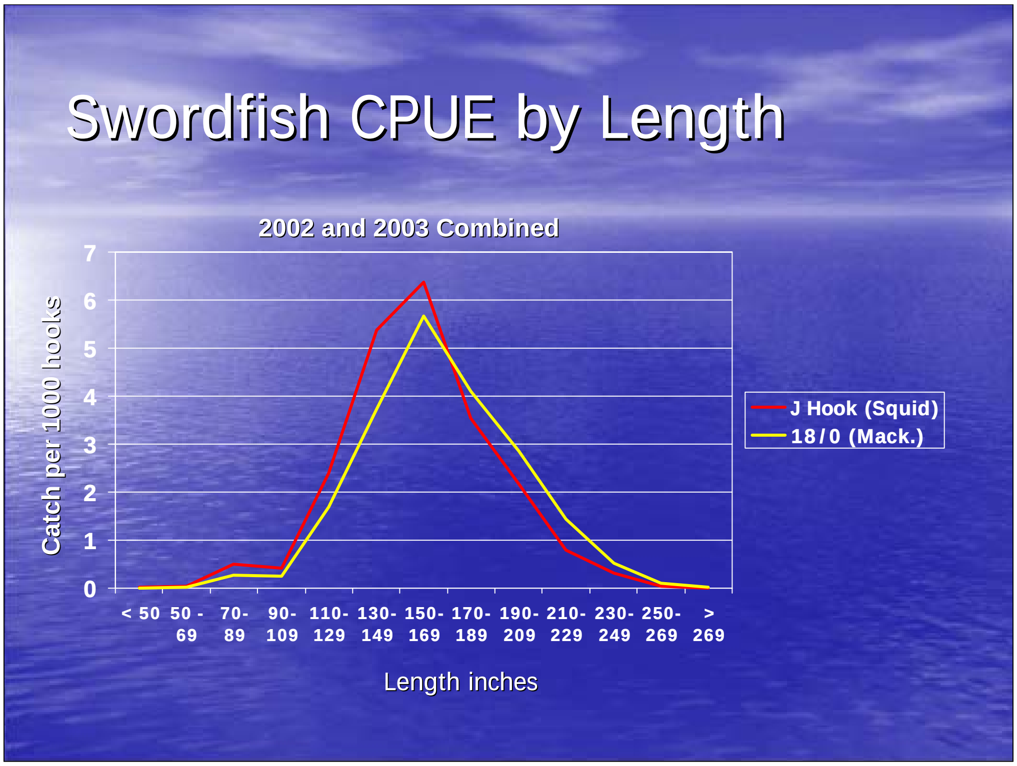




Comparing the effect of the experimental hook and bait combinations on blue shark bycatch, the 18/0 with squid had a slight increase of .4% while both mackerel bait/hook combinations resulted in a decrease in blue shark bycatch of 28% for the 18/0 and 37% for the 20/0.

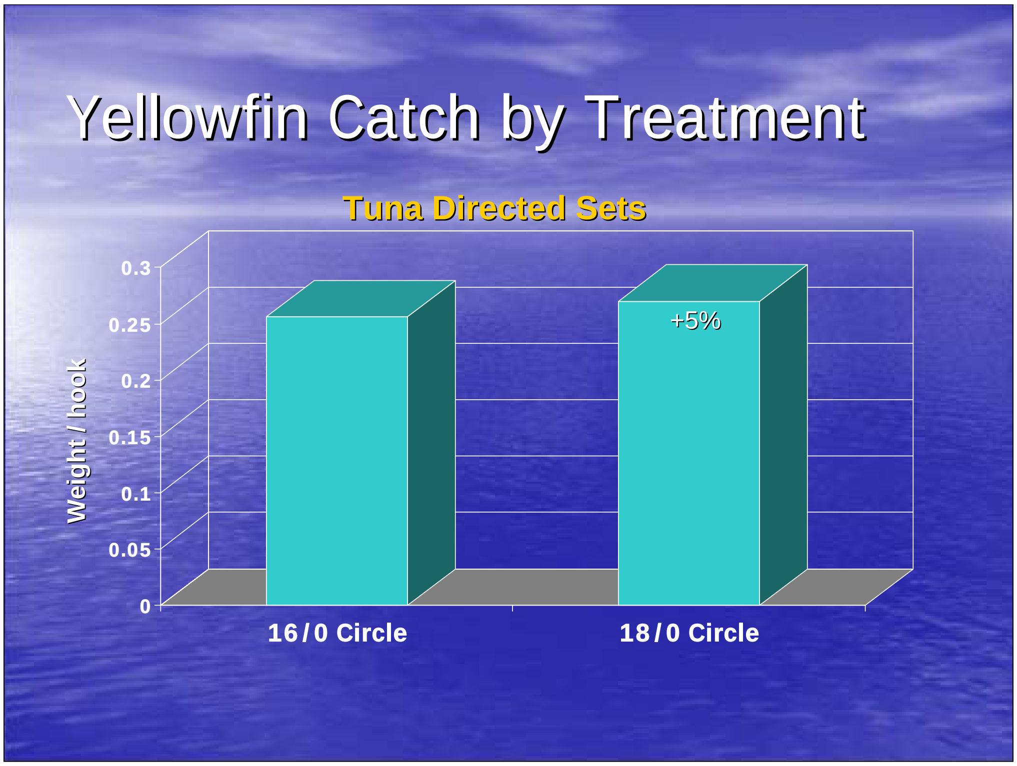


A comparison of the CPUE by count of swordfish by length for the J hook w/squid and the 18/0 offset circle w/mackerel show that the 18/0 w/mackerel reduced the take of swordfish under170 inches, including bycatch of swordfish under 120 inches.

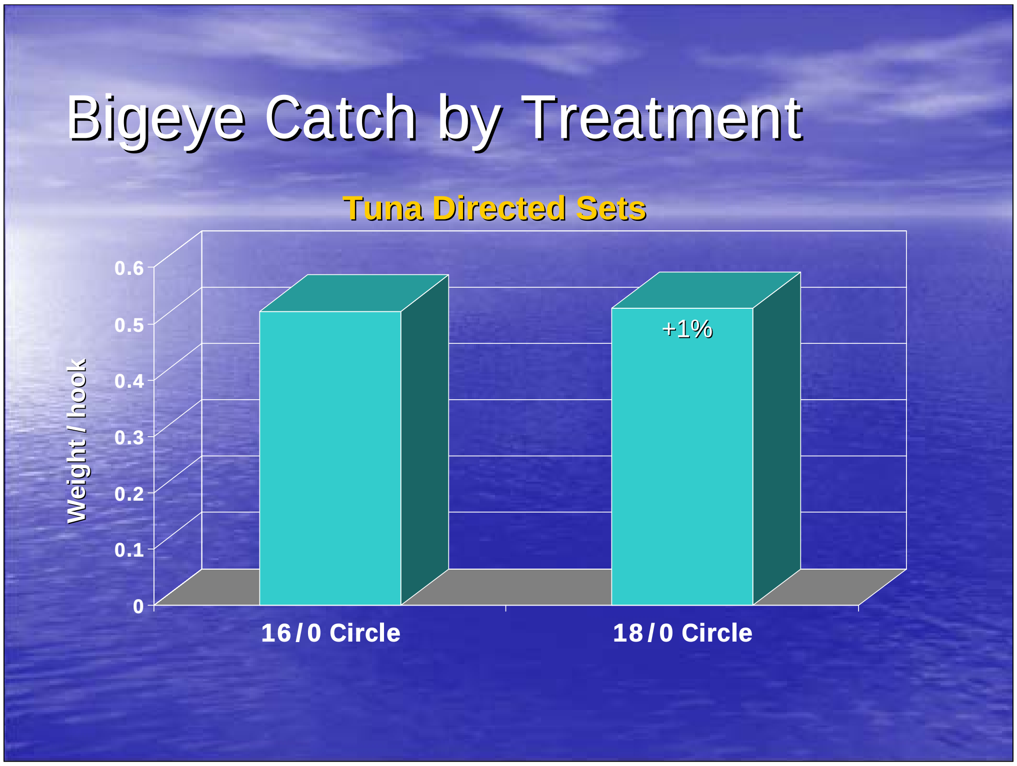


The same comparison was made with the data from 2002 and 2003. Again the 18/0 circle w/mackerel had a lower bycatch of undersize swordfish (< 120 inches).

Tuna Directed Sets



The experiment during the tuna directed sets resulted in an increase of 5% the CPUE by weight of yellowfin tuna with the 18/0 circle with squid as compared to the 16/0 with squid.



The bigeye tuna results for the tuna directed sets were similar to that of the yellowfins. The 18/0 circle with squid had a slightly higher (1%) CPUE by weight than did the 16/0 with squid.

Statistical Summary – Dr. Arvind Shah

<u>TREATMENTS (Trts) --- 2003 data</u>

A: 9/0 J Hook with Squid Bait (9JS) – CONTROL

B: 18/0 Circle Hook with Squid Bait (18CS)

C: 18/0 Circle Hook with Mackerel Bait (18CM)

D: 20/0 Circle Hook with Mackerel Bait (20CM)

E: 10/0 J tuna (Japanese) Hook with Mackerel Bait (10JM)

F: 16/0 Circle Hook with Squid Bait (16CS)

G: 18/0 Circle Hook with Squid Bait (18CS)

SWORDFISH DIRECTED SETS:

Set 1: Trt A (Control) versus Trt B (Expt) – 211 sets (225,266 hooks)

Set 2 : Trt C ("Control") versus Trt D (Expt) – 255 sets (275,670 hooks)

Set 3: Trt C ("Control") versus Trt E (Expt) – 44 sets (45,596 hooks)

TUNA DIRECTED SET:

Set 0: Trt F (Control) versus Trt G (Expt) – 29 sets (31,706 hooks)

TOTAL: 539 sets (~ 578,050 hooks)

Trt A: 211 sets (112,633 hooks)

Trt B: 211 sets (112,633 hooks)

Trt C: 299 sets (160,633 hooks)
– pooled from sets 2 & 3

Trt D: 255 sets (137,835 hooks)

Trt E: 44 sets (22,798 hooks)

Trt F: 29 sets (15,853 hooks)

Trt G: 29 sets (15,853 hooks)

CATCH COUNT BY SPECIES:

Trt	Sets	# hooks	#LH	#LB	#SF	#BT	#YT
A	211	112633	45	29	2345	266	4
B	211	112633	16	3	1549	333	0
C	299	160633	7	18	3170	59	0
D	255	137835	5	10	2530	31	0
E	44	22798	0	0	406	6	0
F	29	15853	13	4	167	175	95
G	29	15853	4	0	125	178	93
Total:			90	64	10,292	1048	192

CATCH PER HOOK (cph) - Counts :

Obs	trt	lhcph	lbcph	sfcph	btcph
1	A	.000399528	.000257473	0.020820	0.002362
2	B	.000142054	.000026635	0.013753	0.002957
3	C	.000043578	.000112057	0.019734	0.000367
4	D	.000036275	.000072551	0.018355	0.000225
5	E	0	0	0.017809	0.000263
6	F	.000820034	.000252318	0.010534	0.011039
7	G	.000252318	0	0.007885	0.011228

Percent hooks and catches (counts) by treatment (???)

trt	hooks	perhooks	perlh	perlb	persf	perbt	peryt
A	112633	19.4850	50.0000	45.3125	22.7847	25.3817	2.0833
B	112633	19.4850	17.7778	4.6875	15.0505	31.7748	0.0000
C	160633	27.7888	7.7778	28.1250	30.8006	5.6298	0.0000
D	137835	23.8448	5.5556	15.6250	24.5822	2.9580	0.0000
E	22798	3.9439	0.0000	0.0000	3.9448	0.5725	0.0000
F	15853	2.7425	14.4444	6.2500	1.6226	16.6985	49.4792
G	15853	2.7425	4.4444	0.0000	1.2145	16.9847	48.4375

Swordfish directed Set 1 [trt A (control), trt B (expt)]

Variable	N	Maximum	Sum	Mean	Std Dev
hooksset	211	1610.000	225191.000	1067.256	189.960
contlht	211	18.000	45.000	0.213	1.351
exptlht	211	5.000	16.000	0.076	0.441
contlbt	211	4.000	29.000	0.137	0.463
exptlbt	211	1.000	3.000	0.014	0.119
contsf	211	53.000	2345.000	11.114	9.082
exptsf	211	31.000	1549.000	7.341	6.321
contbt	211	31.000	266.000	1.261	3.178
exptbt	211	41.000	333.000	1.578	4.261

contlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	194	91.94	194	91.94
1	9	4.27	203	96.21
2	6	2.84	209	99.05
6	1	0.47	210	99.53
18	1	0.47	211	100.00

exptlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	201	95.26	201	95.26
1	8	3.79	209	99.05
3	1	0.47	210	99.53
5	1	0.47	211	100.00

contlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	188	89.10	188	89.10
1	20	9.48	208	98.58
2	1	0.47	209	99.05
3	1	0.47	210	99.53
4	1	0.47	211	100.00

exptlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	208	98.58	208	98.58
1	3	1.42	211	100.00

Swordfish directed Set 2 [trt C (‘control’), trt D (expt)]

Variable	N	Maximum	Sum	Mean	Std Dev
hooksset	255	1564.000	275578.000	1080.698	190.235
contlht	255	1.000	7.000	0.027	0.164
exptlht	255	1.000	5.000	0.020	0.139
contlbt	255	6.000	17.000	0.067	0.425
exptlbt	255	1.000	10.000	0.039	0.194
contsf	255	41.000	2791.000	10.945	7.771
exptsf	255	35.000	2530.000	9.922	7.075
contbt	255	4.000	42.000	0.165	0.514
exptbt	255	3.000	31.000	0.122	0.475

contlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	248	97.25	248	97.25
1	7	2.75	255	100.00

exptlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	250	98.04	250	98.04
1	5	1.96	255	100.00

contlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	243	95.29	243	95.29
1	11	4.31	254	99.61
6	1	0.39	255	100.00

exptlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	245	96.08	245	96.08
1	10	3.92	255	100.00

Swordfish directed -- Set 3 [trt C (‘control’), trt E (expt)]

Variable	N	Maximum	Sum	Mean	Std Dev
hooksset	44	1346.000	45580.000	1035.909	206.647
contlht	44	0.000	0.000	0.000	0.000
exptlht	44	0.000	0.000	0.000	0.000
contlbt	44	1.000	1.000	0.023	0.151
exptlbt	44	0.000	0.000	0.000	0.000
contsf	44	22.000	379.000	8.614	5.691
exptsf	44	25.000	406.000	9.227	6.265
contbt	44	5.000	17.000	0.386	0.895
exptbt	44	2.000	6.000	0.136	0.409

contlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	44	100.00	44	100.00

exptlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	44	100.00	44	100.00

contlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	43	97.73	43	97.73
1	1	2.27	44	100.00

Cumulative Cumulative

exptlbt	Frequency	Percent	Frequency	Percent
0	44	100.00	44	100.00

Tuna Directed set -- Set 0 [trt F (‘control’), trt G (expt)]

Variable	N	Maximum	Sum	Mean	Std Dev
hooksset	29	1440.000	31701.000	1093.138	276.860
contlht	29	5.000	13.000	0.448	1.121
exptlht	29	2.000	4.000	0.138	0.441
contlbt	29	3.000	4.000	0.138	0.581
exptlbt	29	0.000	0.000	0.000	0.000
contsf	29	17.000	167.000	5.759	3.651
exptsf	29	13.000	125.000	4.310	3.537
contbt	29	38.000	175.000	6.034	8.174
exptbt	29	34.000	178.000	6.138	8.145

contlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	23	79.31	23	79.31
1	3	10.34	26	89.66
2	1	3.45	27	93.10
3	1	3.45	28	96.55
5	1	3.45	29	100.00

exptlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	26	89.66	26	89.66
1	2	6.90	28	96.55
2	1	3.45	29	100.00

contlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	27	93.10	27	93.10
1	1	3.45	28	96.55
3	1	3.45	29	100.00

exptlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	29	100.00	29	100.00

trts C combined ('control' from sets 2 and 3)

Variable	N	Minimum	Maximum	Sum	Mean	Std Dev
hooksset	299	80.000	1564.000	321158.000	1074.107	193.030
contlht	299	0.000	1.000	7.000	0.023	0.151
contlbt	299	0.000	6.000	18.000	0.060	0.397
contsf	299	0.000	41.000	3170.000	10.602	7.538
contbt	299	0.000	5.000	59.000	0.197	0.589

contlht	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	292	97.66	292	97.66
1	7	2.34	299	100.00

contlbt	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	286	95.65	286	95.65
1	12	4.01	298	99.6
6	1	0.33	299	100.00

reduction rates (in counts) and 95% confidence intervals:

species	trtcomp	cphcont	cphexpt	redrate	lcl	ucl	pvalchi
LH	A1vsB1	0.000400	0.000142	64.444	37.11	79.91	0.0002
LH	A1vsC23	0.000400	0.000044	89.093	75.82	95.08	0.0001
LH	A1vsD2	0.000400	0.000036	90.920	77.13	96.40	0.0001
LB	A1vsB1	0.000257	0.000027	89.655	66.05	96.85	0.0001
LB	A1vsC23	0.000257	0.000112	56.478	21.64	75.83	0.0043
LB	A1vsD2	0.000257	0.000073	71.822	42.19	86.27	0.0002

reduction rates (in weight) and 95% confidence intervals:

species	trtcomp	cphcont	cphexpt	redrate	lcl	ucl	pvalchi
SF	A1vsB1	1.747	1.248	28.54	21.20	35.89	0.0001
SF	A1vsC23	1.7465	1.9531	-11.852	-27.083	3.435	0.1286
SF	A1vsD2	1.7465	1.8816	-7.730	-23.533	8.090	0.3373
BT	A1vsB1	0.135	0.163	-20.24	-51.82	11.35	0.2079
BT	A1vsC23	0.1355	0.0231	82.952	56.162	100.000	0.0001
BT	A1vsD2	0.1355	0.0132	90.185	61.697	100.000	0.0001

INDIVIDUAL AND COMBINED YEARS COMPARISONS (COUNTS):

year	species	trtcomp	cphcont	cphexpt	redrate	lcl	ucl	pvalchi
2002	LH	A1vsB1	.000444871	.000055609	87.5000	64.67	95.58	.0001
2003	LH	A1vsB1	.000399528	.000142054	64.4444	37.11	79.91	.0002
COMB	LH	A1vsB1	.000417199	.000108363	74.0260	57.53	84.12	.0001
2002	LH	A1vsC23	.000504551	.000042259	91.6243	73.43	97.36	.0001
2003	LH	A1vsC23	.000399528	.000043578	89.0927	75.82	95.08	.0001
COMB	LH	A1vsC23	.000458223	.000043174	90.5780	82.04	95.06	.0001
2002	LB	A1vsB1	.000500480	.000180729	63.8889	31.93	80.86	.0010
2003	LB	A1vsB1	.000257473	.000026635	89.6552	66.05	96.85	.0001
COMB	LB	A1vsB1	.000352181	.000086691	75.3846	57.47	85.76	.0001
2002	LB	A1vsC23	.000504551	.000169038	66.4974	38.29	81.82	.0002
2003	LB	A1vsC23	.000257473	.000112057	56.4783	21.64	75.83	.0043
COMB	LB	A1vsC23	.000395560	.000129521	67.2564	50.79	78.22	.0001
					???			

INDIVIDUAL AND COMBINED YEARS COMPARISONS (WEIGHTS):

year	species	trtcomp	cphcont	cphexpt	redrate	lcl	ucl	pvalchi
2002	SF	A1vsB1	1.8044		32.577	23.130	42.025	0.0001
2003	SF	A1vsB1	1.7465		28.54	21.20	35.89	0.0001
COMB	SF	A1vsB1	1.7720		30.35	24.512	36.190	0.0001
2002	SF	A1vsC23	1.9382	2.5269	-30.3890	-46.8992	-13.879	0.0012
2003	SF	A1vsC23	1.7465	1.9531	-11.8523	-27.0827	3.435	0.1286
COMB	SF	A1vsC23	1.8632	2.1539	-15.6183	-26.4062	-4.830	0.0051
2002	BT	A1vsB1	0.2146		-29.23	-50.94	-7.514	0.0086
2003	BT	A1vsB1	0.1355		-20.24	-51.83	11.346	0.2079
COMB	BT	A1vsB1	0.1703		-25.226	-43.688	-6.764	0.0075
2002	BT	A1vsC23	0.2037	0.0386	81.0015	47.9136	114.138	0.0001
2003	BT	A1vsC23	0.1355	0.0231	82.9520	56.1624	109.668	0.0001
COMB	BT	A1vsC23	0.1770	0.0285	83.8418	63.4463	104.294	0.0001
					????			

FURTHER WORK:

INCORPORATE EFFECT OF SOAK TIME (DAY & NIGHT), TEMPERATURE, AND OTHER INFLUENCIAL VARIABLES THROUGH MODELING OF CATCH.

USE RATIO ESTIMATE FOR POSSIBLY SHORTER CONFIDENCE INTERVALS ON REDUCTION RATES

NED 2003

SEA TURTLE DEMOGRAPHICS AND EXPERIMENT RESULTS

Sheryan Epperly

This is a review of the 2003 results of the NED Experiment, in partial fulfillment of the annual reporting requirements of permit #1429. The results for the 2001 & 2002 experiments can be found posted as watson1.pdf and watson2.pdf at http://www.mslabs.noaa.gov/mslabs/docs/pubs.html.

OUTLINE

Incidental Take

Sea Turtle Demographics

- Genetics
- Size Distributions

Leatherback Lift

NED Experiment Results

- Hook Locations
- Hooks Removed
- Careful Release Protocols

This is an outline of the presentation.

I want to stress that these results are very preliminary and may be subject to change.

We have not had much time to complete these analyses and they were done under a lot of stress to meet today's deadline. We have had no opportunity to review the analyses and check for errors.

INCIDENTAL TAKES NED 2003

Species	Description	Take Statement		Actual Take
		Live	Dead	All Live
Loggerhead	Longline	172	2	82
	& PAT tag	15		4
	& Satellite tag	15		6
	Dipnet & PAT tag	15	0	14 / 10 tagged
Leatherback	Longline	160	2	79
Kemp's Ridley	Longline	2	1	0
	Dipnet	0		1
Hawksbill	Longline	2		0
Green	Longline	2		0
Olive Ridley	Longline	2		1
Unidentified Hardshell	Longline	2		0

We were authorized to capture 202 loggerheads on longlines, PAT tag 15 of them and satellite tag another 15.

We caught 92 on longline and PAT tagged 4 and put satellite tags on 6.

Additionally, we were authorized to dipnet and PAT tag 15 loggerheads.

We dipnetted 15 turtles: 14 loggerhead and 1 Kemp's ridley (which was not authorized) and PAT tagged 10 loggerheads.

We were authorized to capture 160 leatherbacks on longlines and we captured 79; 5 of these were boated.

We were authorized to capture via longlines 2 each of Kemp's Ridley, Hawksbill, Green, Olive Ridley, or Unidentified Hardshell.

We caught 1 Olive Ridley.

All sea turtles were released alive.

The identification of the 2 ridleys was confirmed by photographs and the DNA samples.

I am very proud of the observers for correctly identifying these 2 animals.

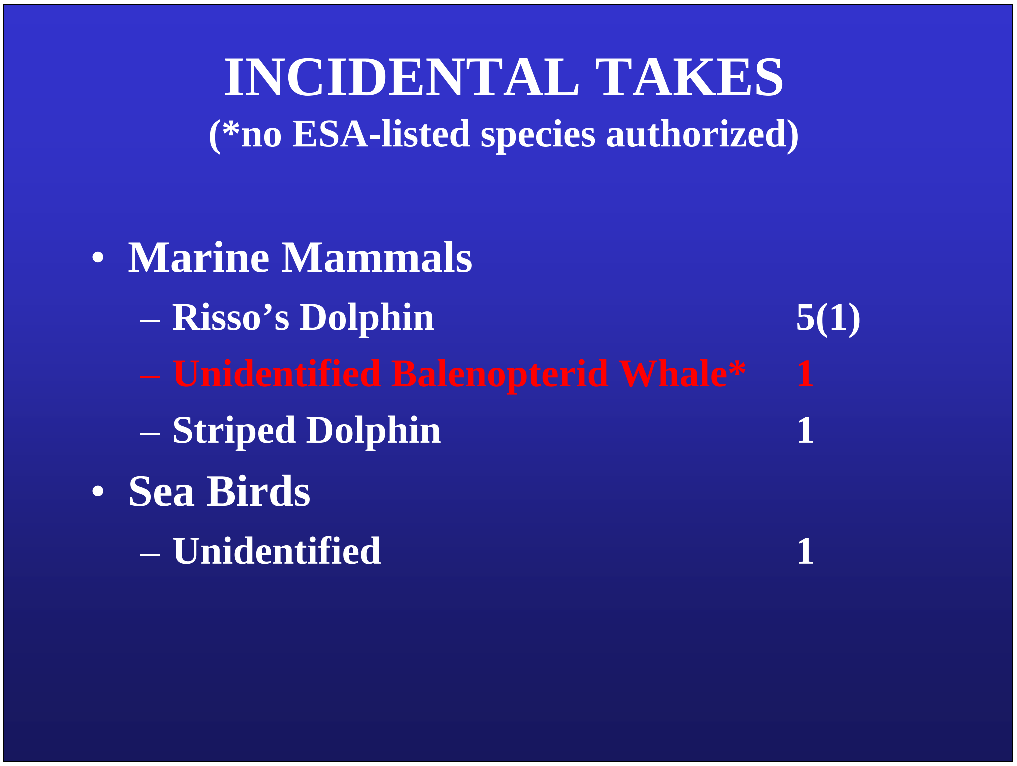
Here are pictures of the 2 ridleys captured on the Grand Banks in 2003.

The olive ridley is on the left and the Kemp’s ridley is on the right.

Below each is a better photograph of the 2 species, but not of the animals captured in our study.

Note the round shape of the carapace and, for the olive ridley, the high lateral scute count.

Both have inframarginal pores.



MARINE MAMMALS

On the longlines we captured 5 Risso's dolphins, 1 unidentified balenopterid whale – likely a fin or sei whale, and 1 striped dolphin.

One Risso's dolphin was released dead (it has swallowed the hook).

The other mammals were released alive.

We did not have authorization to take an ESA-listed marine mammal – the whale, but we reported it within 24 hours.

Fortunately, it was released in apparently good shape with no gear remaining on the animal.

It possibly was a sei or a fin whale.

It was dragging 3 floats and a beeper, but slid off the gear (parted end) quickly.

It dragged the gear approximately 5 miles. All gear was recovered.

1 Risso's was hooked in the tail. All but 6" of line was removed. Animal was released with hook.

1 Risso's & 1 striped dolphin were entangled only and were released without any gear attached.

1 Risso's was entangled and hooked. All gear was removed.

1 Risso's was caught, but leader broke and animal swam away with hook and 33 ft. of monofilament

SEABIRDS

There was one seabird captured, possibly a shearwater. It was entangled, but not hooked. It was dead.

GENETIC SAMPLES

	Loggerheads	Leatherbacks
2001	125	0
2002	100	124
2003	101	62
Total	326	186

Over the 3 year period we have collected 326 biopsies of loggerheads and 186 biopsies of leatherbacks, in addition to the samples taken from the 1 olive ridley and the 1 Kemp's ridley.

These samples are being analyzed to determine the genetic origins of the foraging populations.

They are being processed at the Sea Turtle Molecular Genetics Lab, a NMFS SWFSC Lab in La Jolla, CA.

Dr. Peter Dutton has just provided us some preliminary results.

He and his colleagues there will continue to process the samples and analyze the data.

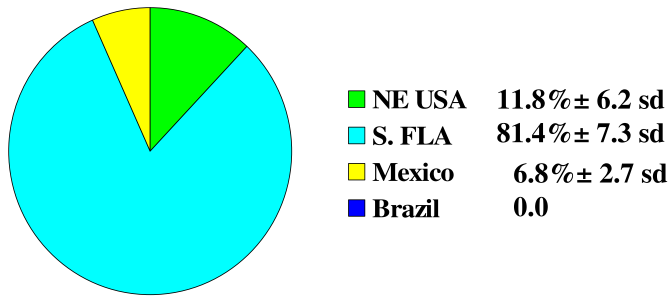
They will prepare a report for us by the end of the month and they will present 2 posters on these results at the upcoming Sea Turtle Symposium in San Jose, Costa Rica, in February.

Peer reviewed manuscripts will be submitted for review and publication.

Here are those preliminary results:

Estimated Stock Composition of Loggerheads in NED

Based von mtDNA analysis of 279 samples



NE USA=Amelia Island, Georgia, South Carolina, North Carolina

Sea Turtle Molecular Genetics Lab, NMFS SWFSC, La Jolla, CA

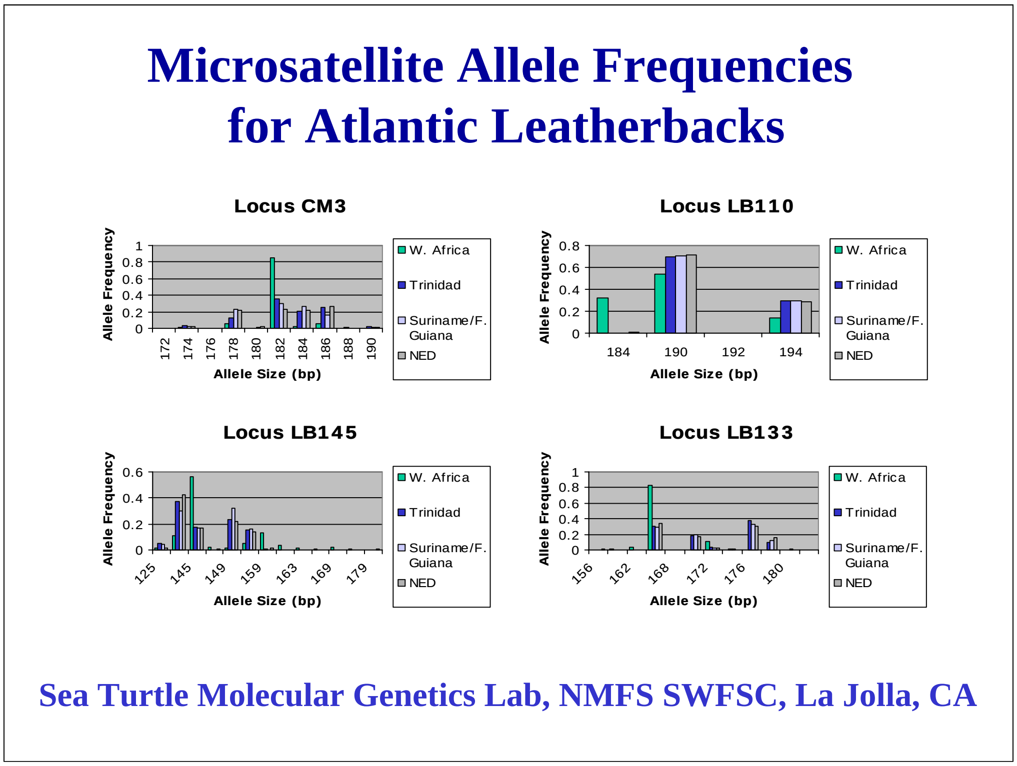
Haplotypes may be shared by the subpopulations; sometimes they are unique.

The foraging population is analyzed and then statistical models are used to predict how the resolved haplotype frequencies could have been obtained given the possible source populations.

Summary - Loggerheads

- A total of 279 samples have been analyzed to date using mtDNA sequence data
- Preliminary analysis suggests most of the loggerheads encountered in the NED are of South Florida nesting stock (>80%)
- The NE US nesting stock contributes approx. 12% of the NED bycatch
- Results should be interpreted with caution: further analysis ongoing

There are about 50 more samples to process and include for the final analysis.



This slide shows results for 4 of the 12 microsatellite loci that we have analyzed.

These are representative results to illustrate that these markers detect significant differences between West Africa rookeries and Caribbean (even though this was not possible with mtDNA).

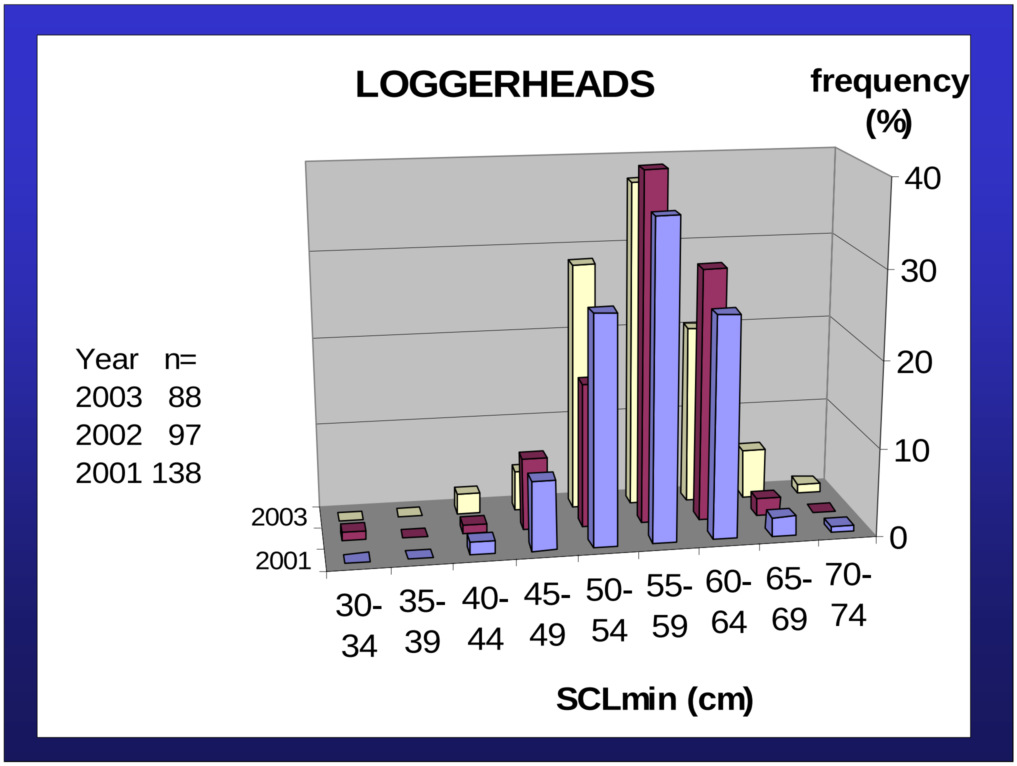
E.g. Locus LB110 has a relatively common allele found in West Africa (“Purple” Allele 184bp found at approx. 30% frequency) that is absent in Trinidad and Costa Rica, as well as in the NED, suggesting that animals caught in NED are primarily from Caribbean (W. Atlantic) stock.

Note that frequencies of the other alleles (190 and (194) Locus LB110) for NED incidental take (light blue) are almost identical to those in the these Caribbean rookeries (red and yellow), and different from W. Africa.

Same pattern for the other 3 markers (loci) illustrated here (CM3, LB145 & LB133).

Summary - Leatherbacks

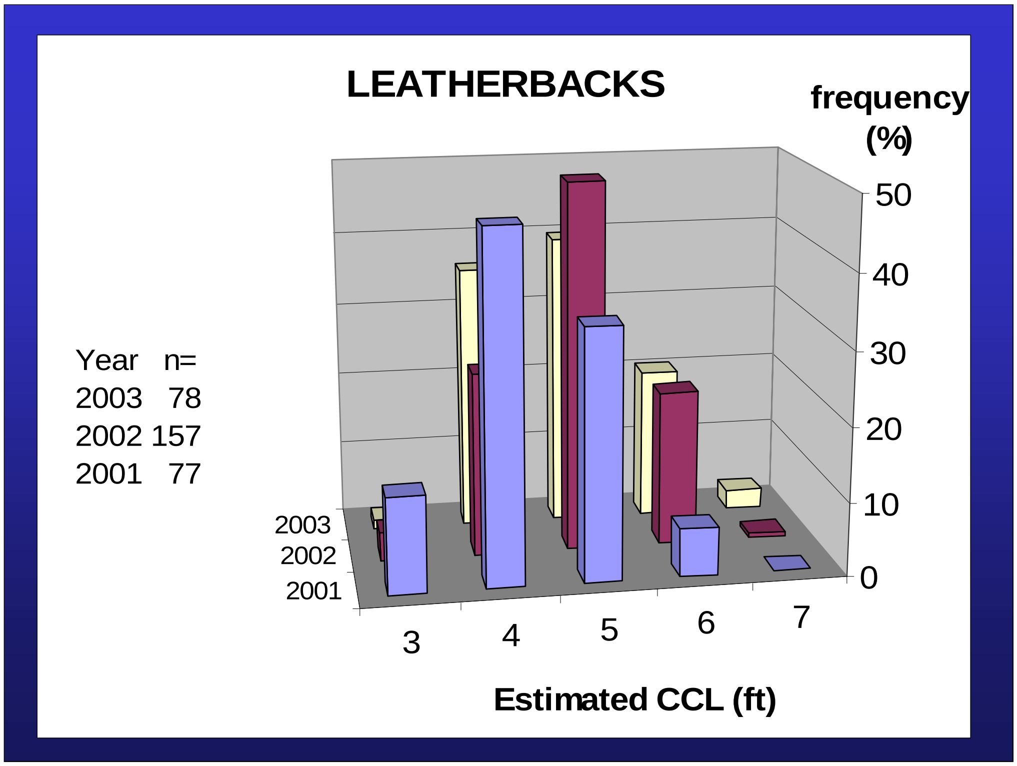
- The array of 12 Microsatellite markers we have developed are useful for Atlantic leatherback stock ID
- Leatherback encountered in the NED Fishery are primarily from Western Atlantic (Caribbean) breeding populations rather than West African or South African stocks
- Further mixed-stock analysis of these microsatellite data is underway using Bayesian methods to estimate % stock contribution (and CVs) to NED leatherback bycatch.



SIZE DISTRIBUTIONS (standard straight line carapace length)

The size distributions for loggerheads were very similar among the years *(ANOVA, p=0.95).*

Turtles ranged from 32.4 – 72.0 cm SCL(min) and averaged 56.8 cm *(N=323).*



With rare exception, leatherback carapace lengths were estimates because they rarely were boated.

The turtles ranged from 3-7 ft.

Estimates in 2001 were in metric units and in ft. in the following years.

This may be the source of the diffences in estimated sizes between 2001 and the following years.

In a group effort, we designed and constructed a leatherback lift to bring the large turtles aboard in order to remove gear and to collect biological data.

The Eagle Eye II used this lift to boat 4 leatherbacks. Only 1 other leatherback was boated during 2003.

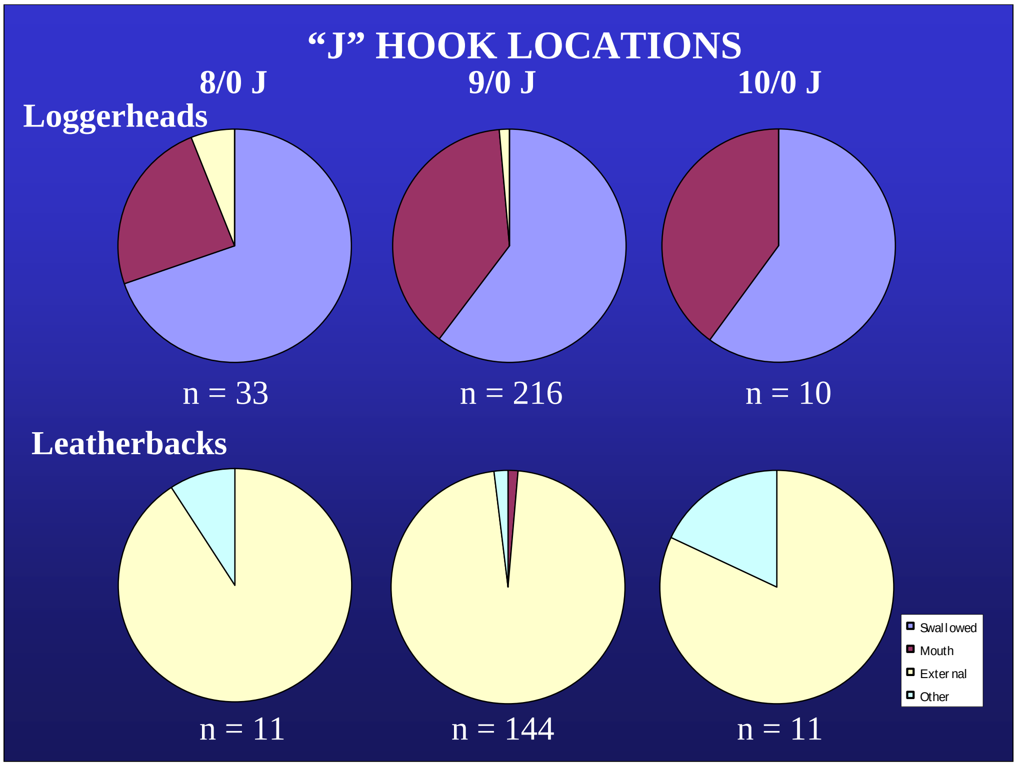
All gear was removed and the turtles were fully worked up for biological data.

We will be viewing the video “Leatherbacks Aboard” later.

A *.mpeg version will be posted on the SEFSC website at http://www.sefsc.noaa.gov/seaturtlefisheriesobservers.jsp

Currently the video can be viewed by accessing the NOAA website for the NED experiments:

http://www.nmfs.noaa.gov/mediacenter/turtles/



Now I will discuss the hook locations: first the locations and then the size of the turtles caught relative to size of hooks and swallowed hooks.

This shows the difference in the proportion of animals swallowing the hook among the 3 “J” hook sizes used in the experiment.

During 2001 all 3 hooks sizes were used. During 2002 and 2003 only the 9/0 size was used.

The proportion of swallowed hooks by loggerheads was highest with the smallest 8/0 hook *(chi-sq p<0.005).*

We don’t see any differences between the 9/0 and 10/0, but that may be because of the small sample size caught on the 10/0 hooks.

Similarly, sample size for the leatherbacks caught on the 8/0 and 10/0 hooks is also small.

Most leatherbacks are caught by foul hooking on the external surfaces of the body – mainly across the shoulders, in the armpit, and on the front flippers.

There is no significant difference among these 3 sizes for leatherbacks.

Loggerheads: *-chi-square comparison with 9/0 J hook*

8/0 (69.7% swallowed, 24.2% mouth, 6.1% other) - chi-sq=7.4, p<0.025

9/0 (60.2% swallowed, 38.4% mouth, 1.4% other)

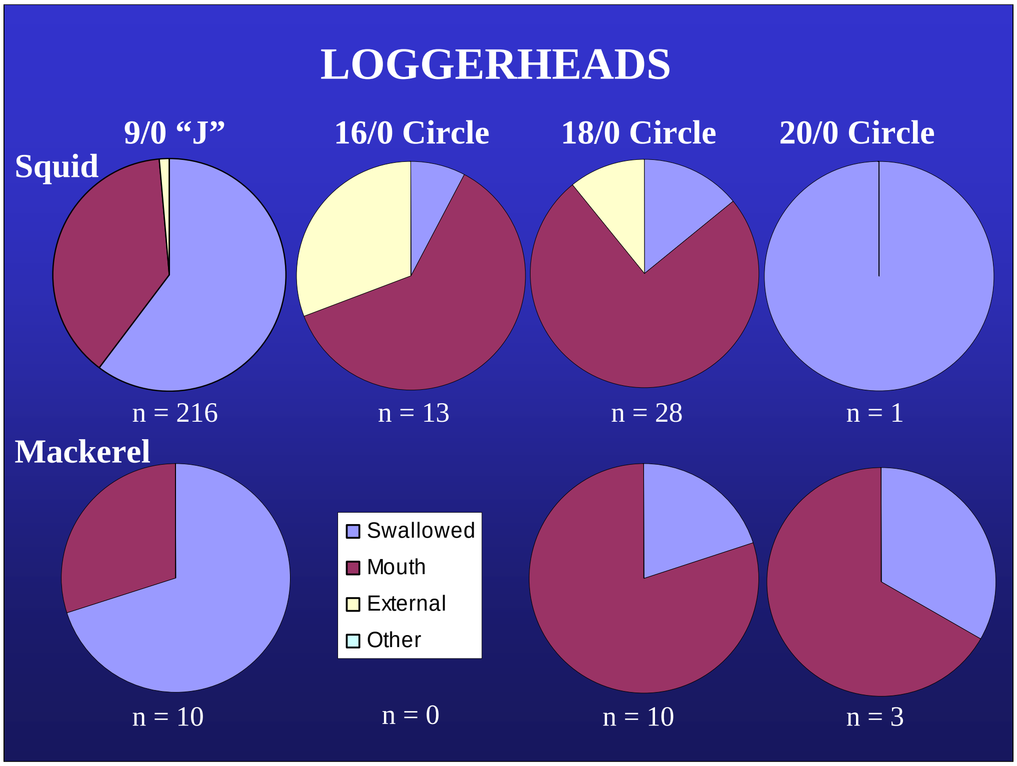
10/0 (60% swallowed, 40% mouth) - chi-sq=0.15, Not significant

Leatherbacks:

8/0 (90.9% external, 9.1 % other) – chi-sq=0.19, Not significant

9/0 (1.4% mouth, 96.5% external, 2.1% other)

10/0 (81.8% external, 18.2% other) – chi-sq=0.40, Not significant



This shows the differences between the control - 9/0 "J" hook baited with squid - and mackerel on the "J" hooks and both baits on the circle hooks for 2001-2003.

The 9/0 "J" hook was used all 3 years.

The 18/0 hook was used during 2002 and 2003.

The 16/0 and the 20/0 hooks were used only during 2003.

The sample size for the 20/0 hook is too small to say anything about.

Comparing the "J' hooks to the 16/0 and 18/0 circle hooks, proportionally fewer loggerhead turtles swallow circle hooks than swallow the "J" hooks *(Chi-square, p<0.005)*, whether the bait be mackerel or squid.

There is no statistically significant difference between the 16/0 and 18/0 hooks.

Squid: J (60.2% Swallowed, 38.4% mouth, 1.4% external) - chi sq comparisons with "J")

18/0 (14.3% swallowed, 75% mouth, 10.7% external) - chi-sq=37.1, p<0.005

20/0 (100% mouth)

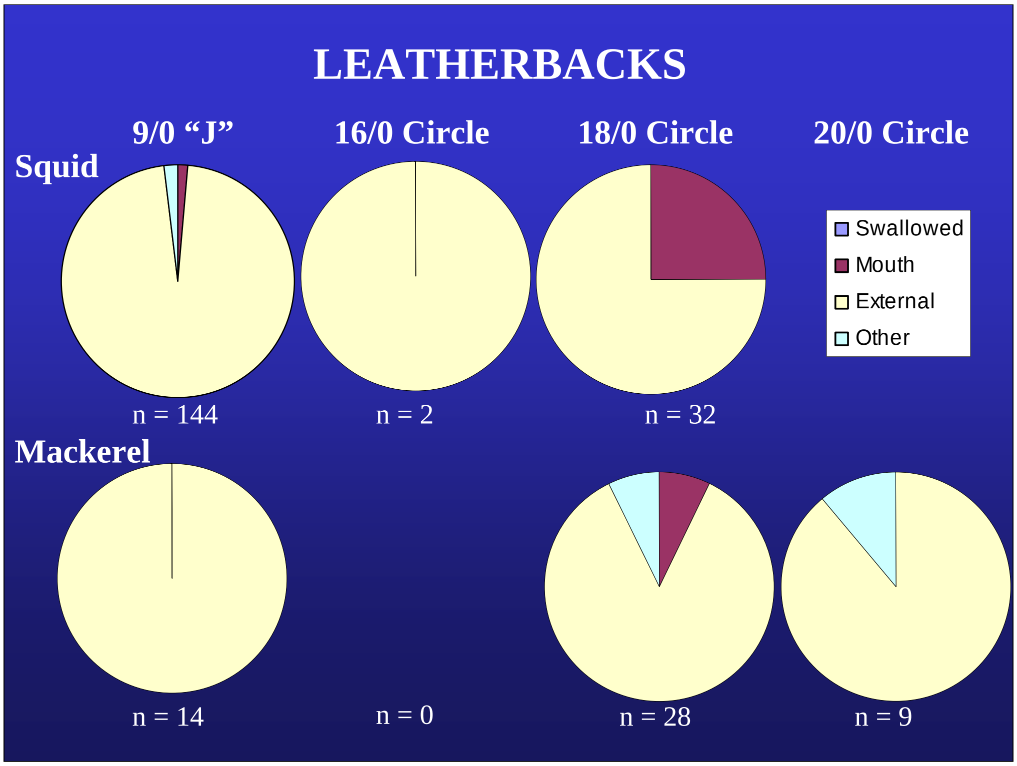
16/0 (7.7% swallowed, 61.5% mouth, 30.8% external) – chi-sq=88.6, p<0.005

comparing 16/0 to 18/0 for squid: chi-sq=5.59, Not significant

Mackerel: J (70% swallowed, 30% mouth)

18/0 (20% swallowed, 80% mouth) – chi-sq=11.9, p<0.005

20/0 (33.3% swallowed, 66.7% mouth)



This shows the differences between the control - 9/0 "J" hook baited with squid and mackerel on the "J" hooks and both baits on the circle hooks for 2001-2003.

The 9/0 "J" hook was used all 3 years.

The 18/0 hook was used during 2002 and 2003.

The 16/0 and the 20/0 hooks were used only during 2003.

The sample size for the 16/0 hook is too small to say anything about.

Leatherbacks are most often foul hooked, but the circle hooks apparently do allow the turtles to sometimes get the baits to their mouths when the hook is baited with squid *(chi-square, p<0.005)*.

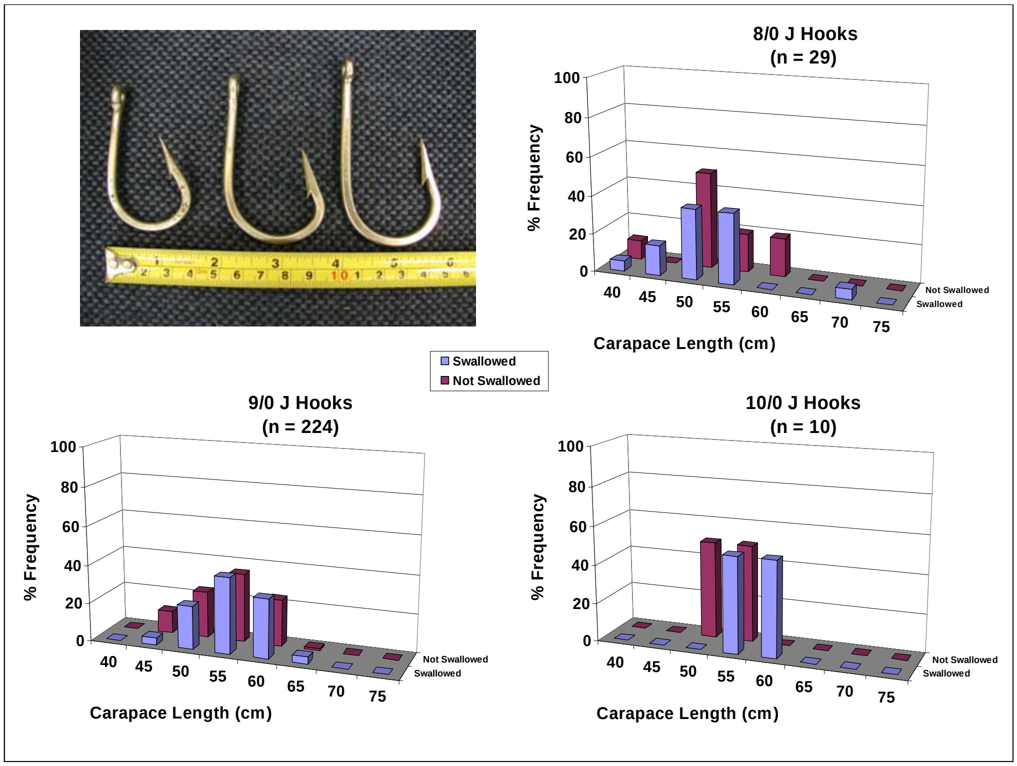
Dr. Jeanette Wyneken may be able to shed some light on this.

She is a professor at Florida Atlantic University – a functional morphologist who studies reptile anatomy, swimming, and behavior.

I would like to ask Jeanette to explain how leatherbacks swim and how that differs from all other sea turtle.

Squid: 9/0 J (1.4% mouth, 96.5% external, 2.1% other) – chi-sq comparisons with "J" hook
18/0 (25% mouth, 75% external) – chi-sq=130.6, p<0.005
16/0 (100% external)

Mackerel: J (100% external)
18/0 (7.1% mouth, 85.7% external, 7.1% other)-chi-sq=0.57, Not significant
20/0 (88.9% external, 11.1% other) – chi-sq=0.11, Not significant



This shows the size of loggerheads caught relative to hook size for the 3 “J” hooks used: 8/0, 9/0, and 10/0 (**swallowed: 8/0, n=19; 9/0, n=137; 10/0, n=6**).

Remember that there is a broad size range of turtles in the area and that the pelagic longlines are selective, catching only the largest of the turtles.

This selection likely varies as a function of hook size.

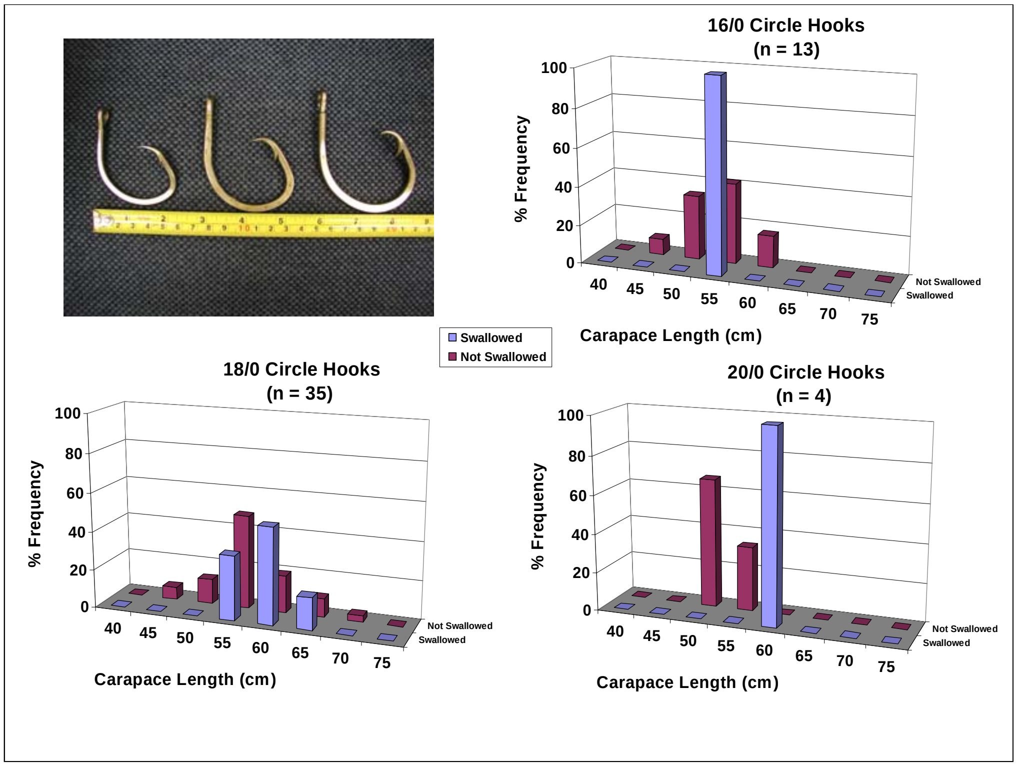
The turtles caught on the 8/0 hooks are smaller than the turtles caught on the larger hooks; the size distributions for the 3 hook sizes are not the same *(ANOVA, p=0.02; Kruskal-Wallis, p=0.01; Median, p=0.02; Van der Waerden, p=0.03; Savage 1-way, p=0.16)*

Generally, for a given hook size, it appears that turtles that swallowed the hook are larger than the turtles that did not (see below), and that there is a difference in sizes of the turtles that swallowed the hook among hook sizes *(ANOVA, p=0.01; Kruskal-Wallis, p< 0.01; Median, p=0.07; van der Waerden, p<0.02).* This holds true for the 9/0 and the 10/0 hooks, but not the 8/0 hook.

For the 8/0 hooks. The size distribution of turtles that swallowed the hook is not different than the distribution of those that did not (ANOVA, p=0.94; Wilcoxon, p=0.48; Kruskal-Wallis, p=0.94; Median, p=0.26; Median 1-way, p=0.52; Van der Waerden, p=0.49; Van der Waerden 1-way, p=0.98; Savage p=0.49; Savage 1-way, p=0.97; Kolmogorov- Smirnov, p=0.99; Kuiper, p=0.96).

For the 9/0 hook, the mean sizes of the 2 groups and the distributions are significantly different (ANOVA, p=0.02; Wilcoxon, p=0.02, Wilcoxon 1-sided, p=0.02; Kruskal-Wallis, p=0.03; Median, p=0.06, Median 1-way, p=0.11; Van der Waerden, p<0.01; Van der Waerden 1-way, p=0.02; Savage, p=0.05; Savage 1-way, p=0.10; Kolmogorov-Smirnov, p=0.07, Kuiper, p=0.29).

For the 10/0 hook, the mean sizes of the 2 groups and the distributions are significantly different (ANOVA, p<0.01; Wilcoxon, p=0.01, Wilcoxon 1-sided, p=0.02; Kruskal-Wallis, p=0.02; Median, p=0.07, Median 1-way, p=0.14; Van der Waerden, p<0.01; Van der Waerden 1-way, p=0.02; Savage, p=0.02; Savage 1-way, p=0.04; Kolmogorov-Smirnov, p=0.06, Kuiper, p=0.36)

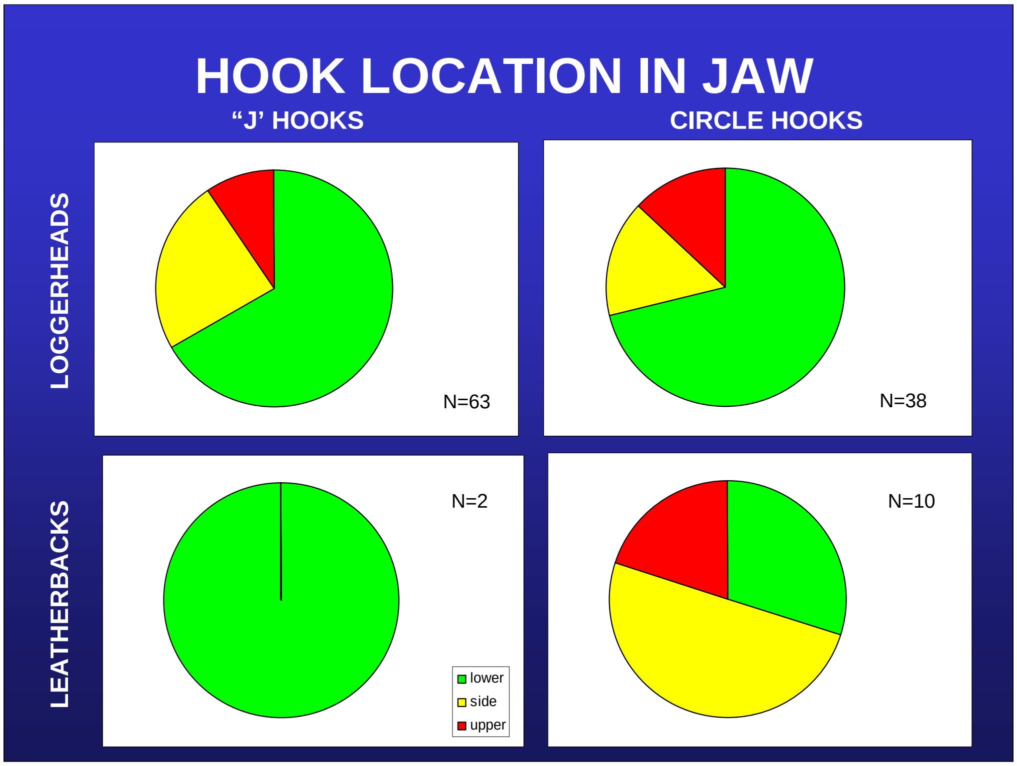


This shows the size of loggerheads caught relative to hook size for the 3 circle hooks used: 16/0, 18/0, and 20/0.

Because only 1 turtle swallowed the 16/0 hook and only 1 swallowed the 20/0 hook, the sample size is too small to say anything about.

Although the distributions appear different for the 18/0 hook, there is no significant differences in the sizes of turtles that swallowed the 18/0 circle hooks (offset and non-offset combined, or separately) *(ANOVA, p=0.29; Wilcoxon, p=0.12; Kruskal-Wallis, p=0.23; Median, p=0.17; Median 1-way, p=0.34; van der Waerden, p=0.12; van der Waerden 1-way, p=0.24; Savage, p=0.19, Savage 1-way, p=0.37; Kolmogorov-Smirnov, p=0.37).*

I believe that as sample size increases we will see a difference in the size distributions caught and the sizes of turtles swallowing the hooks.



This shows the hooks in the different jaw locations: lower jaw (green), side of mouth (yellow), and upper jaw (red) for the 2 styles of hooks: "J" hooks and circle hooks (all sizes and baits combined).

We have seen that circle hooks are more likely to engage in the jaw than J hooks.

For those turtles that are hooked in the mouth by either style, most of the time the hooks lodge in the lower jaw or side of the jaw.

There is no statistically significant difference in location for loggerheads.

The sample size of leatherbacks caught on "J" hooks precludes a comparison for that species, but more are being mouth hooked with circle hooks.

LOGGERHEADS

J-hooks (% in locations)

lower	*side*	*upper*
71.05	*15.79*	*13.16*

Circle Hooks

66.67	*23.81*	*9.52 – chi-sq=1.66, Not significant*

LEATHERBACKS

J-hooks

30	*50*	*20*

Circle Hooks

100	*0*	*0*

Hooks Removed from Loggerhead Turtles (NED 2003)

	Hook Removed?			
Hook Location	No	Yes	Not Applicable	Total
Swallowed	34	2	0	36
Mouth	0	46	0	46
External	0	7	0	7
Unknown	2	0	0	2
Not Hooked	0	0	1	1
Total	36	55	1	92

Another aspect of this research was to test different tools to remove the gear.

We have been extremely successful in this endeavor.

59.9% of all hooks were removed from loggerhead turtles.

All line was removed from 78.3% of the turtles.

Some line may have remained on the remaining hooks, but usually (all but 3 turtles) was less than 2 inches.(range 0.1-10.0 ft).

Looking just at circle hooks, 86.7% of hooks were removed from the 45 turtles caught on circle hooks.

This is because the circle hooks most often are in the mouth where they can be removed, and not swallowed.

Looking at J-hooks which tend to be swallowed more, only 35.6% were removed.

The one olive ridley was hooked in the tongue with a J hook and that hook was removed.

Hooks Removed from Leatherback Turtles (NED 2003)

	Hook Removed?			
Hook Location	No	Yes	Not Applicable	Total
Swallowed	0	0	0	0
Mouth	1	3	0	4
External	14	34	0	48
Unknown	3	5	0	8
Not Hooked	0	0	19	19
Total	18	42	19	79

77.2% of all hooks were removed from leatherback turtles (70.6% of the circle hooks and 64.3% of J-hooks).

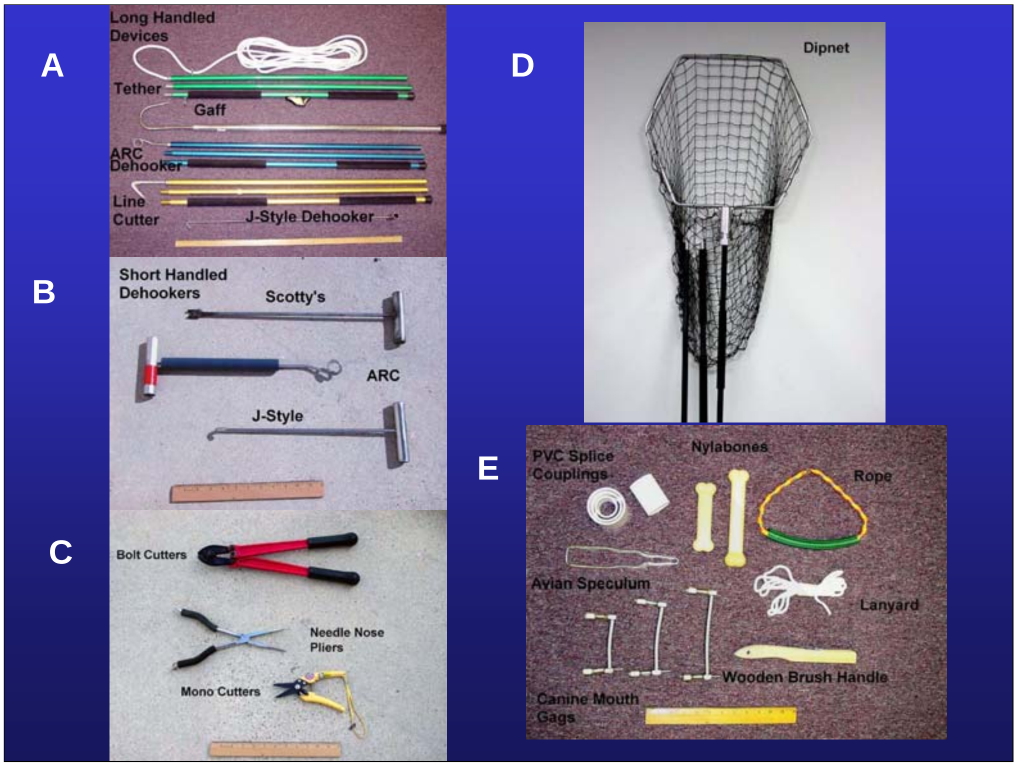
All line was removed from 87.3% of the turtles.

Line remained on 10 turtles and on all but 2 it was 2 ft or less (range 0.1-30 ft). (Note, est. for all hooks includes turtles not hooked at all, but est.s by hook type do not).

I want to point out that 3 of the 4 hooks in the mouth were removed.

The observers explain that it is more difficult to remove hooks in the armpit (accessibility) and flipper (flexibility) than in the mouth.

Thus, our success in removing hooks from the mouth is about the same (75%) as our success in removing the hooks from external locations (71%).



As a result of our experience testing the tools, we have written Careful Release Protocols using the equipment we tested in the NED experiments.

We expect them to appear as a NOAA Technical Memorandum.

This will have detailed text and photographs about how to use the equipment.

It is time to move this technology to the rest of the fleet and the world.

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Acknowledgments

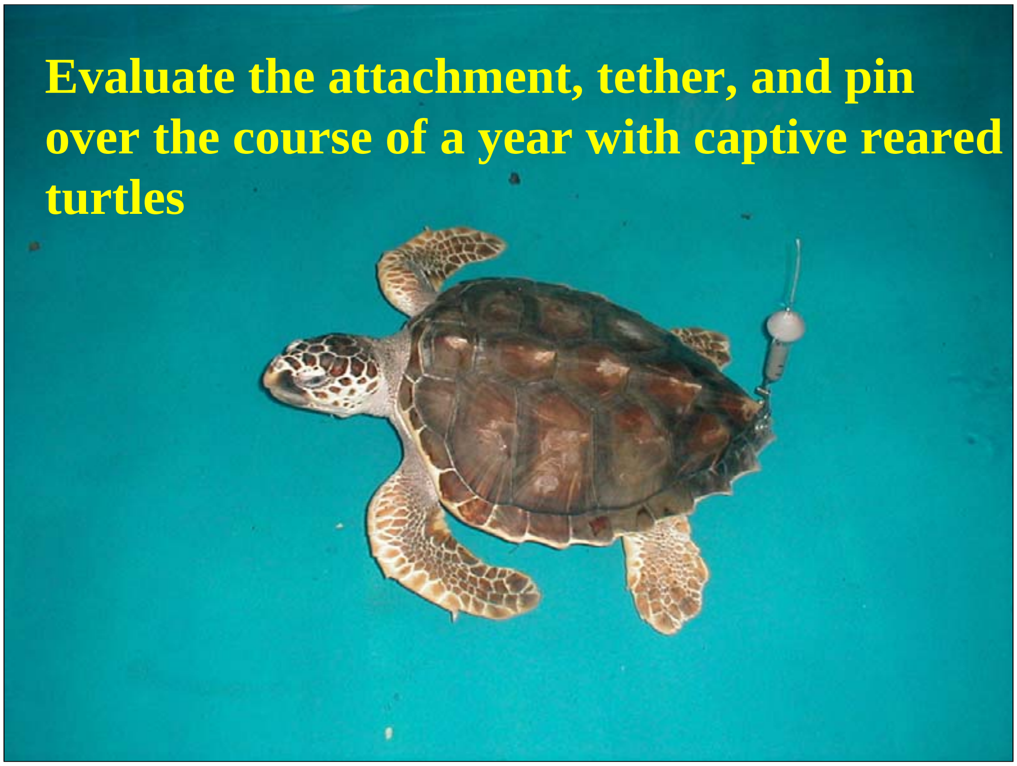
Post-Hooking Mortality -Atlantic Pilot Study

Sheryan Epperly, Christopher Sasso, Eric Prince, Carlos Rivero, and Alan Bolten

NOAA — National Oceanic and Atmospheric Administration, U.S. Department of Commerce

The Archie Carr Center for Sea Turtle Research

This presentation details the results to date of the pilot post-hooking survival study.


Evaluate the attachment, tether, and pin over the course of a year with captive reared turtles

January 2, 2004

PAT TAGS RELEASED

	Test Tags	Controls	Lightly Impacted			Severely Impacted
	Floating Free of Turtle	Dip-Netted	Entangled	Flipper Hooked	Mouth Hooked (lightly)	Swallowed
Azores	4				2	1
NED 2001			2	2	3	9
NED 2002			1	1	4	
NED 2003		9+1	+1	1+1	1	

This shows the number of tags deployed. Loggerheads are the only species being investigated.

Current Injury Criteria

Interaction	Mortality
Entangled only, released with all gear removed	0%
Externally hooked or entangled and released with gear attached	27%
Mouth hooked or ingested hook	42%
Dead	100%