Pelagic Research of Pacific Loggerhead Sea Turtles in Partnership with Japan and Taiwan

By George Balazs

The following is a joint presentation by, Dr. Polovina and I, regarding some very important pelagic loggerhead turtle research that we have undertaken in the last couple of years in collaboration with our Asian colleagues, Dr. Kamezaki from the Japan Sea Turtle Association and Dr. Ching from Taiwan. I would like to emphasize the point of partnership. Nothing can be done with a species that spans such vast areas of the Pacific - nationalities, ethnicities - without partnerships.

Over the past couple of years, five papers have been published on the north Pacific loggerhead turtle. The first was in 2000, on pelagic movements (cite); next was on depth dive with SDR-linked dive recorders (cite); one with Dr. Chaloupka using our data on post release mortality (cite); on the stomach contents from loggerhead turtles from the 1990's high sea's drift net fishery combined with samples collected from the Hawaii-based long line fishery (cite); and more recently in 2004 looking at the movements of these turtles (cite).

Coastal Pound Nets of Japan

At Muroto Point I was very fortunate to have Dr. Kamezaki take me to learn more about the coastal pound net fishery in which loggerheads are sometimes caught as bycatch. Pound nets are common along the coast of Japan, and is a nonentangling type of fishery. For years, I've been trying to understand what a pound net is, because a trap net is very common throughout Southeast Asia. Dr. Ching, in Taiwan, calls them, in his publication, set nets. To me, a set net is something that the turtle swims along and gets entangled in. Nothing could be farther from the truth than that, and it's just a matter of translation.

A pound net is really something like a pound net in Chesapeake Bay, but it's set out over very deep water, and it is very large. The pound net I visited was off Muroto Point where there is a very large operation that sometimes entraps a turtle, but does not entangle the turtle. We have been fortunate in our collaborations to have satellite tags put on these incidentally caught turtles. I was impressed with the immensity of the operation; the amount of net, the amount of gear and money necessary for construction. They are used primarily to collect and catch pelagic fish. It's a massive operation and a very efficient fish catcher.

Description of a pound net (using photos and diagrams from presentation).
Here is a diagram of a pound net. to give you the idea of the immensity of each one of these sandbag anchors, are two tons in weight. the deeper end is set in about 90 meters of water (there's 90 meters of net going down). And as you progressively go to the other end of the net, there are steps that come up, shallower and shallower. And then there's a guide that the fish turn and swim in and collect themselves in there and are incapable of how to get back out. There's ten ships with about 30 or 35 men, closing in to collect the

fish. The netting does not entangle the fish or turtles. And it's set out there all the time. when the typhoons come, they simply sink, take the floats off and sink the net, and then raise it again after the typhoon comes by.

Satellite Telemetry Research

Our tool for studying the north Pacific loggerhead sea turtle, of course, is satellite telemetry. In recent years, the technology has improved considerably. Tags have become more sophisticated and smaller.

A turtle that is caught in a pound net is brought ashore, given a scrubbing and may have a satellite tag attached. And then the turtle is released (map figure x: of turtle released from Muroto Point, generated by Denise: 2002 and 2003, 386 days, traveling 11,333 kilometers, at a speed 1.2 kilometers an hour). I think the biggest point, is that they are bouncing in and out from coastal habitat and spending the greatest portion of their time in pelagic habitat (map figure y: 174 days, 4,500 kilometers).

This map (figure z) is an interesting collaborative, also with Japan's Sea Turtle Association, where I had the honor of visiting a loggerhead nesting beach at Fukeage Beach, Japan. The tag was put on a nesting turtle after she finished her netting -- and this turtle is still transmitting to all of us right now -- she went out into the offshore ocean area, and that's where she stays (figure z). Here in Hawaii we would say, where there's one, there's two or many more. So the turtle has told us, I believe, a place that is reasonably important for post nesting turtles.

In collaboration with Taiwan with the work we're doing with Dr. Ching on the Pacific coast of Taiwan. As it turns out, the Taiwanese have similar pound nets, only smaller and closer to shore, and not quite as massive as in Muroto Point, Japan.

Here's Dr. Ching scrubbing the back a loggerhead taken in Elan County. In our project, all data is shared, and partnerships are acknowledged. Some of these turtles are pretty good size and get up there. Some adults, 74.5 centimeters. Not all of them quite that big. This one, 225 days, 4,500 kilometers. here's one that danced along mainly offshore mainland China, a little bit of inshore. It's when they get inshore, apparently, but every turtle that we caught here at Muroto Point, they don't stay close, they bounce right out. I think their interlude with the shoreline is very brief. And, indeed, they are not really coming that close to the shoreline. At Muroto Point, as I said, they are out over 90 meters of water. So another one that went up just below South Korea. And another one here, again, East China Sea. It's all from Taiwan. Here's one that's 74 centimeters, who decided to go back to its ancestral home to Japan, and right out to 165 east, that is, indeed, very interesting.

Another project is in Japan with turtles that are released from a passenger liner about 40 kilometers off Tokyo in the Kurishio current. To date, I've made four trips over to Japan to work with captured turtles for release with satellite tags. These turtles are raised up to one, two and three years of age. We use a tidal ferry company that goes from Nagoya to

Sendai to Hokkaido. Two ships have been used for releasing the turtles at sea, the Kitikami and Ishikari. These are 300-meter vessels that carry 200 passengers and lots of cargo inside. And they have been extremely cooperative in assisting.

The release point is the Kurishio current. Sometimes the sea is very rough, sometimes the sea is calm, but it can be very exciting releasing turtles. Here's all the little guys very eager about getting out. Turtles are put in baskets a few at a time, and the baskets are lowered over the side, a few feet off the surface, the basket is flipped and into the water they go. The little ones disburse towards the dateline (170 degrees) towards the Hawaiian Islands (map: Camay, 520 days of transmissions, a movement of 11,749 kilometers).

This presentation is followed by Dr. Polovina to provide some of the oceanography associated with the migratory habitats of north Pacific loggerhead juvenile turtles.

The Kuroshio Extension Current Bifurcation Region: A pelagic hotspot for juvenile loggerhead sea turtles

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Abstract[1]

Satellite telemetry of 43 juvenile loggerhead sea turtles (*Caretta caretta*) in the western North Pacific together with satellite-remotely sensed oceanographic data identified the Kuroshio Extension Current Bifurcation Region (KECBR) as a forage hotspot for these turtles. In the KECBR juvenile loggerheads resided in Kuroshio Extension Current (KEC) meanders and the associated anti-cyclonic (warm core) and cyclonic (cold core) eddies during the fall, winter, and spring when the KEC water contains high surface chlorophyll. Turtles often remained at a specific feature for several months. However, in the summer when the KEC waters become vertically stratified and surface chlorophyll levels are low, the turtles moved north up to 600 km from the main axis of KEC to the Transition Zone Chlorophyll Front (TZCF).

In some instances, the loggerheads swam against geostrophic currents, and seasonally all turtles moved north and south across the strong zonal flow. Loggerhead turtles traveling westward in the KECBR had their directed westward movement reduced 50% by the opposing current, while those traveling eastward exhibited an increase in directed zonal movement. It appears, therefore, that these relatively weak-swimming juvenile loggerheads are not passive drifters in a major ocean current but are able to move east, west, north, and south through this very energetic and complex habitat.

These results indicate that oceanic regions, specifically the KECBR, represent an important juvenile forage habitat for this threatened species. Interannual and decadal changes in productivity of the KECBR may be important to the species' population dynamics. Further, conservation efforts should focus on identifying and reducing threats to the survival of loggerhead turtles in the KECBR.

WORKSHOP PRESENTATION

The following information is, as George previously mentioned, due to eight year collaboration with our Asian colleagues. This presentation summarizes the release of 40

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[1] Paper published in (complete citation)

juvenile loggerhead turtles off of Japan, in an area in the Western Pacific, the Kurishio extension region.

We began our work in the early '90s, focusing on capture/release animals that were caught in the Hawaii-based long line fishery that observers put transmitters on. We tracked those turtle to look at how animals were using the ocean habitat (cite). More recently, we've focused on the area west of the date line, where animals have been either released from vessels, off of nesting beaches in Japan, or released from hatcheries. All have traveled into the Kurishio extension region (cite). An interesting fact about the diving physiology of loggerheads is that they are shallow divers, they are diving 90 percent of the time in the top 40 meters of the ocean.

If one looks at the turtles in the Central Pacific and compare their daily positions over their whole duration, with satellite ocean color data (which measures surface chlorophyll), a key finding after looking at many overlays of tracks of animals and ocean color, is that the turtles are using a boundary between this low, warm, vertically stratified, subtropical gyre water, and the more vertically mixed, high chlorophyll -- high surface chlorophyll transition zone water (figure).

A turtle follows the boundary between two water masses of low and high chlorophyll water. The boundary moves up rapidly as the ocean warms and turtles swim to stay close to the boundary, and it goes east to west following the boundary. If one were to look at a whole basin picture of the North Pacific, a three-dimensional version of surface chlorophyll, we see that there's always (in the winter and in the summer) two regions of surface chlorophyll in the ocean; namely, a warm subtropical gyre. Hawaii is in the lower region and the boundary in the winter is around 30 north. In the summer, as the ocean warms up, this boundary moves to the north. The turtles, for the first time, have shown us this boundary that is a convergent zone where fronts occur, where food webs develop, that provides to forage for these turtles (i.e., surface dwelling prey aggregate). Since then, we identified that albacore and albatross use this boundary as well. Biological oceanographers have always known that these two regions in the ocean of high chlorophyll and low chlorophyll existed, but no one ever paid any attention to the boundary. Based on the turtle work, we've named this boundary the Transition Zone Chlorophyll Front, because it's a new feature that moves between the transition zone, from 30 north up to 40 north in the Central Pacific.

What turtles are doing in the pelagic environment is a fruitful area for study. In the Western Pacific there are two data sets: 1) Central Pacific released animals from longline vessels that have come past the dateline into the Kurishio current extension region, and 2) releases of juvenile loggerheads off of Japan and traveling through the Kurishio extension current region. Longline caught turtles were released from vessels between 140 and 160 degrees, and they traveled westward and piled up around the dateline (figure). The animals that were released off of Japan were released at 140 east, and they spent most their time between about 160 and the dateline (figure); some of these have been out there for up to 500 days.

The turtles seem to be spending time, however, between 155 east and the dateline. An interesting part of the Kurishio extension current. The Kurishio, comes off of Japan and becomes the Kurishio extension current at about 35 north, a strong current flowing eastward, with some meanders. Then, it encounters a region of topography, the Shatski Rise, where the current bifurcates (breaks apart). A weak northern branch goes up around 40 north, and the main flow drops a little, around 32 or 33, and meanders along. When you look at satellite imagery of sea surface height, there is a region from Japan to about 155, where there's some very tight, contour lines of sea surface height, indicating a very strong zonal flow. Most of the energy is flowing along a band of around 33 north, the main part of the Kurishio extension.

In the bifurcation area there are a lot greater mizo scale features, meanderings and eddies in the region. Past the dateline the current flow is weak and very broad. This is the North Pacific current. In summary, there are three oceanographic regions, and the place that loggerhead turtles are using is the region between 155 east and the dateline: the Kurishio Extension Current Bifurcation Region - the eastern part of the Kurishio extension which is unique because of all the eddies, meandering features, and primary productivity region of the ocean.

There is a seasonal movement of how turtles are using this very dynamic feature in the Western Pacific, taking advantage of the interaction between the high chlorophyll and the strong flow of the Kurishio extension. In the summer, when it becomes stratified and there's no surface chlorophyll (and no food webs), the turtles move up to 40 north. Furthermore, hatchery released animals are behaving just as the wild released animals, using the same environment.

There has been some speculation about turtles being passive drifters, being swept along in the currents. I emphasize that that's not the case. They not only know where they are relative to the features, they can navigate through this very complex environment. They move north and south, and they navigate through warm and cold core eddies taking advantage of upwelling. Furthermore, the turtles that are in the Central Pacific, east of the dateline, are moving westward at 15 centimeters a second. Once they get into the Kurishio current extension region their westward velocity drops in half. This could be because they are encountering an opposing flow, but it's also likely that they're going around meanders and eddies and not traveling westward; perhaps foraging in a way that slows down their progress. They are moving around in this region, but are not progressing as much as they were outside this region.

What's emerging is a picture that makes us rethink our paradigm that the life history of these animals. They don't just leave Japan beaches transit through the Pacific, and pile up in Baja where they spend decades. What we see is that, some animals, are spending a considerable amount of time in a pelagic environment. And the animals that we've tracked are generally going westward. We have seen very few animals that have come this way and very few animals that have gone to Baja in our pelagic tagging, which is a real curious phenomena. On the other hand, transmitted turtles from Baja don't show a lot of movement out of Baja. That habitat has a very different kind of dynamics.

What we're working on now is to develop a movement model, a spatial model, that we can drive with remotely sensed data to try to capture all of the dynamics that we see going across the North Pacific, to try to further describe the whole juvenile loggerhead habitat population movement. To summarize, the Kurishio extension is a very dynamic region tied to large scale climate forces. The inter-annual and decadal variability have a big impact on productivity, on growth and on survival of juvenile loggerheads and their population dynamics.

QUESTIONS

Dr. Simmer: I'm curious as to what the target species is in the pound net fisheries.

Mr. Balazs: Many species.

Ms. Fahy: I think it's pretty amazing that we have so few tracks that go from the Northern Pacific down to Baja; yet we have a lot of information on the length of -- the size of those animals. Do you have any idea, comparing the size of turtles taken in the longline fisheries and those seen in Baja, when they would start to move down to Baja, and why perhaps we haven't been able to track them. Where are they, and when are they going down to Baja, or what age?

Dr. Polovina: That's a great question. We have looked at sizes, but maybe Hoyt or George or someone wants to...

Mr. Balazs: Well, the sizes you put satellite tags on, in our partnership, were in the same ballpark.

Mr. Peckham: All the collections that Jay made over the past ten years of turtles stranded and carcasses found in dumps, and captured turtles, the size of these are almost completely overlapped. We'll be showing a slide of that. The averages of the turtles caught in the North Pacific longline fishery is around 61 or 62 centimeters. And off Baja, the average is about the same, but actually getting higher, which is a point of concern.

Dr. Nichols: I just have a quick question for both of you, or anybody who has any ideas may answer. Thinking back to that map, we have got kind of this area that we don't know much about, the Kurishio extension, and then some other areas that we know more about. Can you speculate as to disbursal of hatchlings, with the animals you released in track, and then juveniles, not particularly small animals.

Mr. Balazs: In the one case, one, two and three years old, the smallest we could get the new tags on is about 28 centimeters, and that's the ones we were just showing.

Dr. Nichols: So I'm thinking about the time between the hatchling and 28 centimeters is probably a couple of years. Something is happening in there. And maybe Jeff could speculate on, where are those animals being pushed to?

Dr. Polovina: Yes. I think, if they do get out of the Kurishio extension, the system would start to carry them out there early on.

Dr. Nichols: And, then, over the course of two years, assuming a hatchling is completely subject to the current, rather than these older turtles that are apparently able to do their own thing, for the most part, where would a hatchling end up after two years of riding the current?

Dr. Polovina: Well, if it were just a passive particle, this is the perfect region for it to end up. That is a region, where, for example, when there's large populations of sardines or anchovies, the juveniles get invected. The larvae of sardines and anchovy are out in this region. This is a very -- really dynamic sort of habitat for a lot of organisms, albacore tuna, blue fin tuna. The amazing thing is that you get these small animals, the ones that George and his colleagues released, were one-year-olds to three-year-olds. So those seem to come out and be able to move actively through this region, north and south. They weren't just swept through this region. So even as a one-year-old, they are actively swimming, actively migrating, it seems.

Mr. Balazs: And it's entirely possible -- I mean, we bought this paradigm for years; that the hatchlings can't -- they are just passive drifters. But I would question that. I would say that if the 25-centimeter ones can be moving around like that, on their own scale, that those hatchlings or post hatchlings, six months old, or whatever, could be negotiating. There may be some threshold there or gradation of it. The other thing that I wanted to point out, although we didn't present that data here. We have put SDR satellite dive recorders on some of those animals that were captive reared. And it's astonishing to see within the first day after release, dives down to 80, 90 meters, even though they had never been in water over 2 meters deep in their life. The thesis that captive-reared animals are somehow messed up does not seem to bear any reality to the loggerhead turtles from Japan. Maybe they're a lot smarter than the ones that Ross Wickam used to release down in Florida that everybody felt were going to be just -- just a public relations stunt that they were being released.

I'm convinced of that, and the things that Jeff has imparted to me and told me about how they are moving and not being different than the wild ones -- well, they're all wild. But I point that out anyway for our SDR work was another body.

Dr. Limpus: I urge you to go back and reread Ken Loman's papers on the behavior of the post hatchling loggerheads, or small loggerheads, in the experimental situation of being exposed to magnetic fields, changing as you go around the (indiscernible) in this case, the North Atlantic. And he's certainly demonstrated these animals are not just inert things out there; they are actually directing their swimming in response to where they are in the jar. And, I guess, I'd respond to your initial question that, while the current may take them in one direction and there may be eddies that perhaps would tend to hold them in an area, Ken's work would say to me, if they have a target that is part of their inherited

biology, they can direct their swimming to go in that direction. So go back and look at Ken's stuff, and see if it has some bearing here to what you are trying to resolve.

Mr. Balazs: I'll just summarize so that nobody misunderstands. There's no denying that the loggerheads in Baja is important habitat for the North Pacific loggerhead. I think what we're beginning to feel from this data, or see from this data, is there are other places that may even be more important that do not extend -- there's no denying that the loggerheads get all the way over to Baja. We all know that from the genetics, they proved that some years ago. It's a question of where is the major nursery growing area for these animals. And it certainly looks like the case is they're just going back and forth out there in the middle of no man's land, to us, but an important fishery area to fisherman. So, again, elevating a conservation result from a collaboration of partnerships around the Pacific.