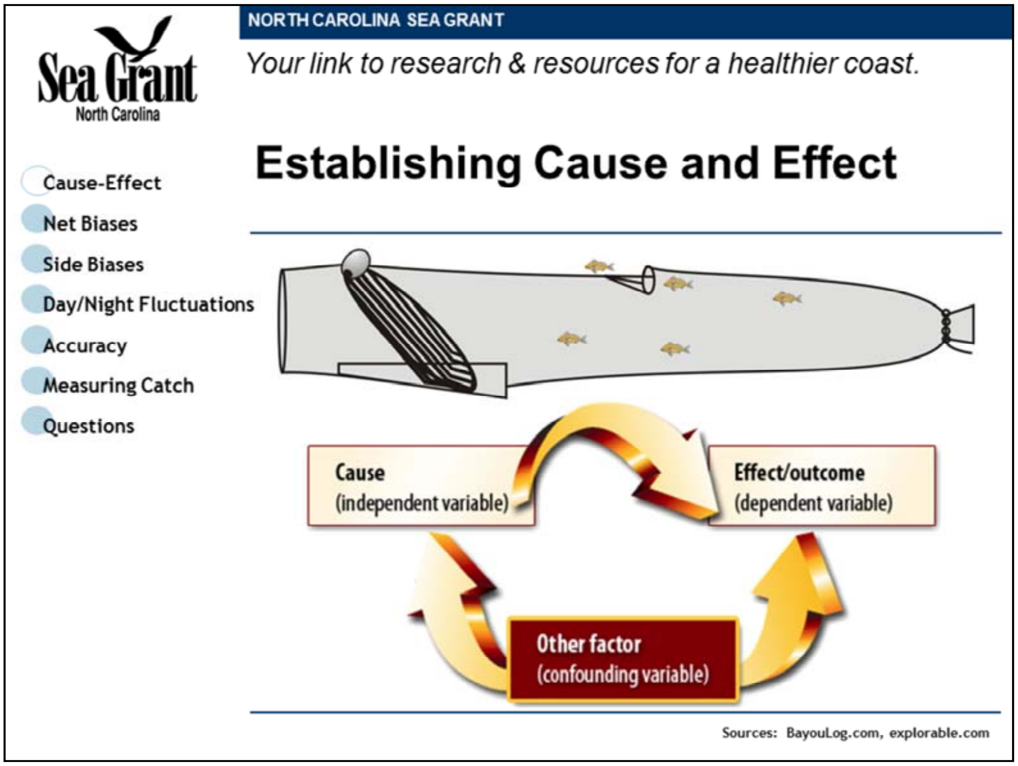
Three different funding sources funded different facets of the research.

In November 2014, the research team received monies from the N.C. Marine Fisheries Commission's Conservation Fund, with matching support from industry, to begin testing in the 2015 summer brown shrimp fishery.

The project team received additional monies from two, peer-reviewed funding sources: NOAA Fisheries' Bycatch Reduction Engineering Program (which was used to test BRD prototypes in the 2016 summer brown shrimp fishery) and the National Fish & Wildlife Foundation's Fisheries Innovation Fund (which allowed for testing of the BRD prototypes in the 2016 fall white shrimp fishery).

For the purposes of this research, a bycatch reduction device (or "BRD") is any gear **or** trawl modification designed to allow finfish to escape from a shrimp trawl.

Most of the research methodology follows NOAA Fisheries' *Bycatch Reduction Device Testing Manual* (2008), which establishes a standardized process for evaluating the ability of BRD candidates to meet the established federal bycatch reduction criterion to be certified for use by southeastern shrimp fishermen in federal waters. Collecting data in this manner will allow all of these gear evaluations to be considered by NOAA Fisheries for certification, making these efforts not just a benefit to North Carolina fishermen but to all shrimpers in the South Atlantic and Gulf of Mexico.



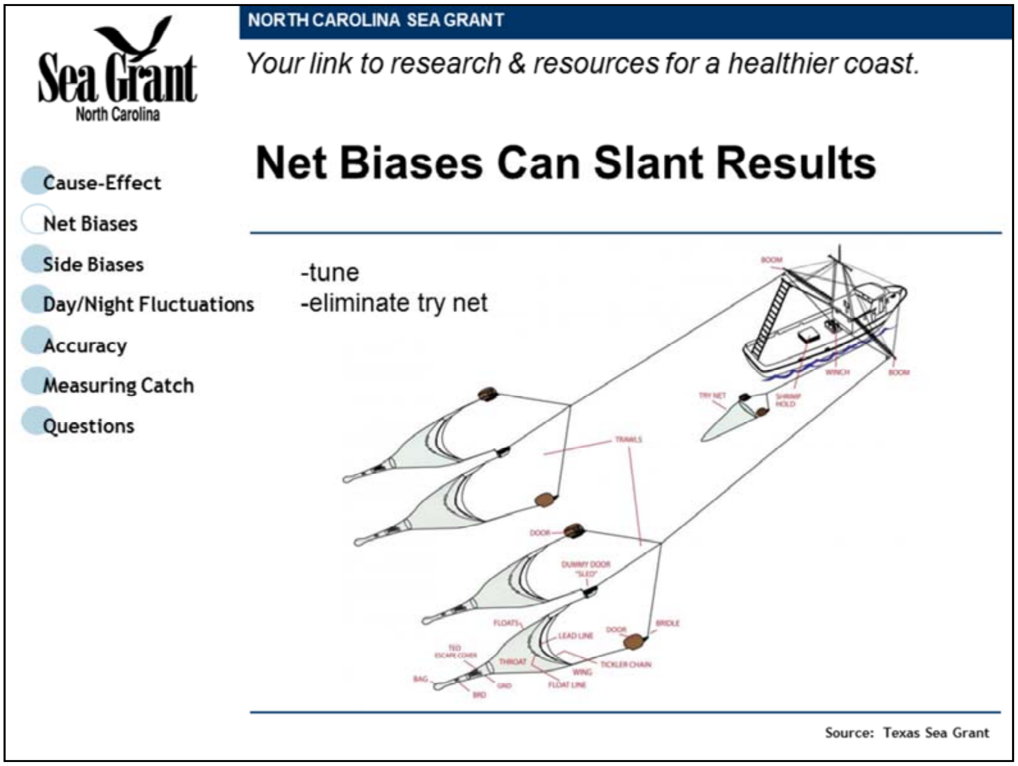
The research team is working collaboratively with the commercial fishing industry to identify and field test gear technologies or other novel fishing practices that have a high likelihood of reducing bycatch in North Carolina's Penaeid shrimp trawl fishery.

The effect or outcome being sought is a 40% reduction in bycatch, by weight, beyond that observed in control nets (which carry a standard TED and a standard Florida Fisheye BRD). The cause (i.e., independent variable) is the BRD prototypes.

To be certified for use by the shrimp fishery in federal waters from North Carolina through Texas, a BRD prototype must demonstrate a consistent reduction of total finfish bycatch by at least 30%, by weight, when compared to a control net. The control net for federal research is a net with **no** BRD, sometimes called a "naked" net. The North Carolina research must use conservation gears (TED and BRD) in the control net. Thus, a 70% (30% + 40%) reduction over a naked net will not be achieved. If a federal BRD still allows 70% of the finfish to get trapped in the trawl net, this research is aiming to reduce that 70% by 40%. So instead of 70% (over a naked net) getting through, only 42% will get through. In other words, more than 1 out of every 2 fish that enters the net will swim out to live another day.

Several things, statistically termed "confounding variables," if not controlled or eliminated by the research team would damage the validity of these experiments and make the team incorrectly announce that there is a causal link between BRD prototypes and catch observations.

The primary assumption in assessing the bycatch reduction efficiency of the BRD prototype during paired-net tests is that the inclusion of the BRD prototype in the experimental net is the only factor causing a difference in catch from the control net.



#1 Net Biases.
A paired-net test means a control net and an experimental net are fished simultaneously, and the catches and catch rates **between** the nets are compared.

The control net for this project consists of a typical commercial shrimp Otter bottom (flat) trawl with a Florida Fisheye BRD, a TED with 4-inch bar spacing, and a 1.5-inch stretched-mesh tailbag.

The experimental trawl means the trawl that is equipped with the BRD prototype during one specific field trial.

While net makers generally fabricate nets similarly, they do not precisely measure all elements, such as the head rope, foot rope and bridle length. So, nets first must be “tuned.” Tuning a net means adjusting the trawl and its components to be exactly similar in lengths and setup. Only by doing this will the net/side biases that exist between the two nets be minimized.

There is one other thing that could cause net bias, and this is use of a try net, since it is pulled ahead of a trawl net and can affect catch rates in the main trawl net. This bias is mitigated by using the outside nets of four-barrel (quad) rigs or by minimizing the use of the try net on double-rigged vessels.

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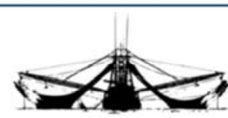
Don't Forget About Side Biases



#2 Side Biases.

Even though nets are tuned at the start of research, subtle net differences can develop with time. For example, twine may stretch and relax more on one net over the other. Over the course of a research project, one net might begin to catch more or less efficiently than the other. To control for this, test and control nets are switched from side to side every five tows or at the end of a sampling day (if more than five tows are made), ensuring an equal number of successful tows will be made with the BRD prototype on each side.

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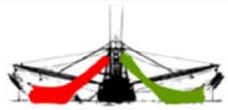

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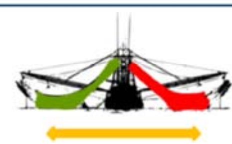
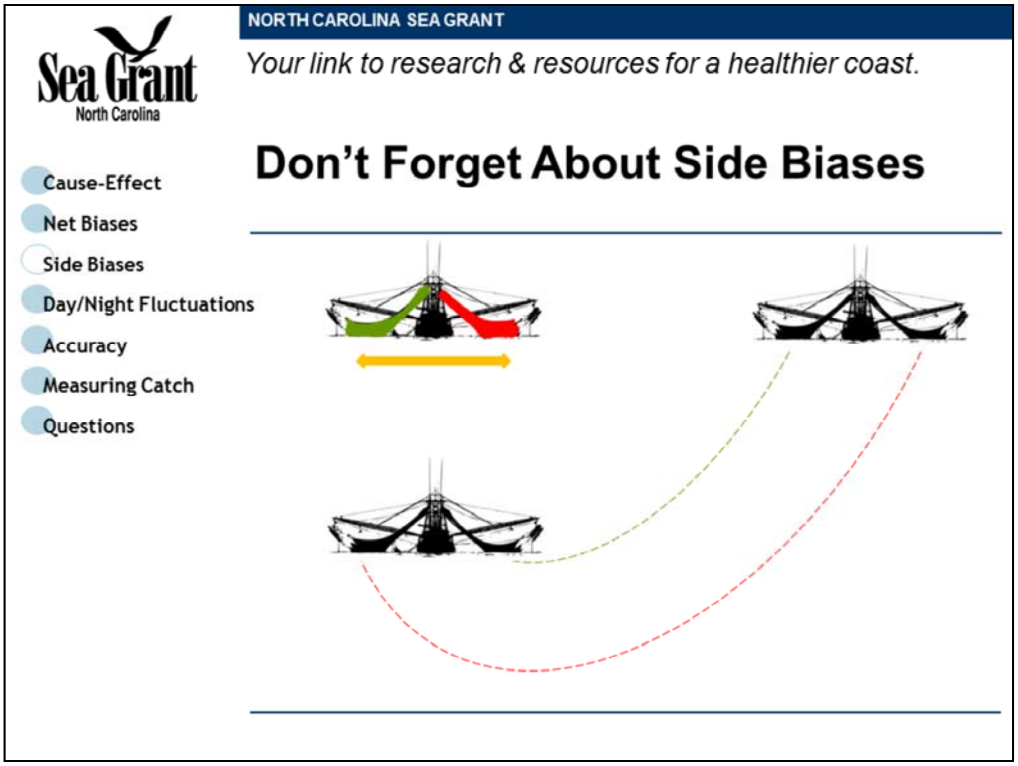
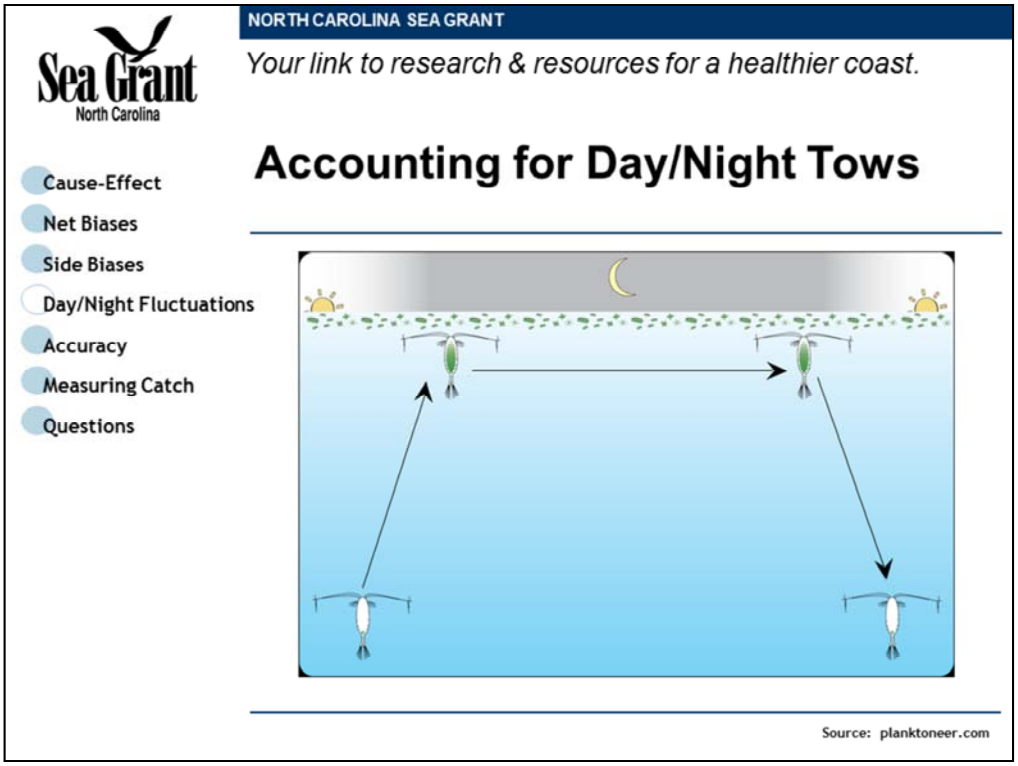




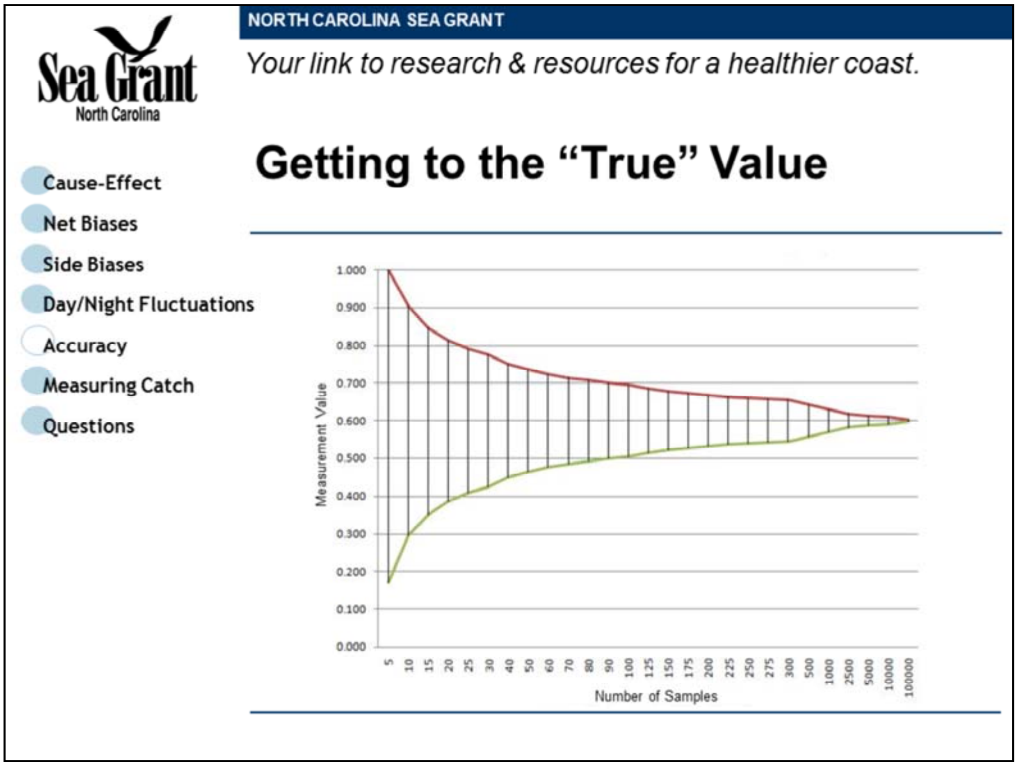
Another good reason for periodically switching the nets from side-to-side relates to the physics of turns made while towing. Water resistance and small turning radius reduces the speed of the inner net.



The testing of BRD prototypes to-date primarily has been where the gear modifications can be most effective - in shallow, often muddy conditions like that of Pamlico Sound, N.C.

But in these inshore, muddy habitats, shrimp most often feed at night (although some daytime feeding will occur in turbid water) on sediment, detritus, algae, and benthic organisms.

This behavior, called diel vertical migration, can be a factor in determining the quantity and composition of trawl catches. In studies like this when trawl surveys are not “exact” replicates in terms of fishing times and areas, the estimation of catch indices should allow for the possible bias introduced by shrimp behavior. The research team is using a statistical model to take into account such effects.

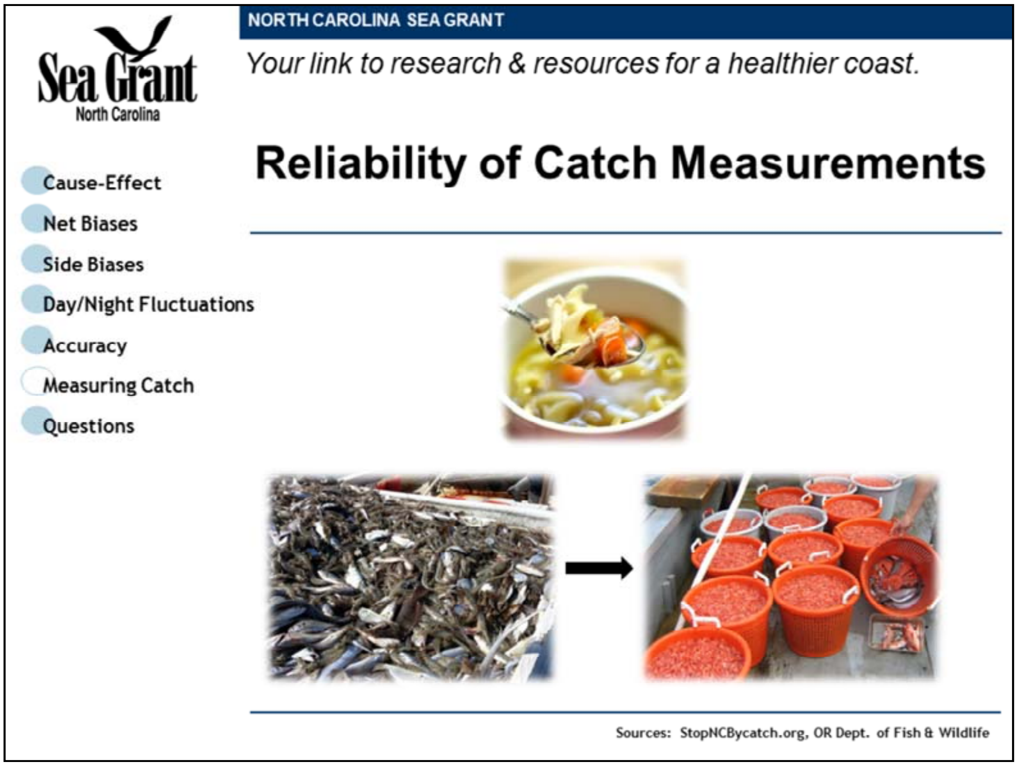


In the fields of science, engineering and statistics, the accuracy of a measurement is the degree of closeness of measurements to that quantity's true value.

So, sample size influences the "probability" (often reported in scientific publications as the "p-value") of the test depicting the "true" value.
Basically, the smaller the number of samples, the less robust/stable the statistical results are.

In this example, the "true" value equals 0.6. One can see that once the sample size gets to 100, the measurements start to get fairly close to the true value. But, also notice that increasing the sample size to 300 does not get substantially more accurate measurements. At some point there becomes a tradeoff between accuracy and efficiency, so scientists normally accept anywhere between a 5-10% "margin of error."

The federal government has determined that a minimum of 30 **successful** paired tows are required to achieve no more than a 10% probability that the true reduction rate of the BRD candidate is within 5 percentage points or less than the 30% finfish reduction criterion. In 2015 per the N.C. Marine Fisheries Commission's funding stipulations, the research team conducted 60 paired tows of BRD prototypes. In 2016, the team returned to the federal government standard of 30 paired tows.



Observers aboard partner trawl boats have mandatory data collections: recording the weight of the total catch of each test net (control and experimental nets), the catch of shrimp in each test net, and the catch of total finfish in aggregate in each test net.

Sampling of the entire catch is not required, because DMF staff can understand what is going on in the fisheries by sampling a portion of the catch and applying a statistical model.

As an example, on average, do you need to eat a whole bowl of chicken noodle soup to know if there is chicken in it? No. By simply stirring the soup up with your spoon (to get a random sample) and then taking a few spoonfuls, you can say with a high degree of confidence whether the soup has chicken. You might have heard the word “sub-sampling,” and this is what that is.

It was the recommendation of the industry work group that whole-haul sampling be performed instead of subsampling. The entire catch from one haul is separated into shrimp and finfish and a total weight for these two major categories is recorded. Catches from the control and experimental nets must be examined separately. Industry felt it would be hard to get a perfectly mixed sample of the catch. If everything was weighed, it would remove this potential sample bias. And, this is a true statement.

The only thing is, with 60 paired tows (that’s 120 nets full of catch per BRD prototype) wherein everything in the net had to be sorted and weighed, it did not allow time enough before resetting of the net for species characterization. (That is, sort, then weigh and count, all individuals by species.)

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