Sea Trials to Assess Knotless Codend Mesh Selectivity

Final Project Report Submitted to the
Northeast Consortium

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Summary:

The selectivity of knotless twine used in the codend of a groundfish trawl was tested, relative to a standard codend constructed of knotted twine. Between April and July of 2003, 13 tow pairs (26 tows) tests were conducted aboard the F/V Bad Penny, berthed in Boothbay Harbor, Maine. Analysis of catch per unit effort (CPUE) and length frequency by species detected no significant differences between catches from the knotless and knotted codends. It is strongly suspected that the knotless codends allow more sublegal American plaice (dabs) and perhaps other flatfish species to escape, but a larger sample size is required to confirm or deny this suspicion. Evaluations were somewhat hampered by a low catches in both control and experimental tows.

Video footage suggests a general tendency for the knotless twine to remain more fully open during trawling, and escapees from knotless codends may perhaps suffer less scale loss and other damage during the escape process. The knotless twine is lighter, easier to handle, and more supple. Future work should focus on the health of escapees, and on continued field trials.

Introduction:

Knotless twine holds appeal for some in the trawl industry, even though it is more expensive than conventional webbing. For example, a savings in fuel costs may be realized by using knotless twine, since the drag of the twine is less than knotted twine (Wray, 1990). In addition, knotless twine is lighter and often longer-lasting. When arranged in a square-mesh configuration, knotless twine does not slip. Knotless meshes therefore retain their shape much more effectively, avoiding enforcement problems. The possibility of using pre-certified twine, such as occurs in Norway, may also be a benefit in the enforcement arena.

The selective properties of knotless twine are of interest to fishermen, scientists and resource managers. Since knotless webbing may hold its shape more evenly, and since there are no knots to obstruct escapement, such twine may allow better escapement of flatfish such as American plaice (*Hippoglossoides platessoides*), winter flounder (*Pleuronectes americanus*) and grey sole (*Glyptocephalus cynoglossus*).

This project was initiated to examine knotless codend performance. It was performed as a 'sister' project to the NEC-funded development project: **Feasibility Study for Knotless Cod Ends**, with Capt. Kelo Pinkham as Principal Investigator.

The specific objective for the present project was "...to augment and enhance work already planned, for the basic evaluation of the selective properties of knotless 6 1/2" mesh, in the codend of a bottom trawl, used in the groundfish fishery of the Gulf of Maine."

Methods and Materials:

Two codends were constructed, by Reidar's Manufacturing, Inc., of Fairhaven MA. Both utilized 6 1/2" (16.51 cm) diamond mesh, and were 60 meshes in circumference and 50 meshes long. The control codend was constructed with green-color 5.5mm doubled RedLine netting, and the experimental (knotless) with UltraCross twine, black in color (Figures 1 and 2).

Figure 1. Knotted twine used in Control codend.

Figure 2. Knotless twine used in Experimental codend.

Codends were used on a groundfish net aboard the F/V Bad Penny, owned and operated by Capt. Stanley Coffin of Edgecomb, ME. Some specifications for the net and for the Bad Penny are below, with additional details available on www.fishresearch.org. A photo of the vessel is shown in Figure 3.

Fig. 3. F/V Bad Penny, owned and operated by Capt. Stanley Coffin.

F/V Bad Penny

Length: 54 Ft.
Beam: 16.5 Ft
Horsepower: 300
Engine: Volvo Penta, TMD 121
Doors: Steel, 650 lbs
Groundgear: 30 fa. 2.5" cookies over wire
Net Headrope/Footrope: 120ft/140ft
Flotation: 11 - 8" dia. trawl floats
Sweep: Disk-and-spacer, 12" disks

An alternate-tow approach was used, such that one tow with the control codend and one with the experimental codend constituted one paired observation. Towing areas for both tows in a pair were kept as close as possible, and the first tow of the day was split evenly between control and experimental codends. Details such as starting/ending locations, start/end times, depth, tow speed, and amount of main wire deployed were kept, by tow.

Catch sampling:
Once the catch was emptied on deck, the crew and sea samplers worked to separate it by species. Weights were taken with a Hansen Viking 45.5kg (100 lb) spring balance for heavier weights, or with a Pesola 10 kg (22lb) spring balance for lighter weights. Basket weight was accounted for and all weights were real totals; each tow completely was weighed.

Length frequencies for selected species were taken via a measuring board and plastic strip insert, graduated to the nearest centimeter. In cases where numbers of a given species were too large to permit measurement of all individuals, a subsample was taken. Weights of these length-frequency subsamples were taken, to calculate the percent (by weight) of the total catch that was taken for length data.

Fuel consumption:
An attempt was made to track fuel consumption by the vessel, with respect to each codend type. Fuel consumption was intended to act as a proxy for measuring the drag of each codend type. A FloScan Series 6500 CruiseMaster fuel metering system was purchased and installed aboard the Bad Penny, though subsequent use showed the system not sensitive enough to usefully compare fuel consumption between codend types.

Video monitoring:

Two attempts were made to collect useful video observations of the codends, as they were being fished. Capt. Bill Lee, of Rockport, MA, was contracted to do the video work. Capt. Lee visited Boothbay on (DATE), and fished for a day aboard the Bad Penny, and on June 11, Kelo Pinkham, crewman Peter Johnson and Dana Morse fished with Capt. Lee aboard his boat, the F/V Ocean Reporter, using the test codends and Capt. Lee's groundfish net. The initial date did not produce any useful video, due to lack of fish, but the Rockport visit did achieve its' goal.

A 15-minute condensed version of some of the footage was produced, and is available through Maine Sea Grant. Video clips are also available for viewing on the Maine Sea Grant Web site: www.seagrant.umaine.edu.

Mesh size measurement:

Mesh sizes were verified midway through the project. Sizes were taken using a TOP-ME Wedge-type mesh gauge, with a weight of 5.0 kg (11 lbs) attached to the wedge. Three lines of five meshes in a row were chosen at random from each codend, and measurements were taken. Mean mesh size in mm, plus/minus two standard deviations (as the 95% confidence interval) are below:

Knotted codend:	165.0 mm ± 7.5mm (6.5" ± 0.3")
Knotless codend:	169.6 mm ± 3.8mm (6.7" ± 0.1")

Data Analysis - Weights:

Weights for each species captured per tow were divided by the tow length, to arrive at a Catch Per Unit Effort (CPUE) rate. CPUE's were tested for homogeneity of variance (homoscedasticity) with the f-Test embedded in the Excel spreadsheet program. The appropriate paired t-Test (one for paired samples with similar variances, or one for paired samples with different variances) was then applied, also via Excel. All tests were run at the 95% confidence level.

Data Analysis - Length frequencies:

Length frequency (L-F) observations were pooled by species for all tows in which they were encountered. Due to low catch rates for several species, only plaice, grey sole and monkfish had sufficient numbers for L-F analysis. The Kolmogorov-Smirnov test was used to assess differences in the length frequency composition of these three species, and the test was applied separately to the sublegal size range, and to the legal size range. Minimum sizes for plaice, grey sole and monkfish are 35.6 cm (14"), 35.6 cm (14") and 42.8cm (17") respectively. Therefore, analysis of sublegal place and sole included individuals 35cm and below, while sublegal monkfish were counted as individuals 42 cm and below. L-F data was analyzed at the 95% confidence level.

Results:

Catch data:
Thirteen useable tow pairs were obtained from the fieldwork in this project. The general areas fished were Three Dory Ridge and Harvey Black's Ridge.

Total tow times for the control and experimental codends were 34.02 hours 33.88 hours, respectively. Average tow times for individual tows (plus/minus two standard deviations) were 2.6 $\pm$ 1.3 hours for the control codend and 2.6 $\pm$ 1.9 hours for the experimental codend, thus they were not significantly different from one another.

Comparison of catch weights by species:
A summary of the catch rates and t-Test results are given in Table 1. Meaningful analysis was not possible for several species due to low numbers of fish. Species not analyzed, and the number of tows in which they appeared includes: Cod (11 tows, only 4 of which involved more than two or three fish), Haddock (6 tows), Redfish (6 tows), and Pollock (6 tows).

Table 1. Weight summaries and t-Test results for 6.5" diamond knotted/knotless codend comparison, F/V Bad Penny, 2003.

Species	Control N*	Experimental N*	Ave Control CPUE (kg/hr)	Ave. Exp. CPUE (kg/hr)	Significant Diff. between Cont. and Exp? (t-Test)
Monkfish	13	13	51.6	48.2	No
Am Plaice (dab)	13	13	9.1	7.8	No
Grey Sole	13	13	2.5	2.7	No
Skate species	13	13	11.1	12.7	No
Lobster	9	10	3.2	3.5	No
Crab species	13	13	5.0	5.2	No

* N refers to the number of tows in which the species was recorded

Comparison of length frequencies by species:
Because of low numbers of individuals of many species, useful analysis of length-frequency data was possible only for plaice, grey sole, and monkfish. K-S test results indicated no significant differences between the nets in all comparisons made, except for a slight difference detected for legal dabs. The knotted and knotless codends retained 309.0 kg and 255 kg of dabs respectively, all of which was used for L-F analysis. All catch of grey sole in the knotted and knotless codends, 87.7 kg (lbs) and 86.8 kg (lbs) respectively, was used in L-F analysis. Of the 1,871.4 kg of monkfish caught in total by the knotted codend, 645.5 kg was used for LF analysis, or 35.0% of the total by weight. The knotless codend retained 1,641.8 kg of monkfish, of which 1,330.4 kg were used for LF's, or 35.8% by weight. Table 2 summarizes the results of K-S test analyses:

Table 2: Summary of data used in length frequency analysis, and results of K-S tests for dabs, grey sole and monkfish, from knotted/knotless codend comparison, F/V Bad Penny, 2003.

Species and size	# Individuals in Knotted codend tows	# Individuals in Knotless codend tows	Predicted KS Statistic	Observed KS Statistic	Significant difference between knotted and knotless?
Plaice sub-legal	275	190	12.82	6.76	No
Plaice legal	375	334	10.23	10.28	Yes
Grey sole sub-legal	117	129	17.37	5.78	No
Grey sole legal	135	136	16.52	12.28	No
Monkfish sub-legal	471	433	9.05	4.94	No
Monkfish legal	129	126	17.03	15.13	No

Figures 4,5 and 6 describe graphically the length frequency distributions of dabs, grey sole and monkfish, respectively.

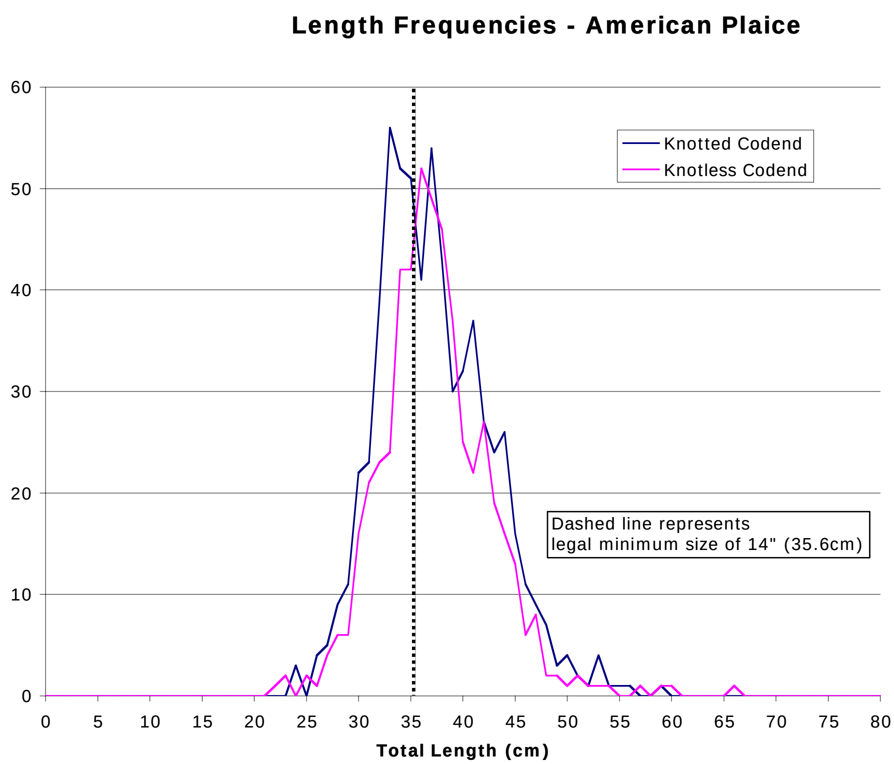

Figure 4. Length frequency distribution of American Plaice (dabs) caught by the knotless and knotted codends.

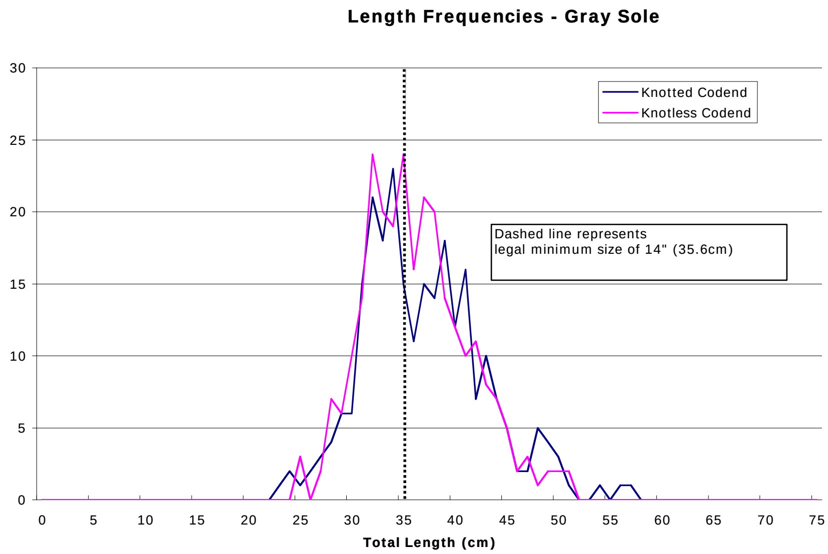

Figure 5. Length frequency distribution of Grey Sole (witch flounder) caught by the knotless and knotted codends.

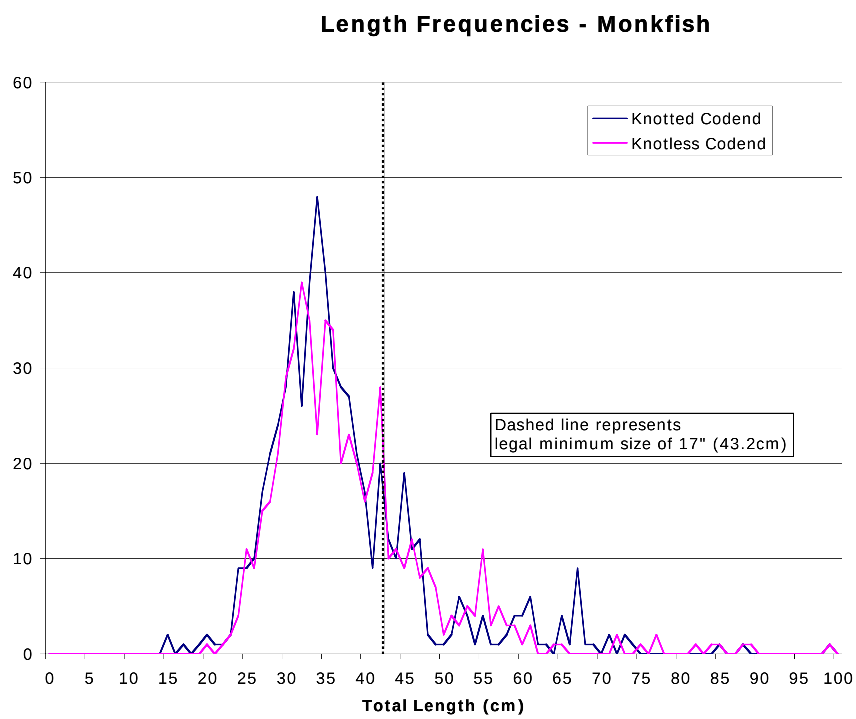

Figure 6. Length frequency distribution of Goosefish (monkfish) caught by the knotless and knotted codends.

Discussion:

While striking differences in the selectivity of the knotless codend were not found, the participants involved feel generally successful about this piece of cooperative research. The industry and scientific partners each contributed to the planning and implementation of the work, and the project was strengthened by those contributions.

Perhaps most importantly this project and the sister project run by Capt. Pinkham indicate that further investigation into the use of knotless twine codends may be very productive. These investigations should focus on:

1. Further sea trials of knotless codends, perhaps in other regions and aboard other vessels, and

2. Investigation into the health of escapees from knotless codends, relative to that of escapees from knotted codends.

The rationale behind these recommendations is as follows:

Further sea trials:
This recommendation is based primarily on the trends demonstrated by the L-F data for dabs, both on the trials from the Bad Penny, and also from the Jeannie C. This sister project used the same codends as this study, fished with a standard groundfish net, and used the identical paired-tow methodology. Twelve paired tows resulted from that work.

Recalling the trend shown in Figure 4, the knotless codend caught fewer sublegal dabs than did the knotted, but not significantly so. Data from the Jeannie C. study indicated a similar situation. When the data were combined, to include 25 tow pairs, graphs indicate that the trend may be **exactly what would be hoped for: in the size classes just under the legal size, the knotless twine may be more selective against dabs and perhaps other flatfish** (Figure 7). **A real difference is strongly suspected to exist, but data is insufficient to bear this suspicion out.**

This project and its' sister were plagued by low catch rates of flatfish; observations from the fishing industry indicate that it is a 'slow year for dabs.' Larger number of dabs are required, and some prediction of the numbers needed can be made, if the suspicion is to be more fully assessed. Specifically, the Kolmogorov-Smirnov test, when calculated at a given level of confidence, delivers a predicted test statistic based on the sample sizes seen for the experimental and control gears. As sample size increases, the predicted test statistic (which predicts the largest difference anticipated between the relative percents of a given size class in a distribution) decreases.

In the case of the data combining sublegal dabs over the 25 tows, sample sizes were 444 and 372 for the knotted and knotless codends, respectively. The KS test returned a predicted difference of 9.559, and we observed a maximum difference of 7.156. Since the observed difference was less than the predicted difference, the distribution could not be said to be significantly different. What would have happened if the same general pattern of selectivity was seen, but the sample sizes were higher?

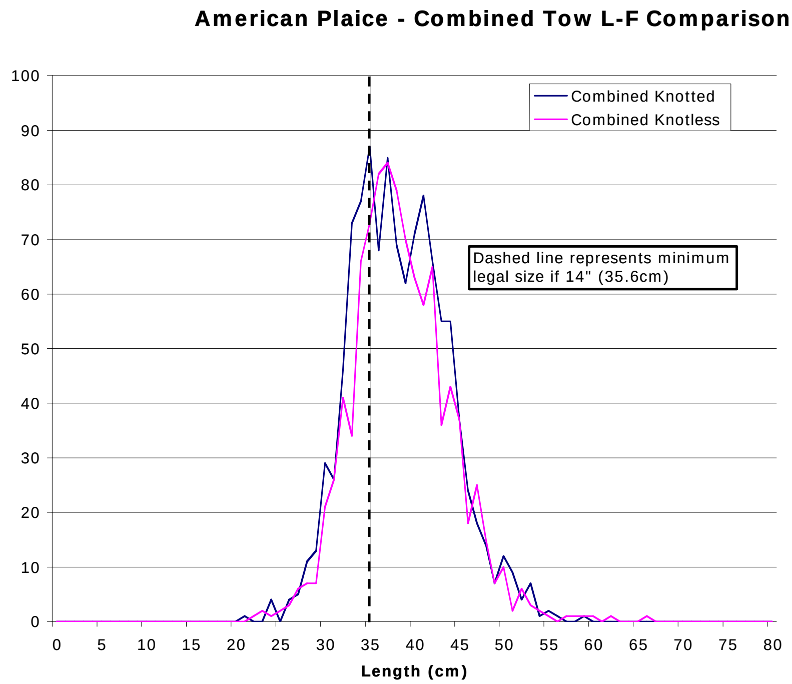

Figure 7. Length frequencies for American Plaice, from data pooled between studies on F/V Bad Penny and F/V Jeannie C, comparing a knotless codend vs. a knotted codend.

Figure 8 illustrates the decreasing values of the K-statistic, given increasing sample sizes for the control and experimental, when tests are carried out at 95% confidence. If we were to assume that further catch data would display the same selective trend, then our observed difference between the percent contribution of each size class could be similar to what we observed in the present work, or about 7.156. We would expect then to reach a predicted value of about 7.1 when roughly 750 fish were measured from each net, and the figures for the predicted value decrease from there. It is therefore proposed that, if the same selective trend were seen in future trials, that a real difference would be seen between the knotless and knotted twine codends, in just the size classes that would benefit the resource and the industry the most. More work in this area could be very useful.

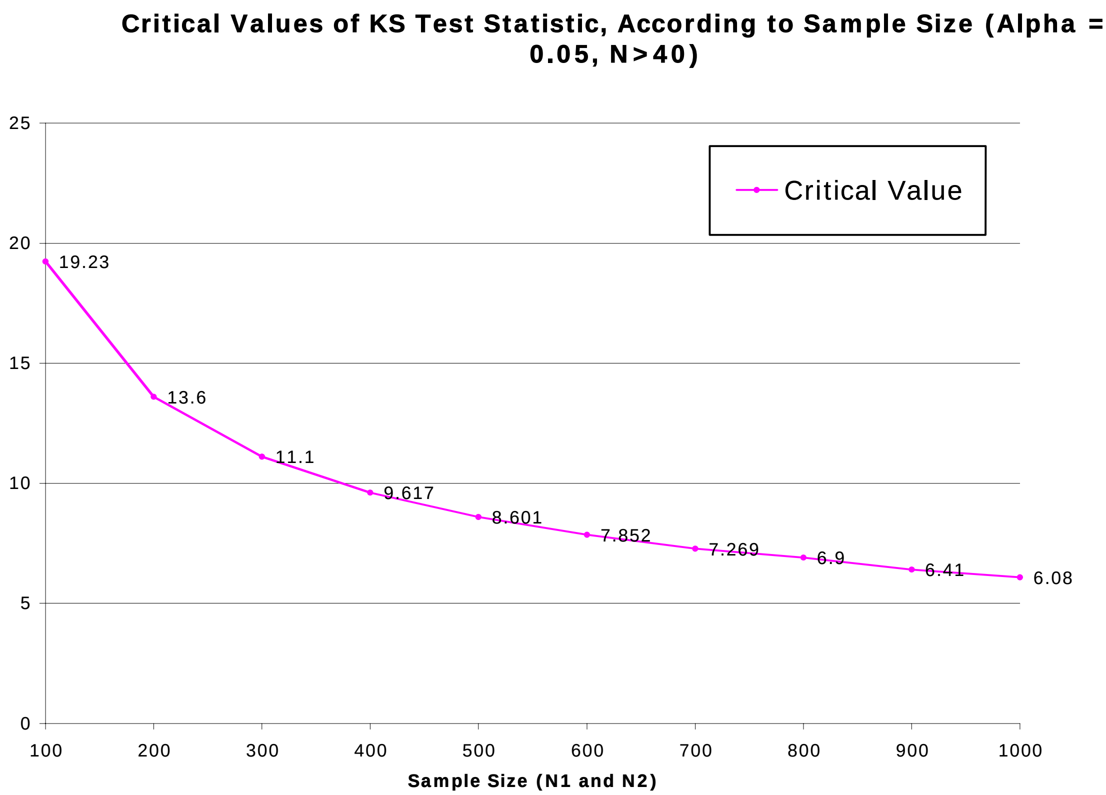

Figure 8. K-statistic values for increasing sample sizes, when Alpha=.05, and N > 40.

This proposition further passes the 'straight-face' test in that the knotless twine appears to stay more open, and may be marginally larger. It would not be expected that a difference would appear in the very small fish sizes, as they could pass equally through each twine type. It would similarly not be expected that a difference would occur in the larger sizes, because mesh selectivity would not be a factor at that point - fish bigger than the mesh size would not make it through either type of mesh.

Health of Escapees:

The topic of trawl escapee survival is a complicated issue, with relevant factors including mesh size, tow time and duration, and species, and indicators of stress including scale loss, acute mortality, and blood chemistry. One aspect often mentioned is that physical damage occurs mostly during capture and exhaustion, and not during the actual escape through the meshes (Suuronen et al, 1996), though even this is not completely conclusive (Farmer et al, 1998). It can reasonably concluded however, that quick escapement from a codend is better for the escapee.

Given the experiences of the participants in handling the knotless codend, the observations of the fish when they are dumped from the codend on to the deck, and the visual information gathered from the video work, it would appear that the knotless twine is somewhat more 'fish friendly' than the knotted. Not only does it handle more easily, but it appears to retain a more open profile when being fished. Figure 9 shows the knotless codend on deck; note how the twine appears to lay very softly. Both factors could contribute to better escapee survival, and such a study would be worthwhile to conduct. In recent years, methods to assess escapee health have improved, and could be easily adapted for this purpose.

Figure 9. A small catch, using the knotless twine. The twine handled more easily, and was lighter than its' knotted counterpart.

Outreach:

Outreach for this project is in progress, and is expected to continue. Activities to date include interpersonal communications with scientists, fishermen and others about the project, and posting of photos and project details on the website for Maine Sea Grant. Once the initial posting was made to the site, an email notice was sent to a broad group of stakeholders, alerting them to the presence of this information.

Future work:

At the time of this writing, most of the activities listed in the grant have been accomplished, with the exception of some of the outreach work. To this end, future work will include:

- Posting of this final report (in PDF format) to the project pages on the Sea Grant website.
- A descriptive article submission to Commercial Fisheries News, the Fishermen's Voice, or similar trade publication
- A presentation at the 2004 Maine Fishermen's Forum
- And or/ a presentation at upcoming Northeast Consortium annual meeting, if the agenda permits

In addition, Maine Sea Grant staff are working to post video clips on the website, including those of the project participants at work, and of underwater video of the codends in action.

Acknowledgements:

This work was a collaboration, and the PI's wish especially to recognize the contributions of Capt. Stanley Coffin of the F/V Bad Penny, and crewman Peter Johnson. Their technical expertise, excellent work ethic and their spirit of cooperation made this work successful. We would like to thank Gayle Pinkham for her work in data analysis on the Jeannie C. project, and willingness to share information. This PI's gratefully acknowledge support the Northeast Consortium for this work, and the support in grant administration of Lynn Wardwell, of Maine Sea Grant.

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