SESSION SEVEN: VESSEL SAFETY

African fishermen *(Photo courtesy of Ousmane Ndiaye)*

OPERATION SAFE CRAB: A RISK-BASED REGIONAL INTERVENTION

Kenneth M. Lawrenson
Commercial Fishing Vessel Safety Coordinator
U. S. Coast Guard Marine Safety Office
Portland, Oregon, USA

Curtis J. Farrell
Commercial Fishing Vessel Safety Examiner
U. S. Coast Guard Marine Safety Office
Portland, Oregon, USA

Daniel E. Hardin
Commercial Fishing Vessel Safety Coordinator
U. S. Coast Guard Thirteenth District
Seattle, Washington, USA

The views expressed herein are those of the authors and are not necessarily the views of the US Dept. of Homeland Security or the US Coast Guard.

> *Any investigative report regardless of its completeness and soundness, aside from good reading, has little or no value, unless immediate action is taken to implement reasonable and sound recommendations made by the board to prevent a repetition.* (Captain Dominic Calicchio, US Coast Guard, Retired, on the apparent lack of action after the sinking of the SS *Marine Electric* in 1983, with a loss of 31 crew. Quoted in *Until the Sea Shall Free Them,* by Robert Frump, 2002.)

Identifying a high-risk fishery can be subjectively easy, even though reliable statistical data are often difficult to obtain. Blending casualty, population, and environmental data, along with a healthy dose of best guess, the US Coast Guard's Thirteenth District (see note a) recognized the vital need to develop and implement an at-the-dock safety intervention for Oregon and Washington commercial Dungeness crab-fishing vessels. A tragic series of mishaps during the 1999-2000 season provided the most compelling reason to act and prompted Operation Safe Crab for the last three crab seasons.

Operation Safe Crab is a bold idea for the Coast Guard: An attempt to replace previous random voluntary dockside safety examinations with a targeted, large-scale, on-the-dock Coast Guard presence tied to credible consequences for those vessels unable or unwilling to comply with federal safety regulations. The authors will present underlying data and analyses that support a risk-based approach to improving safety for this fishery. In addition, we will tell the story of the goals, planning, resistance within the Coast Guard to this effort, efforts to ensure the program and related consequences are legal, deployment of resources, cost count, and examination of the results of our efforts.

Hazards of the Dungeness crab fishery

The Oregon and Washington commercial Dungeness crab fishery is extremely dangerous. The season typically opens December 1, although market forces and the state of the crab's hardness and meat content (resulting from natural molting cycles) have delayed the actual start of fishing more often than not in the past 10 years, sometimes by as much as 3 weeks. The hazards arise from several sources.

- Winter presents the worst weather conditions of the year on the Pacific Ocean off Oregon and Washington.
- Oregon and Washington coastal ports are located on river entrances with hazardous bars. Although the Columbia River Bar has perhaps the most notorious reputation (i.e., the "Graveyard of the Pacific"), the bars at Gray's Harbor, Tillamook Bay, Yaquina Bay, Umpqua River, Coos Bay, and the Chetco River can be equally, if not more, treacherous to navigation. Local Coast Guard personnel know from anecdotal evidence that mishaps during hazardous bar crossings account for about two-thirds of the commercial fatalities.
- There is intense pressure to fish: Crab income generally represents a significant part of annual income for typical vessel owners. Adding to this pressure is the fact that although the season remains open until August, 75% to 80% of all Dungeness crab is landed during the first 2 months of season opening. In addition, the holidays are seen as both a reason to deliver product for the lucrative holiday market and as a source of cash to meet holiday expenses. The end result is a fishery that has all of the "race to fish" aspects of any derby fishery.
- Dungeness crab is a pot fishery in which vast numbers of pots are placed in the relative shallows, usually at depths of less than 50 fath-

oms. This places the crabber in close along the coast where surf conditions can be at their worst. It also requires the vessels to travel at low speed, with working gear over their sides, on along-shore course headings that place them beam to the prevailing swell and subject to the greatest potential for rolling. A worse set of operating conditions is difficult to imagine.

- Crab vessels themselves tend to have poor stability characteristics when loaded with pots. Although some vessels are able to load part of their gear into the hold where the low center of gravity maintains adequate stability, the standard practice is to load pots on deck until reaching a pot load that the vessel owner or operator "knows" from personal experience will be "safe." These deck loads, so necessary to ensure large crab landings, inevitably raise the vertical center of gravity and reduce intact stability (see note b). Exacerbating this reduction of stability is the dangerous free-surface effect from liquid loading in the crab holds and frequent water on deck (see note c).

All these factors result in frequent tragedy. Those who push hard and are lucky make good money. Those who push hard and aren't lucky have a bad day and cause the Coast Guard to get involved.

Casualty history

The last seven Dungeness crab seasons off Oregon and Washington claimed the lives of 16 men (Table 1) (see note d).

Calculations involving degree of risk require a denominator, such as number of vessels, number of fishermen, or number of hours operated. Several data sources are typically used, with varying degrees of manipulation and assumptions. Such normalizing of data has been, and continues to be, a difficult issue (US Coast Guard 1999).

Two figures are needed to assess this fishery's risk and the extent to which Operation Safe Crab impacted the fleet: The total number of vessels participating in the season and the number of fishermen working in this fishery. Data compiled from the states of Washington and Oregon by the Pacific States Marine Fisheries Commission's PACFIN database were used to analyze the number of crabbing vessels in the fishery. Actual crab landing information was aggregated by individual vessel for Dungeness crab landed in either Oregon or Washington. Figures for total weight of crab delivered,

Table 1: Casualty history, 1996-2003

Crab season	Vessels with fatalties	Total season fatalities
1996-97	Beach King (1 death)	1
1997-98	*Jolly Roger* (2 deaths)	
	Seeker (1 death)	3
1998-99	None	0
1999-2000	*Blue Heather* (2 deaths)	
	Silver Spray (1 death)	
	Paula C (3 deaths, see note below)	6
2000-01	*Miss Brittany* (2 deaths)	2
2001-02	*Nesika* (4 deaths)	4
2002-03	None	0
Total, 1996-2003		16

Note: The *Silver Spray* and *Paula C* were actually lost off northern California, but the circumstances and geographic proximity are so similar to those accidents off Oregon that they are included in this table.

as well as number of trips and total crab revenue, were then totaled by crab season, rather than by year. The season was defined as the fourth quarter of a year plus the first, second, and third quarters of the following year.

Any crab vessel making at least one commercial landing in that season was included in the list (see note e). However, a Pareto analysis of the "weight landed" data showed that an overwhelming percentage of the vessels on the list landed so few crab that they could not be truly considered "commercial" in the sense we were after–vessels that carried wage-earning crews and that fished the season with the intention of commercial success. For example, in the first quarter of 1997, there were 810 vessels that made at least one commercial crab landing. Half of that number, when rank-ordered by crab weight, were responsible for landing 90% of all crab in that period. Clearly, many permit holders are not commercially viable. To approach a more realistic number of commercial vessels, two cut-off points were examined. The first was the number of crabbers that, when rank-ordered by crab weight landed, delivered 90% of the total amount of crab landed. The second was the number of crab vessels that landed at least 20,000 pounds of crab during the season; this figure represents estimated minimum revenue that would allow payment of meaningful crew earnings (Table 2; Figure 1).

Data for fishing employment were obtained from Woodley (2000, see note f), and an estimate of full-time employees (FTEs) for the Oregon and Washington Dungeness crab fishery was made from the method described by Woodley. The method involves determining an average crew size for a vessel, multiplying the average crew size by the days operated (Table 3), dividing by 365 (days per year), and multiplying by the number of vessels in the fishery. The result is an estimate for annual employment equivalent (AEE). Then a

Table 2: Landings

Crab season	No. of vessels with at least 1 landing	No. of vessels at 90% cutoff	No. of vessels landing 20,000 pounds or more
1996-97	1457	586	306
1997-98	1537	630	342
1998-99	1521	554	337
1999-2000	1516	501	426
2000-01	1538	659	349
2001-02	1546	597	418
2002-03	1330	440	440

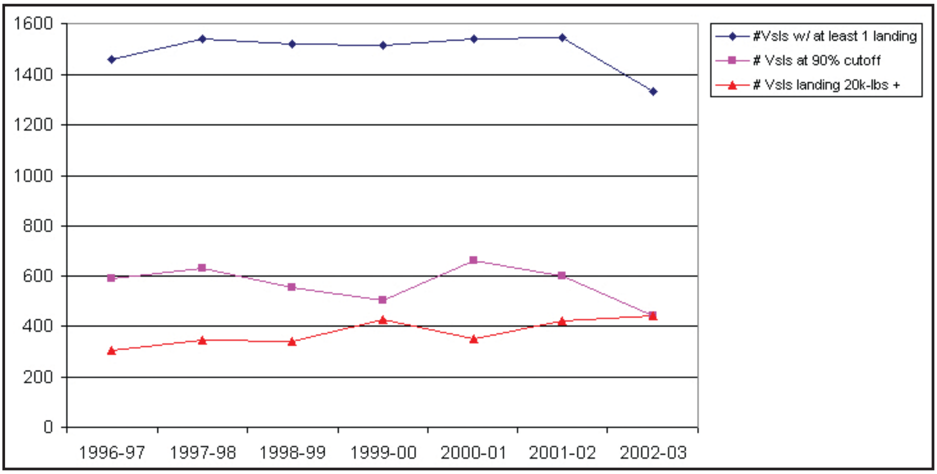

Figure 1: Landings

Table 3: Average number of operational days per vessel

State	1996	1997	1998	1999
Oregon	77	65	62	78
Washington	109	113	136	117

conservative factor of three is used to convert this equivalent to a risk exposure, since the AEE is based on an 8-hour workday, whereas commercial fishermen are typically aboard the vessel (and so subject to vessel casualties) for the entire 24-hour period of that day. Since the number of crab vessels was not divided evenly between Oregon and Washington, an assumption was made that the two figures are roughly equal. Therefore, a straight average for operational days for the entire region was used.

AEE for risk exposure = 3 × (average no. of operational days) × (crew per vessel × (no. of vessels) ÷ 365

Crew size per vessel was assumed to be three for a typical crab vessel, and the number of crab vessels landing at least 20,000 pounds of product is assumed to be the average for crab seasons 1996-1997, 1997-1998, and 1999-1998, or 328. This gives an AEE of 763 for 1996, 730 for 1997, 812 for 1998, and 804 for 1999, resulting in an average AEE of 777 for risk exposure over the 4 years. The total number of fatalities for this period was 10, or an average of 2.5 deaths per year.

The fatality rate per 100,000 workers is typically used to compare risk between different fisheries (or other occupations) and is calculated as 100,000 times number of fatalities divided by AEE. For the Oregon and Washington Dungeness crab fishery between 1996 and 1999, the fishing fatality rate per 100, 000 workers was 322.

This figure is twice as high as the overall national fatality rate for commercial fishing estimated for 1995 (US Coast Guard 1999). Anecdotally, and certainly in our guts, we knew there was a problem. The disaster of the December 1999 crab opening should have come as no surprise. Action was demanded.

Idea of a fisher-specific intervention

Medlicott (2002) describes a common complaint among experienced Coast Guard fishing vessel safety personnel: The voluntary dockside examination program has no teeth to compel compliance with safety regulations. At-sea boardings failed to make up for this deficiency, and no specific action was being taken toward the highest risk groups. Medlicott further described the efforts of the Seventeenth Coast Guard District (Alaska) to implement an at-the-dock effort to reach a large percentage of the Bering Sea king crab fleet during the 1999-2000 season.

Personnel from the Thirteenth and Seventeenth Districts involved in fishing vessel safety have enjoyed a close partnership since the inception of the regulations in the early 1990s. When word spread of the successes by the Seventeenth District, it was obvious that a similar at-the-dock enforcement action could have an impact in the Oregon and Washington Dungeness fishery. Several key factors were present.

- The majority of the vessels involved would be departing from a relatively small number of ports. This meant it would be possible to focus personnel resources on only the ports where the crabbers were actually located. In other words, we would know *where* to find them.
- The majority of the vessels involved would be departing at roughly the same time, a time that would be predictable and was driven by fishery management. We would know *when* to find them.
- The start of the crab fishery is labor intensive: crab pots and other gear are to be repaired and loaded on board, bait prepared, holds are to be inspected by the state. This would mean that vessel crews would be on the docks, working on their vessels, immediately before the opening day. We would know that the *crews* were there.

While there was support for an operation for the 2000-2001 season from the Command at the Coast Guard Marine Safety Office in Portland, Oregon (in whose area of responsibility the bulk of the effort was to take place), there was resistance from several quarters within the Thirteenth District (see note g). Several of the coastal units were worried that such an effort would damage the relationship between the Coast Guard and the fishing fleet, because the Coast Guard had never before threatened to prevent a vessel from fishing until it came into compliance. The District Command was concerned that any actions taken be completely within existing authority and jurisdiction. Lastly, concern was expressed that the industry needed to know well in advance what we were going to do, what they needed to do in order to "pass" our examination, and what possible consequences could befall those failing to comply.

Clearly, the challenge would be in the planning. Thorough planning would sculpt a "stolen" idea into Operation Safe Crab. It had to start with the goals.

Goals of Operation Safe Crab

Eliminating commercial deaths in the fishery by increasing vessel safety was the ultimate goal. To accomplish this, we had to be more specific in our objectives. These were to—

- Examine as many Dungeness crab vessels as possible before the season.
- Focus attention on these most critical issues given the risks inherent to the fishery.
- Keep examinations as short as possible to accomplish our job while minimizing impact to a fleet busy getting ready for the opening.
- Ensure consistency of enforcement.
- Keep the examinations safe for the Coast Guard personnel involved.
- Provide a credible continuum of consequences for vessels that were not in compliance.
- Involve law enforcement personnel of the Thirteenth District.
- Ensure that the industry knew in advance what we would be doing, so that it would not come as a surprise.
- Manage limited budget resources to support the efforts.

Planning the operation

The first objective was to examine as many vessels as possible. Concentrating examiners where the vessels were going to be would do this. The "where" was easy to determine. The timing of the operation, however, became a matter of considerable discussion among the various concerned captains within the Thirteenth District. It was clear to the authors that to check a vessel effectively, the crew needed to be aboard. Therefore, to maximize our chance of meeting both crew and vessel at the same time, the Coast Guard would need to wait until the final few days immediately before the start day. In addition, the vessels were already required to be in compliance, and if boarded at sea in the same condition we found them at the dock, their voyage would be terminated without their being able to continue fishing. Others suggested that the Coast Guard should examine the vessels several weeks before the opening so that a vessel found out of compliance would have the time necessary to come into compliance before the start. In the end, however, the former argument carried the day, although widespread publicity would now become a critical part of the operation. During this discussion, it was clearly reiterated that this operation would *only* involve vessels engaged in the Dungeness crab fishery, rather than any vessel we would come across.

To focus effort on those matters most directly related to vessel safety and to keep the examinations short, three areas of emphasis were to be made: the vessel's stability, the vessel's life raft, and the vessel's emergency position-indicating radio beacon (EPIRB). The vessel's stability was seen as the primary factor preventing vessel casualties and could be appropriately gauged by examining the loading and number of crab pots, the vessel's freeboard, its compliance with stability instructions (if required), and its crab holds and deck freeing ports to ensure minimal free-surface effects. Checks of other lifesaving equipment (the raft and EPIRB) were meant to give the crew the greatest chance of surviving a vessel casualty. In previous crab vessel losses, the condition of these two pieces of gear had been found to make the critical difference between surviving and not surviving. A checklist was developed to gather some basic data on the vessels and to document the checks for these three areas. Our goal was to go on board a vessel and, if no deficiencies were noted on the checklist, leave within 10 to 12 minutes. This would allow an examiner to complete examinations on five to six vessels per hour.

The checklist would be one method to ensure consistency of enforcement. The other measure involved selecting examiners. It was clear that when doing such an operation for the first time, we needed to use the right people. Six experienced, seasoned examiners were chosen and paired into three teams. Each team leader had been a key planner in the operation, and each had an excellent perspective of the objectives and methods.

To ensure the safety of the Coast Guard examiners, several guidelines were adopted. First, no vessel would be boarded without a crew member being present. Vessels would be examined at dockside only. Vessels would only be examined during daylight. Lastly, each team would check in with the Coast Guard station in that port so that if problems were encountered with a vessel, Coast Guard law enforcement personnel would be available as back-up.

Providing examiners with credible consequences for noncompliance necessitated cooperation and communication with the Captain of the Port (COTP) and the District's Law Enforcement Division. At the very least, vessel deficiencies would be recorded and transmitted to the district at the end of each day, with a final record of vessels in noncompliance made available to all Coast Guard units in the district to help prioritize boardings. Vessels with more serious problems, such as problems that would result in voyage termination if detected at sea, were to be issued a COTP order directing that vessel to remain in port until the deficiency was corrected.

Publicity was critical and started about a month before the projected start of the season. Press releases were sent to coastal radio stations and newspapers, flyers were posted at marinas, and fishing associations were contacted so that the information could be passed on to their membership. This was to be no secret.

The Thirteenth District commander approved the plan. The key aspects were released in message form to all the Coast Guard units involved.

Operation Safe Crab 2000

Originally, we planned for three teams, each assigned an area: north, central, and south. The North Team would examine vessels in the Columbia River ports of Astoria, Warrenton, Hammond, Chinook, and Ilwaco; Willapa Bay to the north of Ilwaco, Washington; and Westport, Washington, on Gray's Harbor. The Central Team would cover the ports of Florence, Newport, Depoe Bay, and Tillamook Bay (all in Oregon). The South Team would be responsible for the ports of Brookings, Port Orford, Coos Bay/Charleston, and the Umpqua River (Winchester Bay and Reedsport) in Oregon.

At the last minute, the marketability of the crab required the season to be split, north and south; the south opened on December 1, but the north was delayed 2 weeks. Rather than remain with the plan and chance missing many vessels, we decided to be flexible and split the teams along the same geographic lines. The North Team would become a second Central Team, and we would send more examiners out to the north 2 weeks later. Fortunately, the Thirteenth District provided the additional funds.

The teams gathered their gear and traveled to their starting locations November 26. Each team had been provided with supplies of checklists, sample

COTP orders if needed, a folder containing pertinent law enforcement intelligence information, daily examination log sheets, stability and regulation pamphlets, and shackles and weak links for correcting life raft installations on the spot.

Examinations were done between Brookings and Depoe Bay on the following 4 days (November 27 to 30), with each team traveling as necessary to maximize time spent looking at crabbers. Similarly, two teams left on December 10, one to Westport, and the other to the Columbia River ports to conduct examinations from December 11 to 14. A total of 266 vessels was examined. Using 20,000 pounds as the cutoff for vessels fishing in the 2000-2001 season (349), we estimate Operation Safe Crab 2000 reached about three-quarters of the fleet. This wildly exceeded our expectations.

An alarming percentage of EPIRBs and life rafts were found to have problems. Almost 43% of EPIRBs were not in compliance, and 10% had problems so serious that the vessel would have been ordered back to port if boarded at sea. Of all life rafts on board vessels, 35% were not in compliance, and 22% were installed incorrectly. Life raft installation problems can prevent the life raft from being deployed when needed, which could lead to fatalities. Fortunately, installation issues are almost always easily corrected on the spot. One vessel was resistant to servicing its life raft (almost 2 years past servicing date), and a COTP order to correct the problem prior to sailing was issued.

When discrepancies were compared to the vessel's dockside exam status, an important conclusion was drawn. Even though almost 70% of the vessels examined during the operation had either a previous voluntary dockside exam or had been issued an examination decal (demonstrating full compliance with the regulations at the time of the exam), little difference was seen in the raft and EPIRB discrepancy rate when compared to vessels that had never been voluntarily examined by the Coast Guard. An early suggestion during the planning phase was to skip those vessels with a dockside exam decal. However, this idea was dropped because we really didn't know what the examination teams would find during the operation. Luckily, the data validated our gut feeling that our efforts should focus on all crab vessels and not just on vessels without decals.

Operation Safe Crab 2001

A similar process was followed the next year; however, the season was not split. Three teams were deployed for a 4-day period, and 148 crab vessels were examined. No COTP orders were required that year. The number of vessels with serious problems decreased by 20% from 2000 to 2001.

Anecdotally, we heard from the major marine equipment supplier that its life raft servicing workload had shifted from a pattern of raft servicing in the spring as fishermen got ready for the summer troll fisheries to one where the rafts were brought in in October and November so that they would be in compliance when the Coast Guard came out before the crab season. In addition, the supplier reported selling out of new EPIRBs in early November and had to backorder safety items.

Eighty-two of the vessels examined in 2001 were repeat exams from 2000, meaning a total of 332 individual crab vessels were examined during the 2-year period. We believe that we examined nearly every active commercial Dungeness crab vessel for an expenditure of 64 man-days, about $8,000 in travel-related costs. On average, each examination cost the Thirteenth District about $20 in travel expenses when comapred to the cost of at-sea boardings, for which the average cutter-day may yield three or four boardings at an operating cost of several thousand dollars per day. Thus, there was little doubt that Operation Safe Crab was saving the taxpayers a lot of money.

But was it saving lives?

Operation Safe Crab effectiveness

The authors had hoped to use Perkins' methodology (Perkins 1995) to show statistical significance by testing a 2-by-2-column table using Fisher's exact two-tailed test. Table 4 was constructed for the 2000-2001 crab season using the total number of vessels (349) from the 20,000-pound cutoff. Only one vessel examined, the *Miss Brittany*, subsequently suffered a fatality during the season. Using the STATCALC module of the Centers for Disease Control and Prevention Epi Info software package proved moot. Due to the lack of differences between examined and unexamined vessels, the p-value was 1.000. This is true also for the 2001-2002 and 2002-2003 crab seasons, since no fatalities occurred aboard crabbers we didn't examine.

Table 4: Vessel fatalities

	Vessels with fatalities	Vessels without fatalities
Vessels examined	1	265
Vessels not examined	0	83

In terms of number of fatalities, deaths decreased, from 9 to 6, in the 3-year period before and then during Operation Safe Crab. Likewise, the number of vessel casualties that resulted in a death decreased from 5 to 2 in the same period. Given a relatively flat trend in crab vessel numbers over these 6 years, these decreases are significant.

Regardless of the numbers–and quantities are admittedly small–the Coast Guard received a considerable amount of praise from the industry. Feedback from individual owners, operators, and crewmen indicated an increased level of safety awareness among the fleet. Even if we weren't changing their operational behavior, we were at least providing an additional safety net by way of enhancing the material condition of the vessels' EPIRBs and life rafts.

The remainder of this work will focus on the specifics of Operation Safe Crab 2002, with the aim of providing advice and lessons learned to other regional regulatory bodies with safety oversight duties for high-risk fisheries. May they fare as well as we have.

Operation Safe Crab 2002 in depth

Introduction

Having conducted Operation Safe Crab for 2 years, we had a solid base for conducting the next operation. The experience gained from the previous years would make Operation Safe Crab 2002 a success. This section will show in detail how we conducted the 2002 operation. We will discuss how we met and accomplished each challenge during the multi-week operation, with what went right, and what went wrong. A discussion of pitfalls and process improvements necessary for future operations of this type will complete this section.

For those who are not familiar with the make-up of Coast Guard commands along the coastal towns of Oregon and Washington, a quick description is prudent. A Coast Guard Marine Safety Office (MSO) is responsible for overall safety in the marine environment, i.e., vessels, facilities, and personnel. Some specific duties for an MSO include inspecting, examining, and certifying merchant vessels and licensing the seamen that operate them; pollution response; port security; contingency preparedness; and investigating casualties. The MSO in Portland is responsible for the coastal area from Brookings, Oregon, to Westport, Washington, and had operational control (OPCON) for Operation Safe Crab 2002. A Coast Guard group oversees search-and-rescue operations for several Coast Guard stations (both air and small boat), and a Coast Guard station operates the small boats directly responsible for conducting search-and-rescue operations. The Coast Guard groups involved in Operation Safe Crab 2002 with their stations include—

Coast Guard Group, North Bend, Oregon
- Station Chetco River, Harbor (near Brookings)
- Station Coos Bay (actually in Charleston)
- Station Umpqua River, Winchester Bay
- Station Siuslaw River, Florence
- Station Yaquina Bay, Newport
- Station Depot Bay

Coast Guard Group, Astoria, Oregon
- Station Tillamook, Garibaldi
- Station Cape Disappointment, Ilwaco
- Station Grays Harbor, Westport

Operation Safe Crab 2002 was conducted over two separate weeks due to the different season openings north and south of Port Orford. The majority of the Oregon and Washington fleet operates north of Port Orford, Washington, so most of the resources were concentrated in the northern areas. Five teams worked from the south: (1) Brookings, (2) Coos Bay, (3) Newport, (4) Astoria, and (5) Westport. These towns had large commercial fishing fleets and were close enough to the smaller ports to allow short drives to accomplish operational goals. The Brookings (south) team started the week before Thanksgiving because of the different season opening date, while the four north teams started the week after Thanksgiving.

Briefings with local units

Personal notification to each local Coast Guard station did not happen the same way at each port of the operation for various reasons with various results. Most stations received an informal in-person briefing, whereas at least one unit received no briefing at all.

Three teams met briefly with the respective local Coast Guard station representatives on Monday morning just prior to the start of operations. They were supportive and offered administrative help. They did not assist in the actual operation. This procedure worked well for these three teams.

A fourth team attempted to meet with the local Coast Guard representative at the local station and group. Both attempts failed as the representatives were unavailable or too busy at the time. This led to problems later. The local Coast Guard units had not read the operational order and without the briefing had no clear picture of Operation Safe Crab or their role in its operation.

A representative from another group actually led one of the teams. This was very advantageous, since the team leader was able to brief his commander at his leisure prior to the start of the operation. The other teams had to travel into town and then try to arrange for a briefing prior to starting Monday morning. One local station from this group was not briefed. The team leader did not anticipate needing any support from that station.

For the most part, the informal briefings worked. However, there was confusion regarding the rules of engagement from the station and the group that had not been available for a briefing. Since that station and group had not been briefed, nor had they read the operational order, they didn't understand the operational goals or the legal discussions leading to the specific rules of engagement. Therefore, future operations should be better described to the local Coast Guard representatives. Though an operation order was sent out, an in-person briefing is the best way to ensure that all participants are clear about their duties and responsibilities.

Communications

We had to keep 11 people from five teams across more than 400 miles of coastline in close communication for incident, daily, and weekly reporting requirements. This wasn't overly difficult with today's technology. The overall flow of communication was good. The following will discuss the different modes of communication used, their advantages, and their disadvantages.

- *Landline phones:* We were able to use phones at the local Coast Guard stations or groups as necessary. These phones are fixed, meaning mobility is a problem, but they are good for long calls, negotiations, or when desk space is needed while communicating.

- *Fax:* The fax was a good tool for issuing COTP orders. We used fax machines at the local stations. The field team leader would draft the COTP order, fax it to the MSO, and wait for a reply. The COTP order was then smoothed, signed by the COTP, and faxed back. The fax copy was then issued to the operator of the subject vessel.
- C*ell phones:* All team leaders carried cellular phones. Naturally, this was the quickest means of communication, and coverage was adequate. A list of all cell phone numbers was given to each team leader. The cell phone was a very good tool, allowing quick answers to questions. Persons with the right answers were always readily available so that no one was left waiting on the dock, unsure of a course of action.
- *Message system:* The Coast Guard message system was used by District 13 to report the status of vessels examined each day to the Coast Guard cutter fleet. This worked quite well, with the result that the cutter fleet had up-to-date information on the vessels they were seeing at sea. This information could then be used to prioritize boardings.
- *Internet*: Remote access to the Coast Guard Intranet user accounts proved difficult. Pulling account information from the unit to the remote unit where we were located was extremely slow and therefore not utilized. Having better remote access to computer accounts would have made some things easier, such as drafting and transmitting the COTP orders.

Personnel

The personnel used for this operation were specifically requested by name. We received excellent personnel support from many units, resulting in very high-caliber examiners for this operation. The experience level was impressive. One of the petty officers sent by a local Coast Guard cutter was its leading boarding officer. Seven people had more than 10 years of experience each as marine inspectors. MSO Portland provided two GS-12s, one warrant officer, and one petty officer. The Coast Guard cutter *Steadfast* provided one petty officer. Group Astoria and Group North Bend each provided a junior officer (ensign and lieutenant junior grade), while Coast Guard District 13 provided the bulk of the personnel with two lieutenant commanders, two GS-12s, and one GS-13 from the Seattle area.

Operational control (OPCON) was the Commercial Fishing Vessel Safety Coordinator from MSO Portland. Team leaders were Brookings - GS-12 from Portland; Coos Bay–GS-12 from Portland; Newport–GS-12 from Portland; Astoria–LTJG from Group Astoria; Westport–GS-13 from Seattle. (One of the examiners from Portland was able to lead two teams because the South Team started 2 weeks earlier due to an earlier opening day for crab season south of Port Orford.)

Walking the docks/rules of engagement

Determining the rules of engagement was a long, difficult struggle. Some Coast Guard members thought we had authority to board any vessel, any time, any place. As discussions developed, we learned from our legal office that we did not have such authority and could not board any vessel, any time, any place. We were told to ask permission to board the boats.

Our fears regarding denial of boarding were unwarranted, as we found that this system actually worked quite well. Most critically, the Thirteenth District allowed examiners the option to inform a vessel operator that failing to allow the Coast Guard to do a dockside safety check could result in that vessel being targeted for an at-sea boarding once the vessel was underway. We hoped not to use threatening language. In reality, we used that threat only four or five times during the entire operation; most operators were very compliant.

Authority and jurisdiction

We discussed three possible sources of authority with District 13 Legal and Marine Safety Divisions: 14 United States Code (USC) 89, 33 Code of Federal Regulations (CFR) Part 160, and 33 CFR §6. First, 14 USC §89 is the basic boarding officer authority for Coast Guard officers and petty officers. Boarding officer authority is a waiver of the requirement for a warrant to search. Obtaining a warrant is not practical at sea. And, although the authority states applicability anywhere (or everywhere), searching vessels at the dock is frowned upon since a warrant is easily obtained from a local magistrate. To date, District 13 has not given us permission to use boarding officer authority at the docks for Operation Safe Crab.

Next, 33 CFR §160 allows the COTP to exercise control over vessels to operate as directed, but does not allow Coast Guard personnel to gain access to those vessels. Finally, 33 CFR §6 (the so-called Super-6) came from the Magnuson Act, which was not designed for gaining access to vessels for enforcement of safety requirements.

We recognized that the Coast Guard does have authority to control the movement of vessels as described above using 33 CFR § 160. Once an especially hazardous condition on board a vessel is identified, then the COTP can issue a written order to keep that vessel from sailing until the especially hazardous condition is corrected. Draft COTP orders were provided for each team, including the list of especially hazardous conditions.

We provided the following recommendations for each of the teams.

Opening lines and statistical information

- We are from the Coast Guard. We are here to conduct a spot check of your safety equipment.
- I am (insert name here) with the Coast Guard. We are conducting exams of safety equipment prior to the beginning of the fishery. Is it okay to come aboard?
- The Oregon and Washington crab fishery lost two vessels and four lives last year.
- Lack of safety equipment and training with that safety equipment was the major cause of deaths for crab fishermen last year.
- Thirty percent of life rafts are rigged such that they will not deploy if the vessel sinks.

Dos and don'ts

Do–

- Be assertive.
- Be friendly.
- Be informative.
- Be truthful.
- District 13 has determined that we can, when necessary, mention to operators that those vessels that refuse a spot check will be placed on a list that will be used by law enforcement units for determining boarding priorities.

Don't–

- Force your way onto a boat.
- Claim authorities you don't have.
- Provide false information.

Coast Guard reception on the docks

Once armed with our rules of engagement, we began meeting and talking with commercial fishermen. They were abundant on the docks, getting their boats ready for the crab season opener. We picked just the right time to catch them all. Asking permission to board per the rules of engagement was scary at first, but it worked. The reason it worked well was because most of the commercial fishermen want to be in compliance and want to be safe. Most of them gladly invited us to board their vessels. Some went out of their way to find us so we could check their safety equipment and ensure that their safety equipment met Coast Guard standards.

Of the 224 vessel contacts made during the 2 weeks, only five (2.2%), refused to allow a team member come aboard to check their safety equipment. Some of the few negative experiences include a fisherman who quizzed the examiners for 20 minutes regarding their knowledge and expertise (kudos for having highly experienced examiners on the docks) and then calmly allowed the examiners on board. Another fisherman growled that he was too busy and too tired. One fisherman restricted by a COTP order for an out-of-service life raft yelled and screamed at the examiners, but he was very cordial to the Coast Guard station personnel when clearing the COTP order.

We were very pleased with the attitudes of the majority of the commercial fishermen. Most of them are as concerned about safety as we are. We were able to do safety checks on hundreds of boats while protecting their rights of privacy.

Weather

Weather was not a factor. We had chilly but dry weather for the entire 2 weeks. Staying dry is important, considering all the data collection we were doing. Had it been wet we would have had difficulty keeping accurate records because we were using regular paper and clipboards. In the future we should improve our data collection tools in case we encounter a wet crab opener.

Timing

We were not able to find a fisherman on all of the vessels every day. Many boats had no one on board initially. We just kept going back to the same locations. Each time we returned we found new people we hadn't met yet. A week was about the right amount of time. At the end of the week we had met with the operator of almost every crab boat in each harbor.

Information gathering

The data collection forms were designed to allow information to be entered quickly. We worked in teams of two or three. For each vessel, one examiner would do a quick safety equipment check, while the other asked some simple questions. We were usually on and off the vessel in less than 5 minutes. This was a good selling point when asking permission to board.

We gathered lots of information, but focused on three main areas: stability, life raft, and EPIRB. Data from previous years showed that drowning caused most deaths of commercial fishermen after their vessel capsized due to overloading. Furthermore, some of the life rafts and EPIRBS, two essential lifesaving devices, had gone down with the vessels because they had not been stowed properly. This has been confirmed as a problem through experience on the docks examining boats.

In 2000, 35% of the life rafts examined were found to be stowed incorrectly and would not have deployed or inflated if the vessel had sunk. The most common problem was the installation of the hydrostatic release. Older models of the Hammer brand hydrostatic release could be installed so that they kept the life raft from deploying. If the life raft never deploys, the painter is never pulled from the canister. If the painter is not pulled from the canister, the life raft never inflates. The new style Hammer has been redesigned and is easier to install correctly.

EPIRBs are another common problem, not only with stowage, but also with regard to their registration with the National Oceanic and Atmospheric Administration. Without a registration, an initial EPIRB signal received from the geosynchronous (stationary overhead) satellite can only tell responders from what hemisphere the EPIRB is transmitting. It can take up to 45 minutes for a polar-orbiting satellite to get within range, and then the satellite must receive several hits to vector in on a search area. With a proper registration, responders have a name, address, phone number, and description of the vessel, which helps significantly with initial response.

Vessel stability was not as easy to check as was the life raft and EPIRB. U.S. vessels less than 79 feet long or over 79 feet *and* built before 1991 are not required to have stability information. Vessels required to have stability information have a booklet from a naval architect with the exact number, size, and location for stowing crab pots. Confirming stability on a vessel with stability information was easy.

Unfortunately, the majority of crab boats in Oregon and Washington do not require stability information, so we had to devise a method for determining unsafe loading and stability. After considerable discussion with naval architects, we decided to apply a standard of 6 inches of minimum freeboard amidships, a down-flooding angle of at least 35°, and roll-period criteria. If a vessel met two of these three conditions, then we would not consider the vessel especially unsafe. It is important to note that this was never publicized as safe loading criteria; rather, it was reserved for examiners so they could be articulate about a vessel's condition when it was clearly not safe. We had a simple chart to assist with those determinations (Figure 2). If we had questions or concerns, we would contact the naval architects at headquarters and be prepared to provide them with more information about the vessel. With that, they could help determine safe freeboard, roll period, etc. Luckily, we found no vessels that were loaded in a questionable manner.

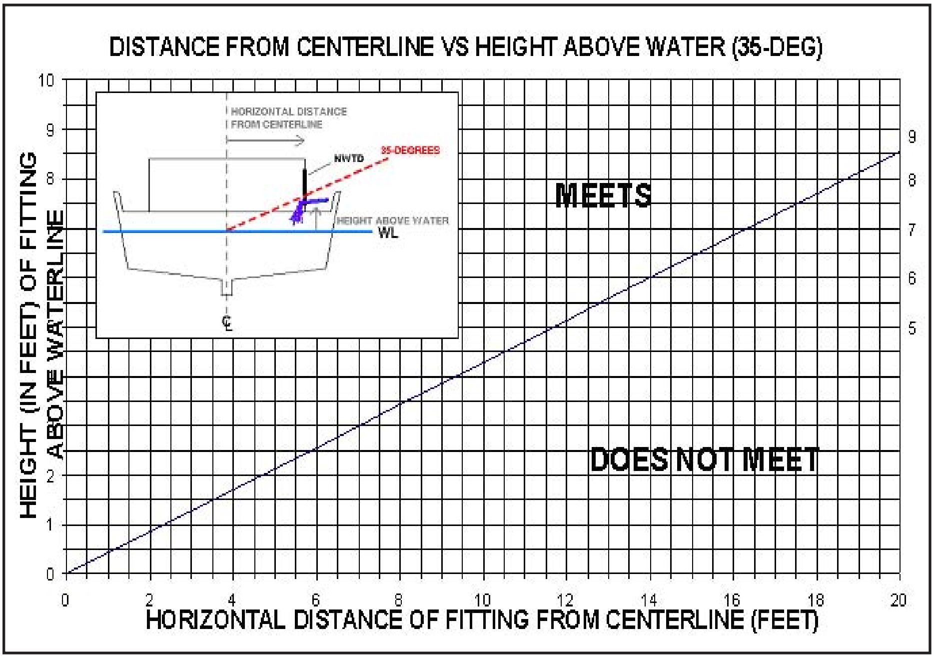

Figure 2: Safety limits

To use the chart, an examiner finds the vessel's nonwatertight fittings (i.e., pipes, hatches, or doorways penetrating the deck or hull) vertically closest to the waterline. Then the examiner measures the vertical distance from the waterline to that fitting and matches that measurement to the left side of the chart. Next, the examiner measures the distance from the fitting to the centerline of the vessel and matches that to the bottom of the chart. The numbers are then run across and up until they meet. The diagonal line on the chart corresponds to the 35° angle. Therefore, points above the diagonal line represent a fitting with a downflooding angle greater than 35° and meet the criteria, and those points below the diagonal line represent a fitting with a down-flooding angle below 35° and does not meet the criteria.

Captain of the Port orders

COTP orders are issued for vessels having especially hazardous conditions. To facilitate the decision and implement those orders, some conditions were defined ahead of time. Examiners were directed to issue a COTP order if we found any of the following conditions:

- No EPIRB on board.
- EPIRB battery more than 2 years past expiration date.
- EPIRB or life raft hydrostatic release unit more than 2 years past expiration date.
- Incorrect hydrostatic release unit rod for EPIRB (a black rod is required: older white rods have been recalled by the manufacturer).
- No life raft on board.
- Life raft capacity inadequate.
- Life raft servicing more than 1 year past expiration date.
- Life raft arrangement, unable to fix or properly stow on the spot
- Overloading.
- Lack of watertight integrity.

We were not limited by this list and could recommend a COTP order if we witnessed an especially hazardous situation not defined above.

A skeleton COTP order was provided for each team leader. If an especially hazardous condition were observed, the team leader would fill in the blanks and fax it to the MSO in Portland. The MSO would proof and smooth the document, get the COTP's signature, and fax it back. This process took a few hours. Once the signed COTP order was in hand, it was delivered to the operator of the subject vessel. The operator would then correct the especially hazardous condition and request a re-examination. Either the local Coast Guard station or one of the Operation Safe Crab team members could do the re-examination. A COTP order rescission letter was then issued to the operator.

We only issued two COTP orders. Both were for life raft servicing.

Reports

The team leaders made reports daily to the operational commander. The operational commander would combine the reports and submit them to the Office of Law Enforcement at the Thirteenth District. The report included the names of vessels contacted, number and type of discrepancies noted, if any, and/or whether the team had been refused permission to board. The daily reports were combined for a final report when the operation was complete.

Media

A media information bulletin was released several weeks prior to the operation. Local radio stations and newspapers announced the program, and at least one television station covered the information with an interview of one of the team members on the docks. Media coverage was positive.

Several commercial fishermen knew we would be on the docks because of the media coverage. They either waited for us to walk by or called and requested an examination. Our public affairs efforts were very effective.

Good press releases should always be a part of this operation.

Pitfalls

Turf battles

One Coast Guard station fought a bit of a turf battle because it felt the Operation Safe Crab team members were intruding. The team was initially treated with indifference. The station had not read the operational order and would not see the team members for a briefing. Then, as the operation continued, personnel from that station verbally challenged the authority of the team and expressed outrage at the rules of engagement that the Thirteenth District had approved. This station put its own armed personnel on the docks talking to and gathering information from the commercial fishermen and put one of their personnel with the Operation Safe Crab team. This caused confusion with the fishermen and an air of anger and distrust between the team and the station personnel. The station initially refused to provide any assistance to the Operation Safe Crab team. They later provided minimal support and then complained about it. The station complained to its group commander that the team was not dressed properly, although team members were dressed in accordance with the Coast Guard Commandant's policy for commercial fishing vessel examiners. Their group commander backed them up. The issue was never properly resolved and could lead to problems for future operations at that location.

Seven other stations were involved, all of which provided excellent support for Operation Safe Crab.

Disgruntled fishermen

The few disgruntled fishermen we met were handled successfully. According to our rules of engagement, we were to attempt to board vessels assertively. If a fisherman got angry and disagreeable, we would back off, well shy of becoming aggressive. Examiners did a good job not crossing that line.

When an attempt to board failed, we would explain to the operator that the vessel name would be placed on a list that the offshore Coast Guard cutters would be given and that could lead to being targeted for an at-sea boarding.

Issuing a COTP order was tough. Telling a fisherman he couldn't go fishing is a difficult task. We issued two orders during the operation. The vessel operators cleared both relatively quickly. In one case, the local Coast Guard station cleared the discrepancy after the Operation Safe Crab team had issued it. That worked well, as the operator, who was very angry with the issuer of the COTP order, was able to clear it with other Coast Guard personnel with whom he wasn't so angry.

There is no good way to handle someone who is yelling and threatening you, especially if you have no compliance authority or tools (weapons). However, I believe dealings with angry fishermen in future operations should be handled similar to past operations. Be calm, listen, state the facts, and leave if things get out of hand.

Cutter follow-ups

Reports included information on vessels not in compliance, vessels in full compliance, and vessels whose operators refused to allow the Coast Guard on board. All reports were sent to the Thirteenth District, which relayed the information to the Coast Guard cutter fleet. However, we saw almost no successful boardings as a result of that information. Many vessels in full compliance reported being boarded, sometimes repeatedly, during crab season with no violations.

The Coast Guard cutter fleet needs to do a better job searching for targeted vessels, rather than boarding the first vessel that crosses its path. Additionally, cutter fleet managers should do a better job of placing the cutters in positions where they will encounter crab boats during crab season.

Conclusions

The Coast Guard has a clear strategic mandate to eliminate deaths associated with commercial fishing. Previous efforts focused on voluntary safety examinations at the dock and enforcement during at-sea boardings. These approaches—dockside examinations and at-sea boardings—have had mixed success, due in the first instance to their voluntary nature and in the second to relative infrequency depending on the availability of expensive Coast Guard cutters. Both approaches share another critical flaw: high-risk fisheries are treated no differently than those with lower risk.

The Oregon and Washington Dungeness crab fishery is among the nation's most hazardous because of weather extremes, treacherous river bars, proximity to the surf, vessel instability, and intense market pressure leading to a "race for fish." Sixteen fishermen have lost their lives in the past seven crab seasons. A fatality rate per 100,000 workers was calculated for this fishery, adjusted for risk exposure, and found to be twice the national fatality rate for commercial fishing and comparable to the rate of deaths in the Bering Sea crab fisheries.

Given the success of the at-the-dock enforcement efforts started in 1999 in Alaska and the loss of six fishermen and three vessels off the Oregon and northern California coast that same winter, effective action by the Thirteenth Coast Guard District was clearly needed. The nature of the fishery, with its predictable locations and timing, easily lent itself to a specific, targeted at-the-dock operation. This was a just-in-time outreach to check stability and crab pot loading, EPIRBs, and life rafts on the vessels most at risk, but with a new dimension: Vessels with especially hazardous conditions would be prohibited from fishing until corrections were made.

The goals of Operation Safe Crab were simple: Examine as many crab vessels as possible, apply uniform standards across the fleet, focus on high-risk causal factors, keep exams short to minimize disruption to vessels, keep the Coast Guard examiners safe, provide credible consequences for noncompliance, involve the Coast Guard's law enforcement personnel, ensure that the operation was well publicized, and make the best use of Coast Guard resources. Thorough planning was the key to meeting these goals. The objectives and methods were communicated among the key players, and carefully selected examiner teams were deployed with data collection tools and reporting documents. Issues of Coast Guard authority were discussed, and clear rules of engagement were given to all examiners.

In the last 3 years, Operation Safe Crab has reached nearly 100% of the Oregon and Washington Dungeness crab fleet. Vessel discrepancy rates have steadily dropped. Critical lifesaving equipment has been brought into proper working condition. Although the numbers are small, a decrease in the number of deaths and vessel losses causing a death has been noted from the 3 years immediately prior to the first Operation Safe Crab and the 3 years since. Anecdotally, we believe safety awareness and spending by vessel owners on safety gear have increased.

A detailed discussion of the policies and actions of our last effort, Operation Safe Crab 2002, was presented. Several lessons learned were given, including the need for better communication and coordination with Coast Guard law enforcement personnel. In the future, continued safety improvements can be accomplished through reallocation of law enforcement effort from fishery management enforcement to fishing safety enforcement.

We believe that following our methods, other regional regulatory safety authorities can attain similar results with a cooperative, risk-based approach to prevention.

References

Medlicott C (2002). Using dockside enforcement to compel compliance and improve safety. *In* Proceedings of the International Fishing Industry Safety and Health Conference (Woods Hole, Massachusetts, Oct. 23-25, 2000), Lincoln JM, Hudson DS et al., eds. Cincinnati, OH: National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2002-147.

Perkins R (1995). Evaluation of an Alaskan marine safety training program. *Public Health Report, pp.* 701-702.

US Coast Guard, Fishing Vessel Casualty Task Force (1999). *Dying to Fish, Living to Fish.* Washington, DC.

Woodley C (2000). Developing regional strategies in fishing vessel safety: integrating fishing vessel safety and fishery resource management. Seattle: University of Washington.

Notes

a. The Thirteenth Coast Guard District comprises the states of Washington, Oregon, Idaho and Montana, and the adjacent ocean waters out to approximately 1200 nautical miles.

b. During the 2001-2002 season, one typical crabber was so overloaded with a tall pot load that the vessel rolled and capsized in the channel moments after the vessel left the dock. Apparently, the roll induced by the vessel's maneuvering (i.e., use of the rudder) exceeded the vessel's angle of positive righting energy, and she slowly rolled until the pilothouse hit the river bottom. No one was seriously injured.

c. Free-surface effect refers to the dangerous loss of stability when a liquid load is free to slosh transversely. The liquid's center of gravity moves as the surface seeks to remain level during the vessel's roll, resulting in a virtual rise in vertical center of gravity (and loss of stability).

d. Casualty data taken from official US Coast Guard records, as collected by the Fishing Vessel Safety Division (G-MOC-3) at Coast Guard Headquarters.

e. Due to data confidentiality concerns, a random vessel identifier replaced actual vessel ID numbers.

f. Data compiled by Christopher Woodley, 2000, during the writing of his master's thesis and e-mailed to the author.

g. Coincidentally, Captain James Spitzer had just been reassigned to Portland as the Captain of the Port after completing the Coast Guard's Fishing Vessel Casualty Task Force Report. He agreed wholeheartedly that more direct action was needed.

EVALUATION OF ALASKA'S COMMERCIAL FISHING VESSEL SAFETY PROGRAM

Alan J. Sorum, MPA
City of Valdez Small Boat Harbor
Valdez, Alaska, USA
E-mail: asorum@ci.valdez.ak.us

Executive Summary

Historically, commercial fishing is the most dangerous occupation in Alaska. Remote fishing grounds, poor weather, and cold water compound the problem. Loss of life prompted Congress to pass safety legislation in 1988. Alaska's Commercial Fishing Safety Program is a direct response to this legislation. The Coast Guard and other major organizations have developed a multifaceted program. Among its components are public education, law enforcement, and voluntary dockside fishing vessel safety examinations.

This evaluation involves three questions. First, are there unrealized opportunities or deficiencies present in the current fishing vessel safety program? Second, has the commercial fishing vessel safety program improved overall safety? Finally, does current, but unutilized, research exist that could help to improve fishing vessel safety? A three-part approach was designed to answer these questions.

1. A qualitative interview conducted with fishermen and representatives of the program.
2. A fishing vessel casualty and fatality data analysis .
3. A review of current literature and research.

Results show strong support for the dockside safety examination program. Deaths and vessel losses have declined in Alaska since the program began. Research suggests a measurable reduction in deaths, national acceptance of some Alaska safety practices, and the potential opportunity to predict specific dangers for Alaska's fishing fleet.

Recommendations developed in this evaluation suggest an increased focus on promoting dockside safety examinations and improving communications among participants. Fishermen value dockside examinations as an opportunity to ensure compliance with complex regulations. Coast Guard representatives favor them as an opportunity for a positive interaction with fishermen. Research shows those fishermen included in initial safety program planning and policy-making efforts continue with their involvement and participation in the safety programs. Many fishermen echoed this thought. They are much more comfortable with continued regulation when they can be part of the safety-related process.

Introduction

Commercial fishing is the most hazardous occupation in Alaska. Poor weather, small vessels, darkness, remote fishing grounds, and cold water only compound the dangers of fishing here in Alaska. Alaska's commercial fishing industry has lost an average of 34 vessels and 23 lives a year for the last 15 years (NIOSH 1997).

During the early 1990s, the death rate for fishermen in Alaska was 200 deaths per 100,000 workers per year (Conway, Lincoln et al. 1999). The overall rate for all workers statewide during the same period was almost five times the national average of seven deaths per 100,000 workers per year. The Coast Guard established the Commercial Fishing Vessel Safety Program (CFVS) to help address this tragic loss (US Coast Guard 1999).

Commercial Fishing Vessel Safety Program

The CFVS program is primarily a Coast Guard scheme to improve safety in the fishing industry. A major driver for establishing this program was the Commercial Fishing Industry Vessel Safety Act of 1988 (CFIVSA)(Williams 2000). The National Institute for Occupational Safety and Health (NIOSH), National Weather Service, Occupational Safety and Health Administration (OSHA), and the State of Alaska, Section of Epidemiology, are also considered major contributors to the Alaska CFVS program.

The current CFVS program is comprised of many different elements. Among these are public education, law enforcement, and voluntary dockside safety examination of fishing vessels. OSHA enforces federal standards for workplace safety, and NIOSH conducts research into improving safety and offers suggestions on how to implement it (NIOSH 1994, 1997; Lincoln and Conway 1999).

Elements of evaluation for the Commercial Fishing Vessel Safety Program

This evaluation of the CFVS program in Alaska addresses three separate questions:

1. Are there unrealized opportunities or deficiencies present in the current fishing vessel safety program?
2. Has the commercial fishing vessel safety program improved overall safety?
3. Does current research exist that could be used to improve fishing vessel safety?

This evaluation uses several approaches to answer these questions. The first is a qualitative interview with those involved in the industry, fishermen, and Coast Guard marine safety personnel. This effort seeks to find common thoughts on the program and hopes to identify unrealized opportunities. Second, a review of fishing-related fatality and vessel casualty data in Alaska is necessary to see if there are any apparent trends or relationships. Finally, this evaluation reviews fishing vessel safety research to gauge the effectiveness of the CFVS program. A research review can also identify missed opportunities and strategies.

Qualitative interview with those involved in the industry

Fishermen and the CFVS program sponsors were interviewed to see if any opportunities or deficiencies in the current program had been overlooked. The interviews provided a way to gauge the effectiveness of the program and its acceptance among those involved in it. This process also generated additional suggestions on how to improve the program.

Interview design

A six-question interview format was designed to gauge attitudes and perceptions of those involved in the CFVS program. The questions were open-ended and offered the opportunity for extended discussion of pertinent topics. The interview started from a general viewpoint and worked toward specific topics. Eight people actively involved in the CFVS program and another 10 people currently working as commercial fishermen were selected for interviews, but the constraints of time and access to those involved limited a truly random selection process. Group sampling appeared to be less important among the personnel working in the CFVS program, since the interviews covered almost all of those working within the Coast Guard's portion of the program in Alaska.

Data derived from the process are used in a number of ways: To identify safety topics developed through the interview process, to determine if there are common safety themes shared between the program sponsors and fishermen, and to develop descriptions showing the relationships existing between the program sponsors and fishermen.

Qualitative interview data and discussion of results

Sponsors and fishing personnel were asked to recall efforts made to improve fishing vessel safety. The most common responses from fishermen were with regard to the dockside safety examinations and safety equipment required as part of CFIVSA. Coast Guard personnel focused entirely on training efforts, including drills, stability, and damage control.

When asked to identify the most effective activity being conducted, both groups overwhelmingly selected the dockside safety examinations. An interesting point was that to most fishermen the dockside exams were important because they helped with regulatory compliance, while the program sponsor's personnel favored the exams as an opportunity to interact effectively with the fishing industry.

Opinions differed among fishermen questioned about what would be the least effective part of the CFVS program. Half of them indicated no problems with the program and were glad to have the Coast Guard available. The majority of Coast Guard personnel who responded focused on an overall lack of vessel inspections. They felt there was a failure to promote more dockside safety examinations. There was also support for more extensive periodic inspections of machinery and hulls.

The fourth question in the interview was designed to gauge the understanding both parties in the program might have of each other. Fishermen, in general, felt the Coast Guard often uses broad, general regulations and tries to apply them to unique, specific conditions. Many fishermen mentioned the need for a more realistic, rational approach to rule making. Regulations are easier to adopt than apply in the working world. Coast Guard personnel expressed a true interest in fishermen's safety and wanted fishermen to know this. A few respondents felt there could be lack of trust between the communities and that this needed to be addressed.

Both groups were asked to identify the one rule they would impose to improve fishing vessel safety. The majority opinion expressed by members of both groups was to enforce mandatory dockside safety examinations of fishing vessels. The consensus was to ensure compliance on vessels prior to their leaving the harbor.

An overall observation made after talking to these interested participants in the CFVS program is that both program sponsors and fishermen support the prevention of marine casualties. Both sides share more common attitudes than they might have initially believed. Saving lives and vessels can create strong bonds.

Table 1: Fatality rate information on Alaska commercial fishing industry

Year	No. of vessels lost	No. of persons on board	No. of persons killed	‡Fatality rate, %
1989	35	119	30	25
1990	31	137	31	23
1991	35	104	28	27
1992	46	114	33	29
1993	21	86	18	21
1994	36	266	13	5
1995	27	118	18	15
1996	39	116	25	22
1997	32	93	3	3
1998	33	145	13	9
1999	31	148	17	11
2000	19	97	8	8
2001	30	130	24	18
2002	22	114	12	10

Source: USCG Alaska District, Fishing Vessel Safety Coordinator.
‡Case Fatality Rate = (number killed / number at risk) x 100.
**Data from* Arctic Rose *not included here.*

Fishing-related fatality and vessel casualty data

The Alaska District of the Coast Guard provided information concerning all fishing vessel accidents since 1989 (Table 1). Sue Jorgenson, Coast Guard CFVS coordinator, was very helpful in describing the material. Coast Guard personnel in Valdez also contributed information specific to Prince William Sound and background on the voluntary dockside examination program.

NIOSH first illustrated the usefulness of calculating case fatality rates by year in the commercial fishing industry. We have reviewed the NIOSH process and updated the published information through 2002 and found the same results. Analysis of Coast Guard data shows vessel casualties have remained relatively constant, with a mean number of vessels lost equalling 31.2 and a median equalling 31.5 since 1989. The number of people on board and at risk has also been constant: a mean of 127.6 and a median of 117. The fatality rate is the relationship between those put at risk and the number killed in vessel casualties. This rate has improved since 1989.

One major problem with vessel statistics is the variability of losses. The commercial fishing fleet has a wide variety of vessel sizes and if a larger vessel carrying more people sinks, it can skew the totals. The sinking of the *Arctic Rose* greatly affected the fatality rate for 2001.

The Coast Guard data set classifies fishing vessel casualties by cause and includes capsizing, sinking, fire/explosion, towing, and grounding. Research suggests that capsizing and sinking incidents pose the greatest risk to the crew (Figure 1) (Lincoln and Conway 1995, 1999; NIOSH 1997; Conway, Lincoln et al. 1999).

Fishing-related deaths can also be classified by cause (Figures 2 and 3). "Man overboard" is the major cause of death for fishermen not involved with a vessel casualty. Sinking and capsizing comprise 50% of the deaths in incidents that involve a vessel casualty.

Data were also provided by the Coast Guard on the number of voluntary dockside safety examinations conducted since the beginning of the program. The Y-axis in Figure 4 was constructed with a logarithmic scale to allow examination data to overlay casualty information. Visually, the chart shows a slight decrease in vessels lost and an apparent improvement in the total number of lives lost. This observation would match well with the CFVS pro-

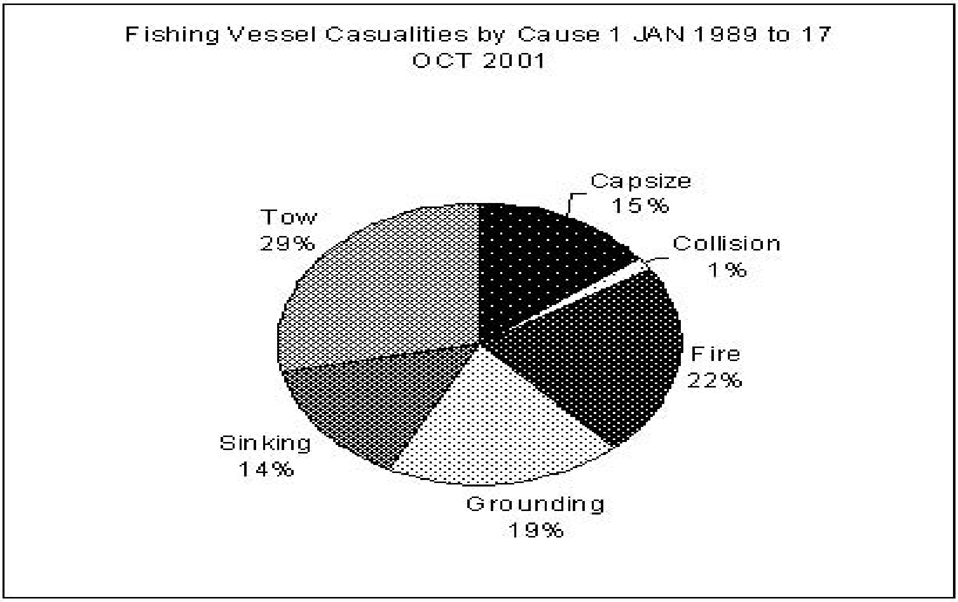

Figure 1: Fishing vessel casualties by cause, 1 January 1989 to 10 December 2002.
Data Source: USCG Alaska District, Fishing Vessel Safety Coordinator.

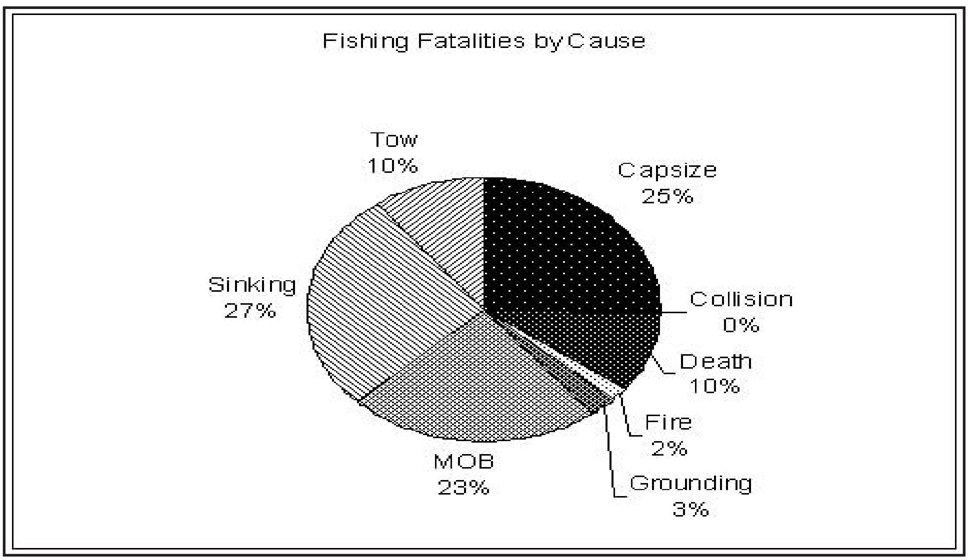

Figure 2: Fishing-related fatalities by cause,1 January 1989 to 10 December 2002.
Data Source: USCG Alaska District, Fishing Vessel Safety Coordinator.

gram emphasis on protecting lives after an accident has occurred. The other observation is that the total number of examinations given has remained very flat, but has decreased slightly since 1994.

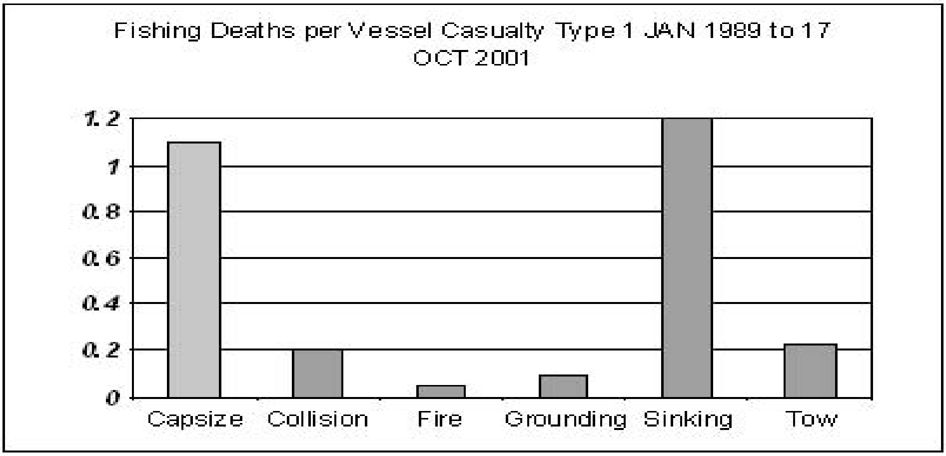

Figure 4: Fishing deaths per vessel casualty type, 1 January 1989 to 10 December 2002. Data Source: USCG Alaska District, Fishing Vessel Safety Coordinator.

Research and literature review

Limited research is available on commercial fishing vessel safety. Related research and literature included in this evaluation came from searches of on-line resources, library records, Coast Guard references, and contacts with various agencies. NIOSH is the research leader in this field. Jennifer Lincoln, of the NIOSH Alaska Field Station in Anchorage, provided the research for this evaluation.

Numerous and lengthy lists of recommendations are available from government, education, industry, and trade groups. It is apparent that many of the same recommendations have been made repeatedly over the years. No one causal factor can improve fishing vessel safety because fishing vessel safety is a puzzle of competing interests and concerns. Rather than list other researchers' recommendations, this section of the evaluation will address information directly supportive of Alaska's effort or present information not noted at the national level.

Research conclusions can be broken into a number of related topics. These describe the effectiveness of Alaska's CFVS program or offer possible improvements to it. They include—

- The Alaska CFVS program benefits from the specific mandates implemented from the CFIVSA.

- Recent CFVS program efforts on a national scale have incorporated many of the safety concepts developed in Alaska.
- The incidence of fishing-related fatalities and vessel casualties can be predicted through the use of statistical analysis. This analysis evaluates external factors that impact the fleet.
- The commercial fishing industry has experienced a measurable reduction in fatalities and vessel casualty rates.

NIOSH findings regarding the Alaska CFVS program

CFIVSA mandated a number of new requirements for safety equipment and training on fishing vessels. These included the use of immersion (survival) suits, life rafts, and radio beacons. Required training includes first aid and emergency drills. Reductions in fishermen's deaths have mainly been the result of keeping them afloat and dry after they enter the water (Lincoln and Conway 1995, 1999; NIOSH 1997; Conway, Lincoln et al. 1999). Eighty-eight percent of all fishing deaths are caused by hypothermia and/or drowning.

Program mandates led to a significant decline in deaths from 1991 to 1998. One criticism of the program is that lifesaving efforts are all post-accident and that not enough is being done to prevent accidents.

National adoption of Alaska practices

Efforts made in developing the Alaska CFVS program have contributed to national efforts to improve fishing vessel safety. The Fishing Vessel Casualty Task Force was established in 1999 to address an alarming increase in fishing accidents on the East Coast. Eight NIOSH Alaska Field Station recommendations for improving fishing vessel safety were adopted by the task force (US Coast Guard 1999).

Prediction of fishing-related losses

Research shows that some fisheries are more dangerous than others (Lincoln and Conway 1995, 1999; NIOSH 1997; Conway, Lincoln et al. 1999). For example, the Bering Sea is especially dangerous because of the poor weather typical for its season. Vessels fish for a limited amount of stock and have only a narrow window in which to fish. Factors affecting safety include vessel size, market price of fish, and experience (Lincoln and Conway 1995, 1999; NIOSH 1997; Conway, Lincoln et al. 1999).

One group of researchers developed a statistical model that predicts which fishing conditions pose the greatest risk to those involved (Jin, Kite-Powell et al. 2001). Conclusions of the study suggest that capsizing and sinking accidents pose the greatest chance of resulting in the total loss of a vessel (Figure 4). An increase in the price of the fish harvested was associated with a decreased chance of a vessel loss. The risk of a fatality is greater in capsizing and fire and explosion accidents. Examination of the data describing Alaska's experience shows that sinking and capsizing events have the greatest risk for fishermen (Lincoln and Conway 1995, 1999; NIOSH 1997; Conway, Lincoln et al. 1999).

Future efforts in the CFVS program could utilize this research method to target and attempt to reduce high-risk situations. The methodology could accept details specific to Alaska and allow for a more customized interpretation of local data. The chart above shows a death per incident rate for various casualty types. It is apparent that accidents placing fishermen in the water are a major risk factor.

Recommendations

The Alaska effort to improve fishing vessel safety has been successful. That being said, no one involved in this industry believes commercial fishing is as safe as it could be. Recommendations developed from this evaluation focus on improving Alaska-based initiatives. There are many excellent recommendations being developed on the national level that have been previously suggested and may eventually be implemented here. In the meantime, actions developed, approved, and taken within Alaska will provide more immediate results.

The following recommendations were drawn from material developed by this evaluation, including analyses of casualty data, review of related research, and discussions with stakeholders. The list is not meant to be comprehensive, but is an attempt to generate discussion of common topics discovered in the evaluation process.

Involve fishermen

Swedish research points to the continued involvement and participation of those fishermen who were included in initial planning and policy-making efforts (Törner 2001). An outreach effort should be made by the Coast Guard any time new policies, procedures, or regulations are considered.

Coast Guard personnel felt that many fishermen believed the agency's role was to impose additional government regulations and increase the cost of doing business. Marine safety employees need to consider every contact with a fisherman as an opportunity to associate a human face with concern for safety.

One example of a positive contact is the Marine Industry Safety Day and Blessing of the Fleet sponsored by the Coast Guard's Valdez Marine Safety Office in 2001. Fishermen were able to practice the use of survival equipment and interact with Coast Guard personnel. The event was well received. It cast a positive light on the Coast Guard's safety efforts and was conducted at minimal cost. Other opportunities exist in the communities of Alaska. Health and safety fairs, high school career nights, and similar events are excellent avenues for public education.

Promote use of dockside safety examinations

Anecdotal comments support dockside examinations. What is apparent from the data is that the level of participation has remained flat since the program was developed. Coast Guard personnel and fishermen were almost unanimous in their support of the exams as an excellent method of interacting and educating fishermen about safety.

There needs to be further incentive for fishermen to participate in the program. The Ship Escort Response Vessel System (SERVS) provides oil spill prevention and response equipment for Prince William Sound. Fishing vessels under contract to SERVS to assist in spill cleanup are required to have a current dockside examination. Finding other organizations that could benefit from dockside examinations should be explored. These could include educational foundations contracting vessels for hire, agencies that place fisheries observers on board fishing vessels, and insurance carriers. Some of these efforts have already begun.

Wide support exists among program sponsors and fishermen for dockside examinations to be made mandatory. Three principal reasons were given. First, current regulations are difficult to interpret. A second opinion helps with compliance. It pays to have outside inspections of required safety equipment. Second, most vessels involved with the program have been part of it for quite a while. Eighty percent of the vessels in Alaska do not participate. Third, the examination process offers a great opportunity for interaction among those involved that is not conducted under threat of punishment.

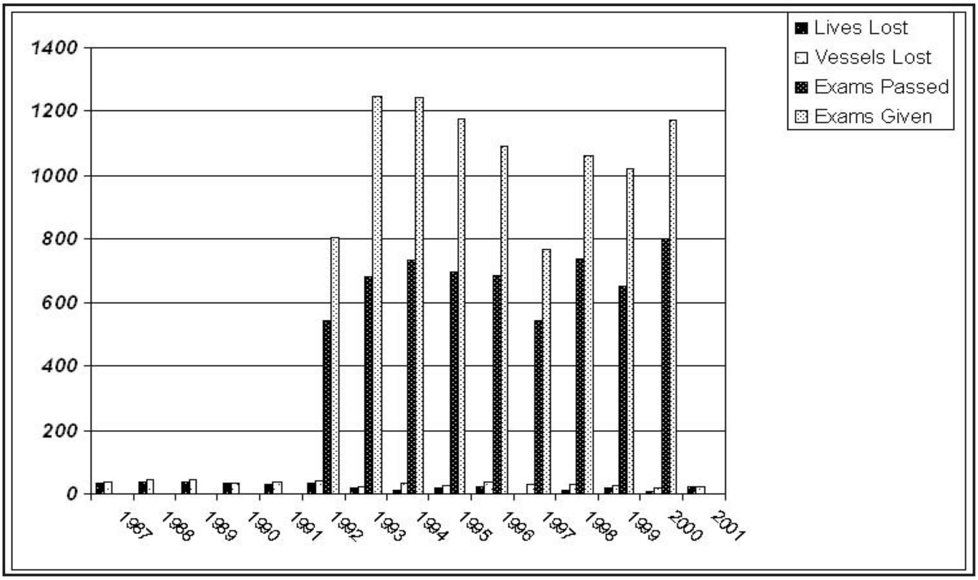

Figure 5: Fishing vessel casualities versus dockside examinations conducted.
Data Source: USCG Alaska District, Fishing Vessel Safety Coordinator.

Dockside examinations are not currently meant to be a strict compliance tool of the Coast Guard.

Conclusions

The number of deaths has decreased since the inception of Alaska's CFVS program (Figure 4). There is no doubt expressed by those interviewed from the fishing industry that there are still too many deaths and vessels lost each year. The Coast Guard has developed the framework of a successful program. Interviews with the program sponsors and fishermen show wide support for the CFVS program. These communities are more united in their concern for safety than either may realize. There are many valid recommendations in existence that could improve the CFVS program. What the Coast Guard lacks now are the tools to complete the mission and implement these important ideas.

References

Conway GA, Lincoln JM et al. (1999). Alaska's model program for surveillance and prevention of occupational injury deaths. *Public Health Report* 114(6): 550-558.

Jin D, Kite-Powell H et al. 2001. The safety of commercial fishing: determinants of vessel total losses and injuires. *Journal of Safety Research* 32(2): 209-228.

Lincoln JM and Conway GA (1995). Preventing deaths in Alaska's fishing industry. *Public Health Report* 110: 700.

Lincoln JM and Conway GA (1999). Preventing commercial fishing deaths in Alaska. *Occupational and Environmental Medicine* 56(10): 691-5.

Törner Marianne (2001). Finding way to support safety in the fishing industry. Proceedings of the Marine Safety Council, US Coast Guard, April 2001.

National Institute for Occupational Safety and Health (1994). Preventing drownings of commercial fishermen. DHHS (NIOSH) Pub. No. 94-107.

Lincoln JM and Conway GA (1997). Commercial fishing fatalities in Alaska: Risk factors and prevention strategies. Cincinnati, OH: National Institute for Occupational Safety and Health. Current Intelligence Bulletin 58. DHHS (NIOSH) Pub. No. 97-163.

US Coast Guard, Fishing Vessel Casualty Task Force (1999). *Dying to Fish, Living to Fish.* Washington, DC.

Williams J (2001). Fishing vessel safety action plan evaluation. *Proceedings of the Marine Safety Council* 58(2):60-63.

Appendix A: CFVS program interview questions

1. What is your involvement with commercial fishing?
2. What efforts can you recall being made to improve commercial fishing vessel safety?
3. The US Coast Guard has a commercial fishing vessel safety program in place. It is composed of many different components such as dockside examinations, research, regulation, investigation, and law enforcement. Is there part of this program you believe has been very effective? Why?
4. Is there part of this program you believe can be improved? Why?
5. The Fishing Vessel Safety Program involves people from within fishing and government communities. What do you think people from the other side of the program fail to realize about your community?

6. If you could propose one rule to improve fishing vessel safety, what would it be? Why?
7. Do you have any further comments that should be considered in the discussion of fishing vessel safety?

Appendix B: Selected respondent comments

- Stability testing of vessels should be required. Many fishermen don't realize how easy it is to roll a loaded vessel.
- Complete a damage control class. The knowledge and skills turned out to be lifesavers for fishermen facing a sinking vessel.
- Mandatory licenses for fishing vessel operators would insure knowledge and practical understanding of marine operations. Many fishermen have little or no experience operating fishing vessels.
- Emergency equipment required by the CFIVSA of 1988 is very important and only represents a minimal level of protection.
- Voluntary dockside safety examinations are very important. They help ensure equipment is functional, that the vessel meets current regulations and offers a great change for interaction between the Coast Guard and fishermen.
- The results of the marine casualty investigations should be readily available to the industry. The Coast Guard's "Lessons Learned" program is very useful.
- Dockside examinations of fishing vessels should be mandatory. Eighty percent of the fishing vessels in Alaska do not participate in a proven program that could save their lives.
- The Coast Guard needs to realize fishermen are operating small businesses. Inspections, regulations and boarding should be planned not to disrupt work whenever possible.
- Safety regulations are easier to draft than enforce. There needs to be a practical application of regulations impacting the fleet.
- There is no inspection required for fishing vessel rigging. Every year several people are killed by falling booms, broken pins, and winches. Deck safety need to be addressed by the industry and regulators.
- Vessel orientation and safety drills are very important. Classroom instruction is not as valuable as on-the-job training in the field. Documentation standards for on-board drills need to be strengthened.
- The Coast Guard is really doing a great job.
- Stress marine firefighting skills and equipment use. A vessel on fire at sea represents a major disaster for the crew.

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS INTEGRATED STABILITY TRAINING PROGRAM FOR COMMERCIAL FISHING VESSEL CREWS AND THE FISHING COMMUNITY

John E. Womack, Naval Architect, MSE, BSE
Mid-Atlantic Shipwrights
Pittsville, Maryland, USA
SNANE, Chairman of Working Group B, Ad Hoc Panel 12-
Fishing Vessel Operations and Safety
E-mail: shipsjw@aol.com

Bruce Johnson, Professor Emeritus, PhD, MSME, BSME, USNA
Annapolis, Maryland, USA
SNAME, Chairman of Working Group A, Ad Hoc Panel 12-
Fishing Vessel Operations and Safety
E-mail: aronj@bellatlantic.net

Summary

The commercial sector of the fishing industry has more diverse types and classes of vessels and fishing methods than any other category in the fishing industry. For this reason, the traditional apprenticeships from deckhand to captain no longer serve as an effective stability training method for fishermen. Under the Society of Naval Architects and Marine Engineers (SNAME) Ad Hoc Panel 12, Fishing Vessel Operations and Safety, a three-component, integrated stability training program using verbal and visual presentations, a written booklet, and a set of table-top hands-on demonstration models has been developed to address this issue. This program has been designed to be flexible for use on board individual vessels, as well as during large meetings where more technical presentation methods can be offered.

Brief history of the evolution of stability training

Until recently, the traditional method of training mariners in ship stability involved long apprenticeships for everyone on board, from deckhands to captains. Mariners-to-be would learn the proper "feel" of sailing the ships of the day under the tutelage of experienced captains. In spite of the crudeness of this approach, it was actually quite successful, and relatively few vessels sank solely because of stability issues. The stability of commercial sailing vessels was capable of being judged by feel because of the way they were propelled and their basic design characteristics.

In comparison, traditional hands-on apprenticeships for stability training on today's fishing vessels are a dangerous proposition. Many different configurations have been developed for fishing vessels to reflect various fishing techniques and local conditions. A subjective judgment of stability in vessels of one fishery cannot be transferred reliably to another fishery having different vessel types and gear. The different fishery vessel configurations have become, in general, more sensitive to stability problems related to shrinking freeboards, numerous openings in the watertight envelope, large and variable capsizing forces related to fishing gear, and significant changes in stability characteristics during the voyage. All of this creates a continually moving target of the vessel's feel that the crew cannot reliably predict.

This lack of predictability has led to the creation and subsequent transfer from captain to captain of many myths and misconceptions about how stability works and whether the feel of the vessel can be used to judge whether stability levels are adequate. The stability characteristics of modern commercial fishing vessels are very complex and can mislead crews, giving them a false impression that all is well when in actuality they may be in imminent danger of capsizing. These misconceptions continue to persist, not through the fault of the fishermen, but through the fault of naval architects, safety trainers, and regulators who have failed to introduce stability training adequately to crews. (For additional discussions on this topic, see Appendix A: Evolution of Stability Training.)

Requirements of an effective stability training program

To rectify problems associated with stability training and improve crew safety, effective means are needed to teach stability to the crews. A few programs are in limited use today, but they tend to have one or more common failings that prevents their practical use. To be effective, a stability training program for the commercial fishing community needs to address numerous issues.

The first issue is for trainers to determine their target audience. While it is obvious that crews are the primary focus of stability training, any useful program must also target vessel owners, the Coast Guard (US Coast Guard 1999) and other inspection agencies, safety trainers, surveyors, insurance companies, and fishing regulators. Other parties that must understand stability issues include the International Maritime Organization (International Maritime Organization 1995; Francescutto 2002), the Food and Agriculture Organization (Turner and Petursdottir 2002), the International Labor Office (Wagner 2002), and accident investigation agencies (Lang 2002). The key to a successful training program is that all members of the commercial fishing community gain knowledge of stability. Vessel owners and their crews need to fully understand vessel stability so that they are able to emphasize and practice safe operations while maximizing productivity. More knowledgeable inspectors and surveyors will focus attention on vessel design and use that affect stability. Fishing regulators can better consider all aspects of a fisheries management plan, including how the fishing fleet can maximize safety, with a better knowledge of stability issues.

The second issue that must be addressed is flexibility. Given the wide audience desired, a successful training program needs to be flexible to adapt to various audience sizes, audience concerns, and presentation venues. Audience size will vary from a few participants, if addressing a single crew, to possibly a hundred, if a presentation is being made at a trade show. Likewise, appropriate venues will range from individual fishing vessels to large trade shows or fisheries management councils. A flexible training program must also be adaptable to handle the specific concerns of a single vessel or fishery, as well as the generic concerns of a large group.

The third issue is the need for hands-on learning. Book work alone cannot effectively deliver the lessons desired (Herbert 2002). By creating a means for crew members to experience a more hands-on lesson, skills will be transferred to the real-world workplace and make the training more believable and understandable.

The fourth issue is integration. A successful stability training program should be integrated throughout fishing vessel safety training programs. In addition, consistency in how the material is presented is necessary for better understanding of the topic.

The fifth issue is presentation. A common refrain in sales is "presentation is everything," and this is certainly true in stability training. To help "sell" the lessons, an effective presentation scheme must be used. This includes the primary use of figures and graphics over words. Those figures and the fishing operations they depict should represent real-world fishing vessels to enhance the transfer of skills and knowledge. In addition, videos of model tests and animations should be used to place the lessons into a real-world context, as well as provide a more entertaining learning experience. To aid visual impact, color should be used wherever possible. For example, by using red, yellow, and green for different stability curves, the relative safety level of each curve can be intuitively and quickly signaled to the audience.

The sixth issue is portability. Any presentation program needs to include learning aids that are easily transported to various venues. Going to crews, rather than having them come to the instructor, can increase the number of audiences. This portability requirement includes hands-on demonstrations.

The last, but perhaps most important, issue for an effective stability training program is the scope of the subject matter to be taught. The program should focus only on teaching the basic concepts of stability and how fishing operations affect a vessel's relative stability levels. No attempt should be made to teach how to calculate a vessel's actual stability. That is the province of a naval architect who fully understands all the complexities and nuances, many of which can contain hidden dangers.

While this simplistic approach may at first appear to fail to provide useful training, it will actually provide more practical knowledge to the maximum possible audience for several reasons. First, complex concepts require long commitments of time to be taught effectively, something most members of the fishing community don't have. It takes a minimum of 4 years of schooling at an institution of higher learning and many years of practical experience for a naval architect to fully understand stability.

Second, the educational level of fishing boat crews varies greatly. Advanced stability concepts are highly technical and rely on fully understanding "imaginary" concepts such as metacentric height. Third, the primary goals of a successful stability training program are to (1) demystify the stability guidance creation process, including the inclining test; (2) provide sufficient understanding of stabiity to allow crews to have faith in the stability guidance given even when it runs counter to past experiences or beliefs, and (3) provide a basic understanding of the way common fishing situations affect stability to allow crews to evaluate their risks in nonstandard loading, operating, and weather conditions.

Thus, a focus on the basics of stability and a focus on preserving lives and vessels are what is needed for most commercial fishermen, not advanced engineering formulae.

Results

Description of the SNAME-developed commercial fishing vessel stability training program

The Society of Naval Architects and Marine Engineers (SNAME), under Ad Hoc Panel 12, Fishing Vessel Operations and Safety, developed a commercial fishing vessel stability training program that addresses the issues raised above. The training program consists of three principal components: a written booklet, a verbal and visual presentation, and a set of hands-on training models. All the figures presented below are examples of those used in the booklet, the presentation, or the hands-on demonstrations. In the booklet, these figures are three to four times larger than shown here to provide good readability.

This stability training program has been under development for approximately 3 years (Johnson, Wallace, and Savage 2002; Johnson and Womack 2001; Womack 2002). During this period, many concepts were developed and tested over a wide range of audiences. Three drafts of the booklet were made available for review on Ad Hoc Panel 12's Intranet site and also directly sent to selected Coast Guard personnel, naval architecture firms, and safety trainers for their comments. In addition, a conceptual version of the hands-on demonstration model, including plastic tanks, was built for trial purposes (see Figures 1 and 2). This conceptual model and several draft versions of the presentation were tested with five fishing vessel crews and owners when stability letters were presented, as well as with the Coast Guard's Commercial Fishing Vessel Industry Advisory Committee, several Coast Guard fishing vessel safety coordinators, members of the Maritime Lawyers Association's Fisheries Committee, SNAME's Panel O-44 (Marine Safety and Environmental Protection), and various naval architects and shipbuilders both within and outside the fishing community.

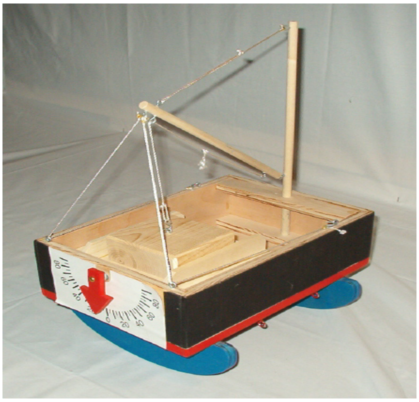

Figure 1: Model, quarter view

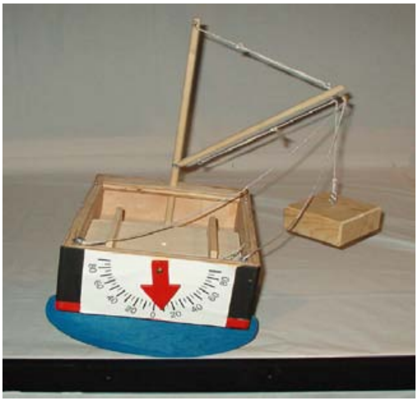

Figure 2: Model, end view

Basic structure of the SNAME stability training program

As mentioned, the stability training program consists of three principal components. In this setup, the presentation and its accompanying set of demonstration models are intended to be the primary teaching tool. The booklet, while of use as self-teaching material by many readers, is intended as a take-home refresher manual. This approach is preferred because no matter how well-written the booklet, within the wider target audience, there will always be questions or topics that cannot be fully addressed during training sessions.

The main presentation consists of approximately 48 Power Point slides, although this number can vary to address individual audiences. Eight companion slide shows of about 14 slides each, which graphically animate the interactions in the hands-on demonstration models, are also available. Furthermore, a series of short videos demonstrating the dangers of operating in heavy seas can be used during the main presentation. The presentation generally takes between 1 to 2 hours, depending on how much of the material is used. When used for individual crews, the time required will generally be closer to 1 hour, which is both practical and tolerable.

The accompanying 8-1/2- by 11-inch (215- by 280-mm) booklet is approximately 60 pages long. In addition to the stability training material described in Section 3.2, the booklet also contains a glossary of key terms and a list of contacts for additional information. For the advanced reader, an appendix shows some of the methods naval architects use to gauge a fishing vessel's stability.

The last component of the stability training program is the hands-on demonstration models. Two sets of models have been built for table-top use at different venues. A large version with a hull length of about 24 inches (600 mm) is intended to be used in large meeting rooms. With all the accessory parts, this version requires two large (30- by 22- by 10-inch)(760- by 560- by 250-mm) and two small (26- by 17- by 9-inch)(660- by 430- by 230-mm) suitcases to transport. A half-scale version with a hull length of about 12 inches (300 mm) is also being developed for individual vessels. This set requires only one large suitcase to transport, making it feasible to use when giving a stability letter to a crew or at a small gathering.

Topics covered by the presentation and booklet

The booklet, presentation, and demonstration models cover five basic topics.

1. A description of stability and how it is created.
2. An explanation of how a vessel's stability can be graphically displayed.
3. Initial and overall stability conflict.
4. Relative effects of fishing and vessel operations on stability.
5. General stability and seamanship guidance.

The first section starts out by defining the differences between "stable" and "unstable" fishing vessels, as this is key to any further discussions. A stable fishing vessel is one that has sufficient righting forces available to counter all capsizing forces encountered during the fishing trip. An unstable vessel does not have sufficient righting forces. Next, the two forces of gravity (G) and buoyancy (B) acting on a fishing vessel to develop these righting forces (i.e., its stability) are introduced. The first section then explains how the interaction of these forces, specifically the shifting of buoyancy as the fishing vessel heels over, either creates a positive righting force or a negative capsizing force (Figure 3).

The second section follows by showing how naval architects can graphically represent the righting forces by using a righting arm curve (Figure 4). Using this curve, the stability characteristics of a vessel under different loading conditions can be evaluated and compared. This section also gives a brief explanation of the inclining test and how a vessel's center of gravity (G) and center of buoyancy (B) are calculated. The purpose is to demystify the stability guidance development process, which can, quite frankly, appear as black magic to crews. To them, the naval architect moves some weights back and forth on the deck, disappears, and then reappears with stability guidance.

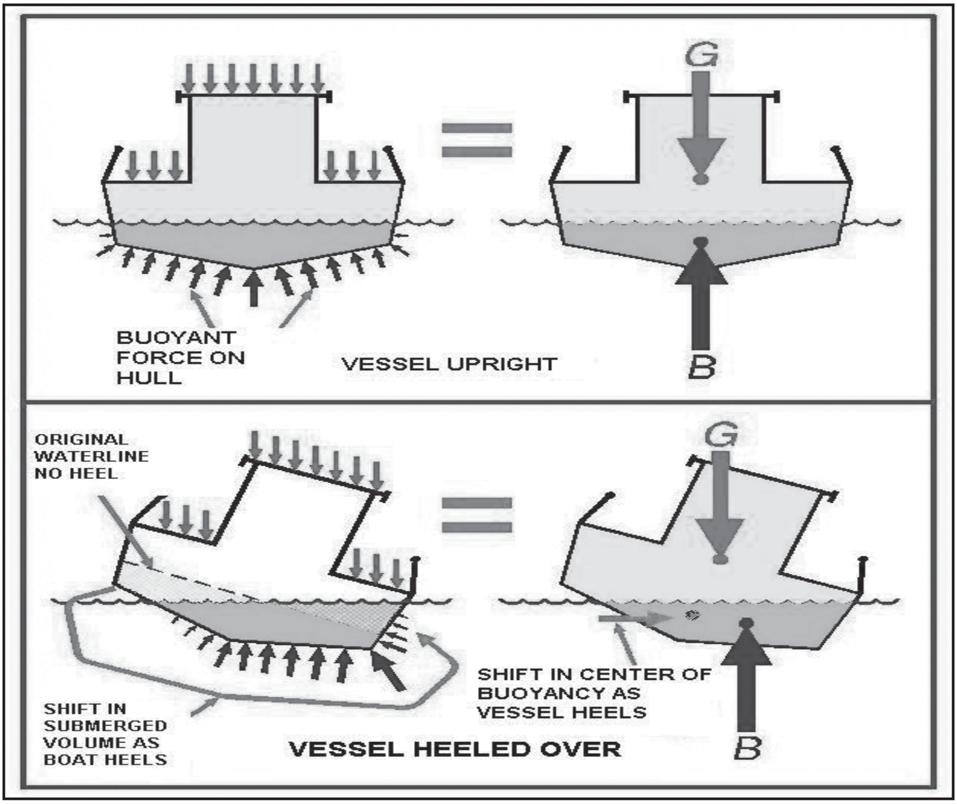

Figure 3: Shifting boyancy (B)

As noted, this sort of maneuver can sometimes run counter to the crew's beliefs.

The third section of the training program explains facts about initial stability versus overall stability conflicts, which is the root cause for many of the fishing community's misconceptions about stability. Quite often, a vessel's stability does not correlate with a crew member's perception of vessel stability based on the vessel's feel. As shown in Figure 5, the difference in stability levels between two loading conditions at high heel angles is quite significant. The problem is that the difference in stability levels is relatively small at the low heel angles typically experienced by the crews. It is from these low heel angles that the vessel's feel is derived by the crews, but, as shown this situation, feel cannot always provide a good indicator of the stability available during severe conditions.

The fourth section of the booklet and presentation shows the relative effect of typical situations on a vessel's stability. This section is broken into four

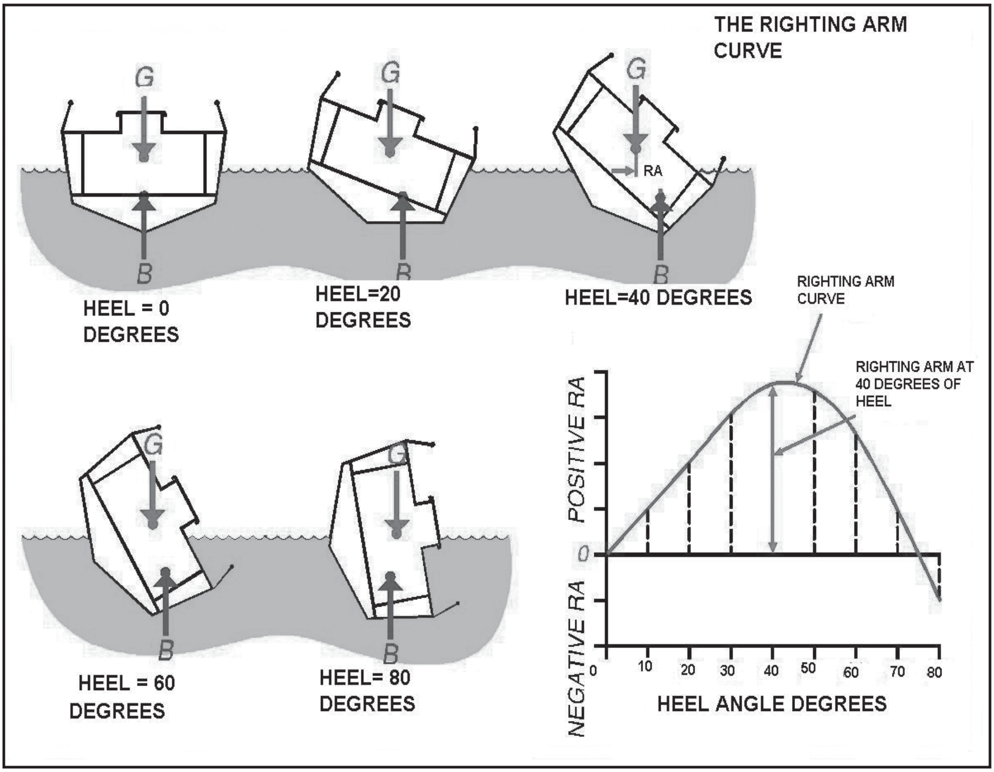

Figure 4: Righting arm curve

main topics: "Initial Versus Overall Stability," "Free Surface," "Fishing Operations," and "Vessel Operations." "Initial Versus Overall Stability" covers vessel loading situations such as overloading (Figure 6), adding ballast, and the cumulative effect of weight creep. "Free Surface" includes the effects of slack tanks, progressive flooding, water on deck, and water trapped in large deckhouses (Figure 7). "Fishing Operations" covers such topics as lifting weights, towing trawls (Figure 8), and shifting loads. The last topic, "Vessel Operations," covers vessel handling in heavy following (Figure 9), quartering, beam seas, icing (Figure 10), and the effects of beam winds.

The relative effects of a particular fishing situation on a vessel's stability levels are shown by way of the righting arm curves. This approach clearly shows the significant reduction in overall stability that can occur during typical fishing situations. The loss in stability is generally twofold: an overall reduction in the righting arms (righting forces) and a reduction in the outer range of positive righting forces. In some cases, such as when water is trapped in the deckhouse (Figure 7), the reduction in stability is threefold: an overall reduction in the righting arms (righting forces) and a reduction in both the inner and outer range of positive righting forces. However, as noted previ-

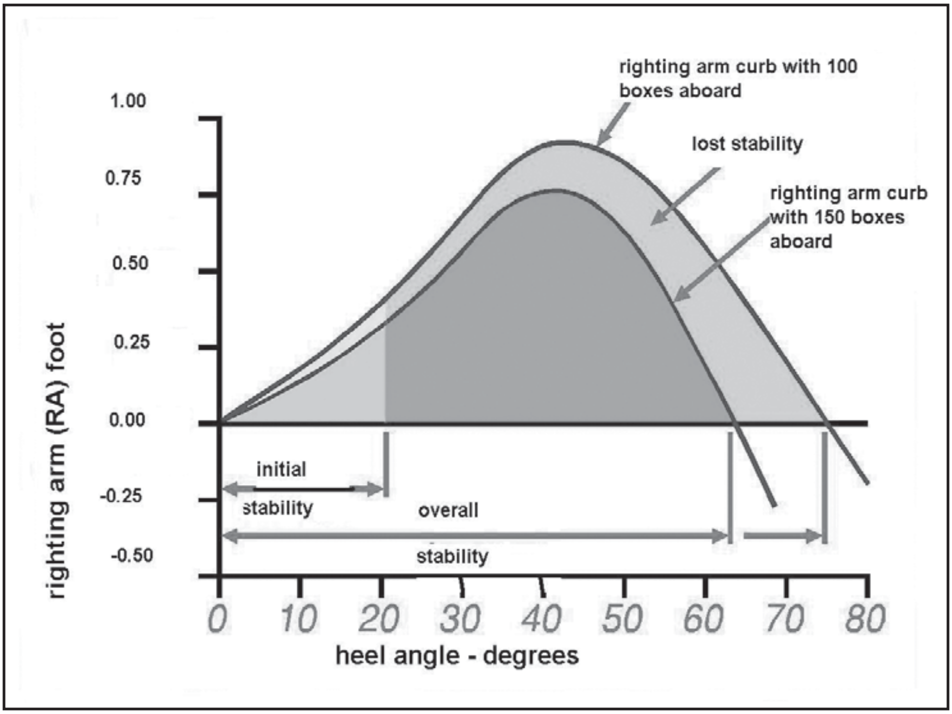

Figure 5: Initial versus overall stability

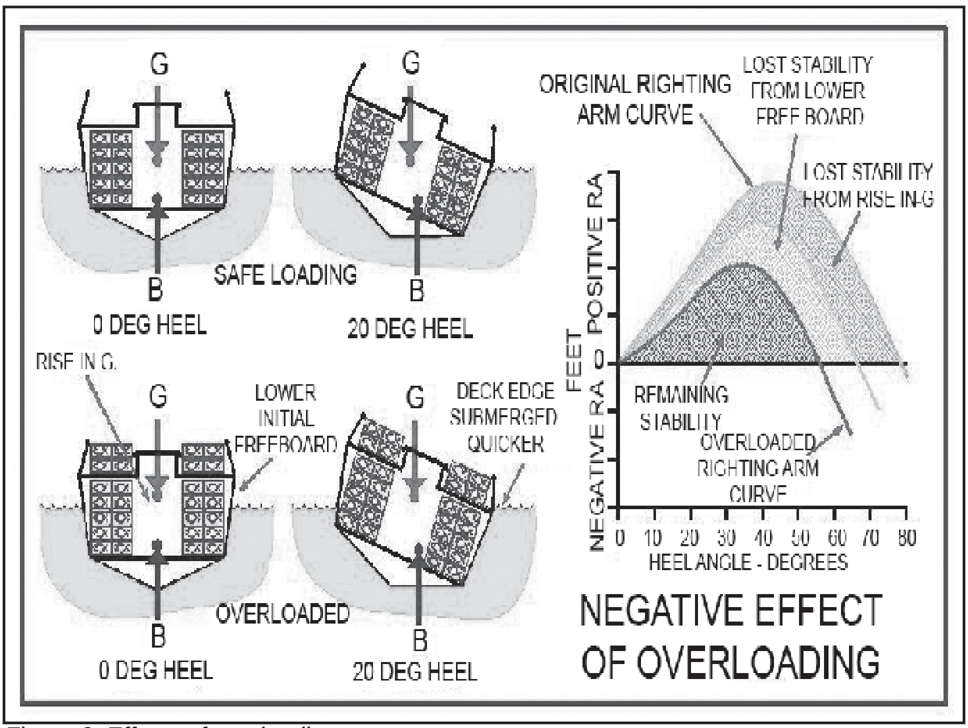

Figure 6: Effects of overloading

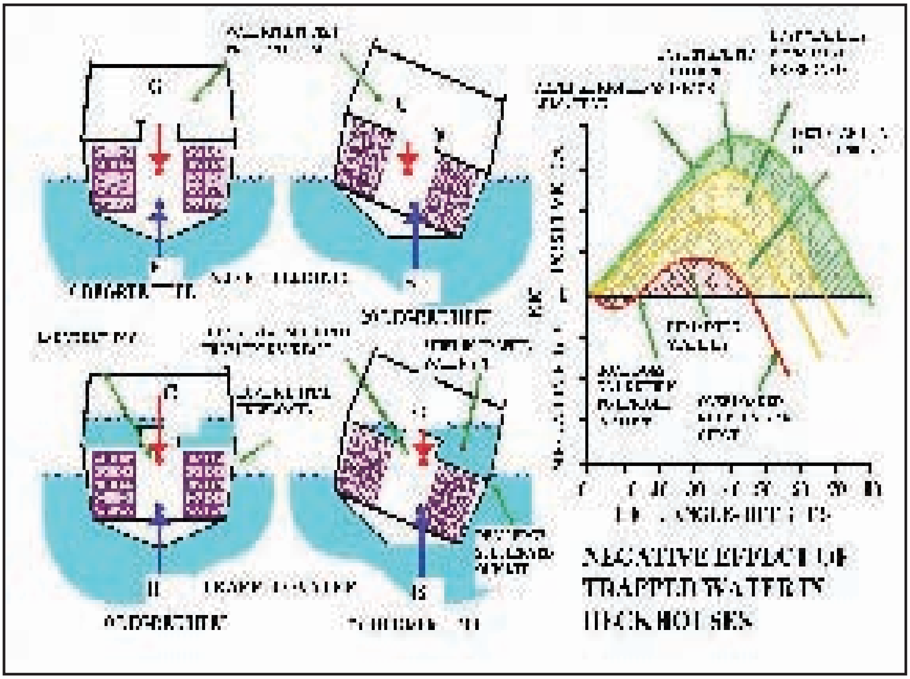

Figure 7: Effects of water

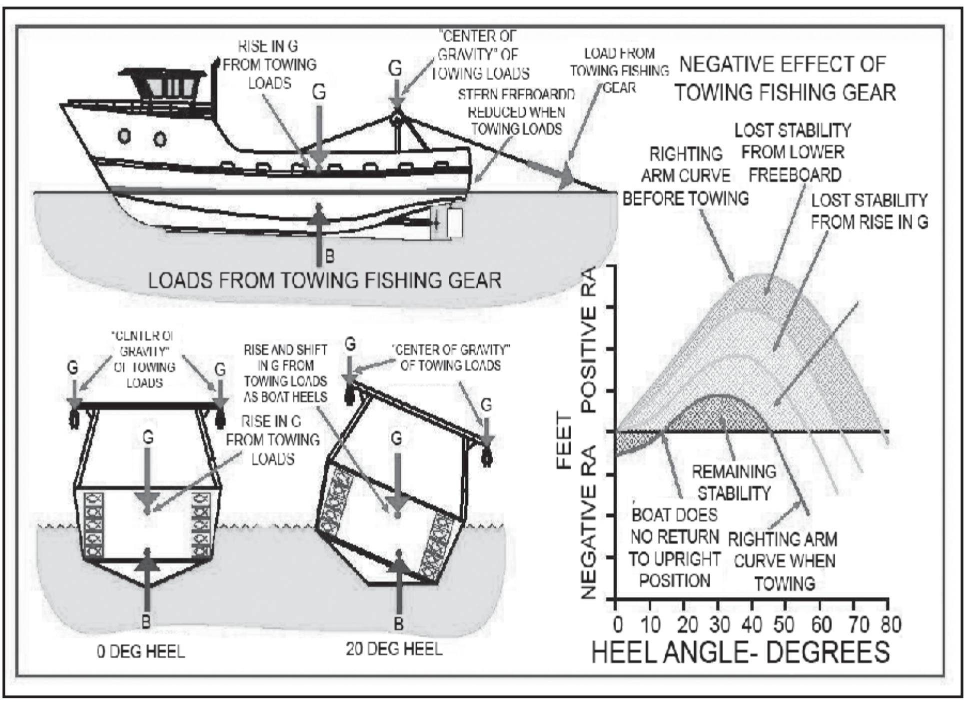

Figure 8: Effects of towing gear

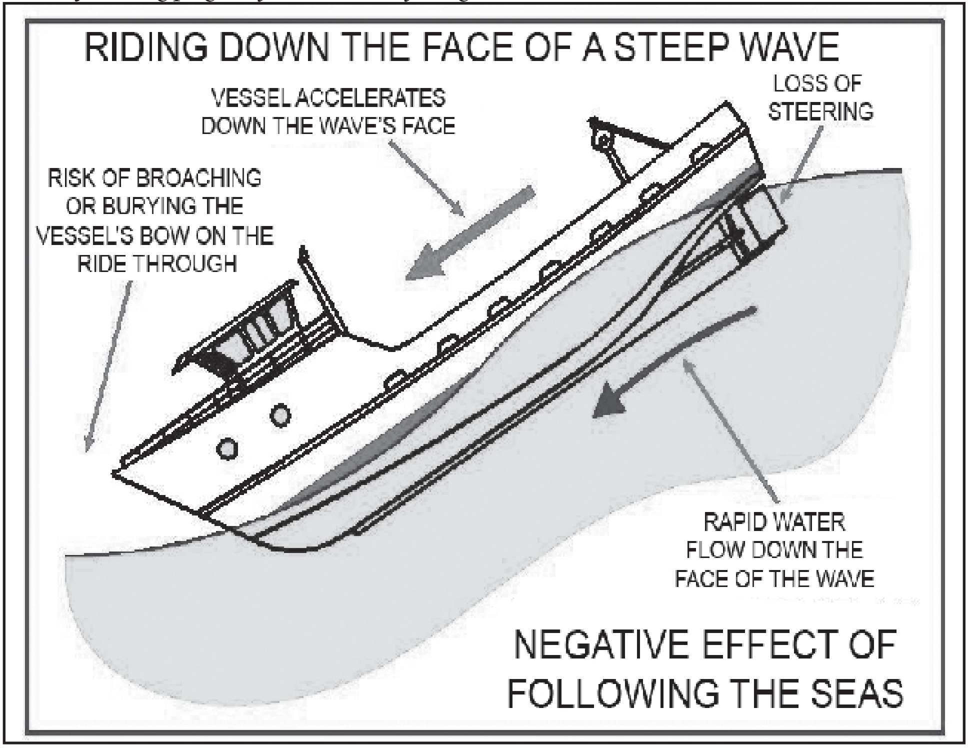

Figure 9: Effects of following seas

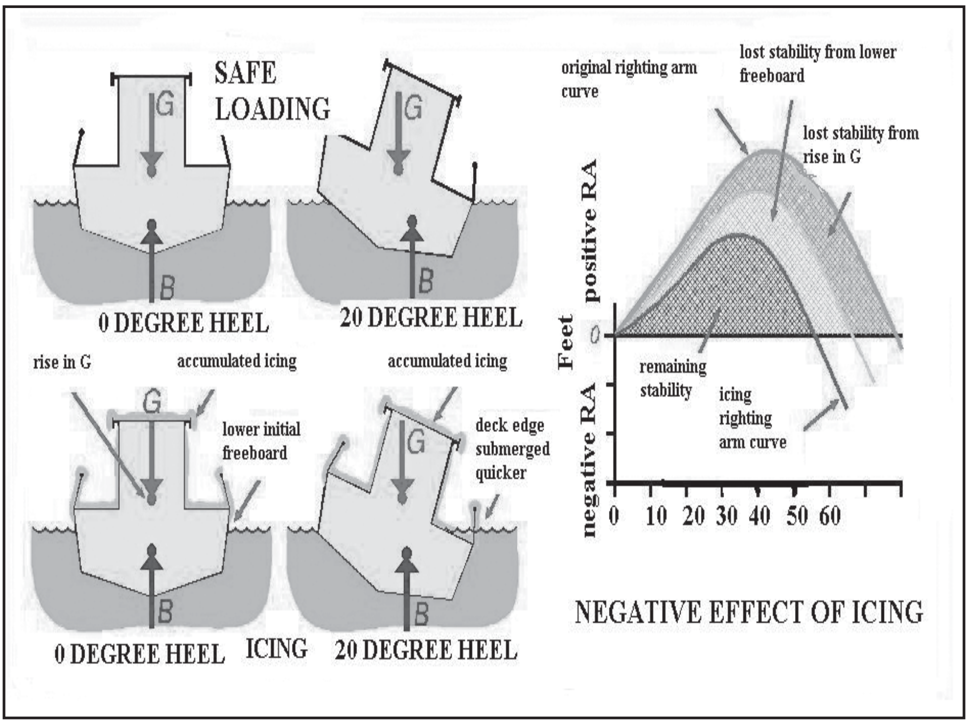

Figure 10: Effects of icing

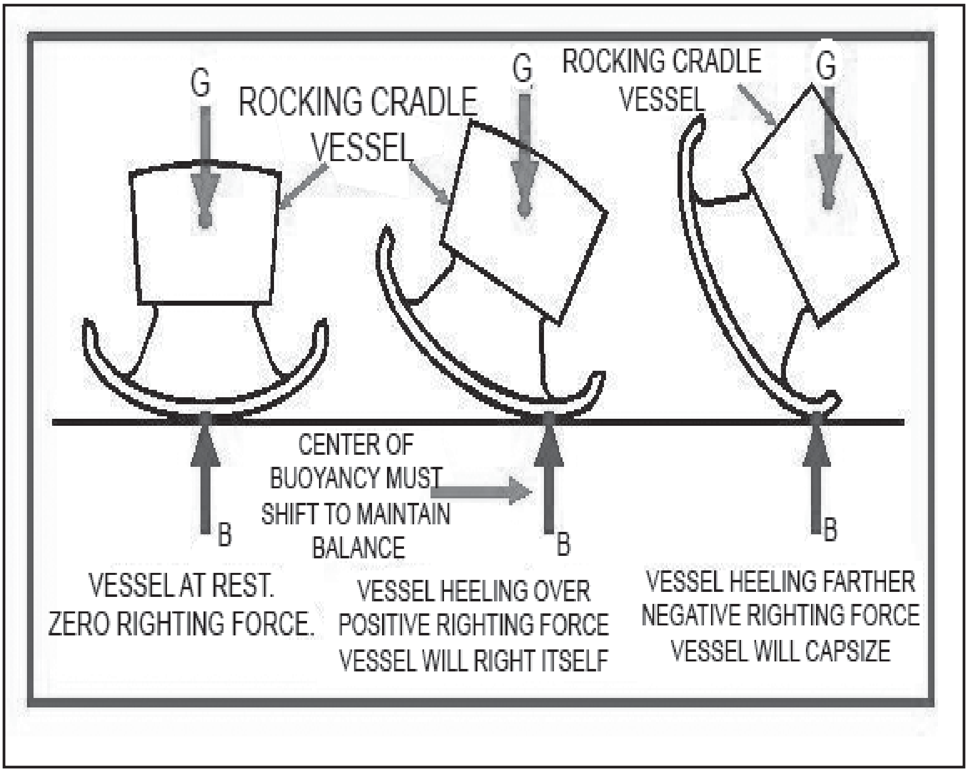

Figure 11: Baby's rocking cradle

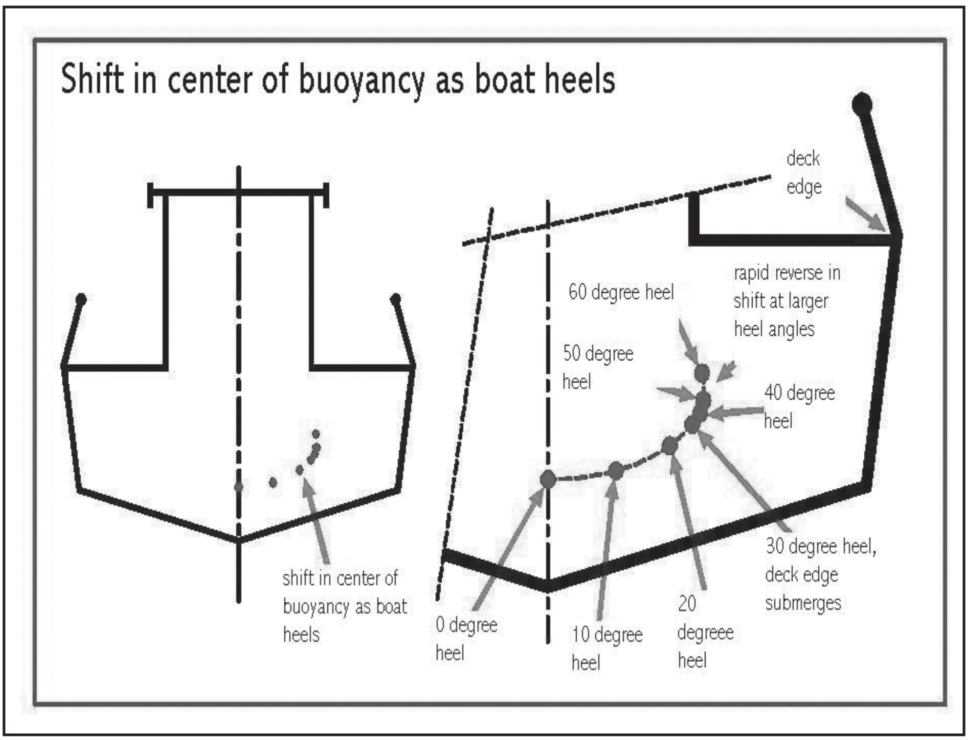

Figure 12: Center of buoyancy path

Figure 13: Model at even keel

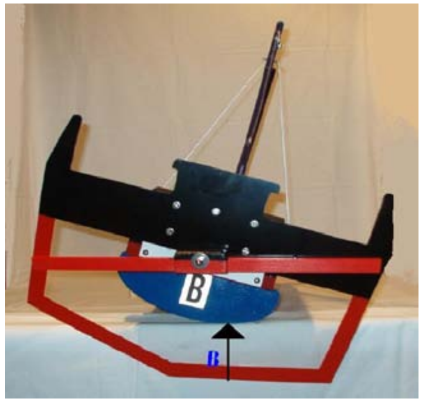

Figure 14: Model heeled over

ously, the impact on initial stability levels, and thus the feel of the vessel, is often minimal and does not correctly convey the magnitude of the reduction in stability levels that has occurred.

This reduction is shown visually by indicating the initial or safe righting arm curve in green and the final or unsafe curve in red. Because many environmental conditions (Figure 10) contribute to a vessel's instability, yellow righting arm curves demonstrating individual impacts are also shown. This exercise further reinforces the take-home message that stability levels can decrease very quickly from multiple causes without the crew being aware of the dangers present. In the example of icing (Figure 10), stability loss occurs from the combined impacts of the added weight of the ice high on the vessel and the loss of freeboard.

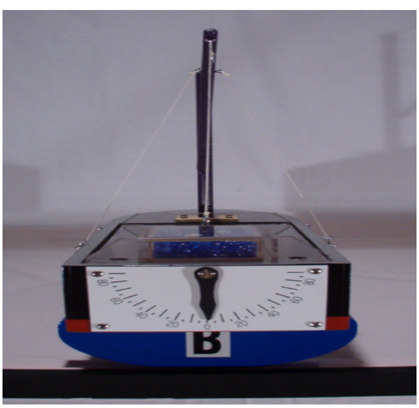

Figure 15: End view

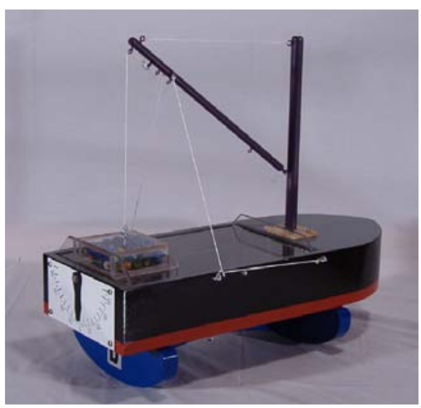

Figure 16: Demonstration model, stern quarter view

The last section of the training program provides general guidance on stability and seamanship to assist crews in preserving their vessel's stability. The topics covered include maintaining watertight integrity, developing and following stability guidance, and prudent vessel operations. These are generic lessons applicable to most commercial fishing vessels. They are also intended to encourage additional discussions by the audience if there are any of the guidance suggestions audience members are uncertain about.

Description of hands-on demonstration models

The hands-on demonstration models are the third and final component in the SNAME-developed stability training program. As illustrated by the material in the booklet and the presentation, one of the key teaching concepts is to equate the ability of a fishing vessel to stay upright with the ability

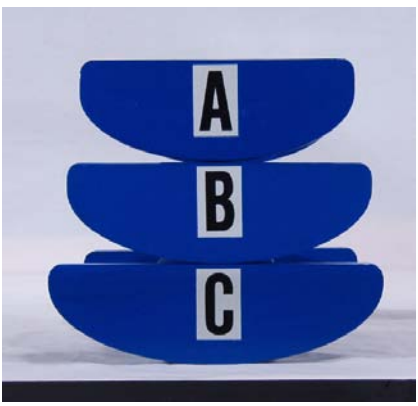

Figure 17: Interchangeable rockers

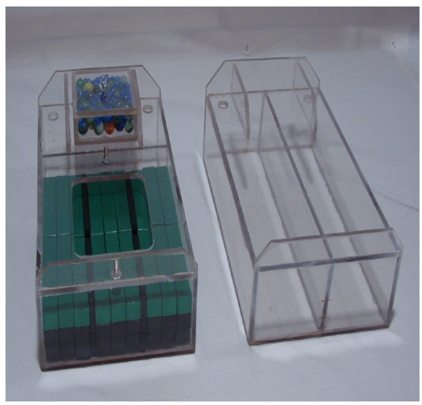

Figure 18: Typical hull inset

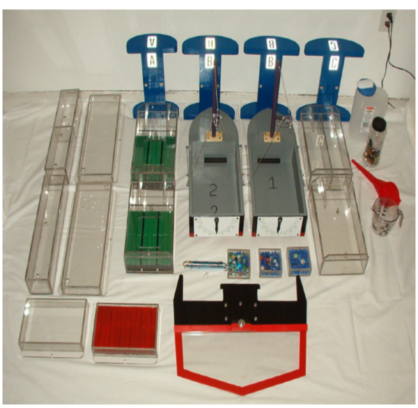

Figure 19: Set sample

of a baby's rocking cradle to remain upright. Both the vessel and the cradle actually work the same way; the point where the cradle's rocker touches the floor is the same as a fishing vessel's center of buoyancy. As shown in Figure 11, as long as the cradle's "center of buoyancy" shifts faster outboard than the cradle's center of gravity, the cradle (and baby) will happily return upright.

What makes this cradle analogy effective is the fact that the typical path of a fishing vessel's shift in center of buoyancy as the vessel heels over, as shown in Figure 12, is very similar to that of a cradle's rocker. By shaping the model's rocker to match the fishing vessel's center-of-buoyancy path, the model will correctly replicate the intractions between a fishing vessel's center of gravity and its center of buoyancy. Figures 13 and 14 show the hull's amidships section overlain on the demonstration model. The blue portion is the model's rocker. Note the black arrows, labeled B, that show the rocker's contact point moving at the geometric center of the submerged hull shape as the model heels. This allows relative changes in the model's initial stability and overall stability, its capsize angle, and variations in righting forces as the model heels to be modeled correctly. These interactions allow the audience to experience directly the effects of common fishing situations safely at high angles of heel.

The base model setup consists of a "hull" (Figures 15 and 16) and a rocker base to which a series of auxiliary components are attached in order to model a series of common fishing situations. Three different detachable rocker bases (Figure 17) are used to model changes in the center of buoyancy's path with changes in the vessel's displacement accurately. From this base model setup, sets of tanks, cargo holds (Figure 18), and/or a removable mast are added for the desired demonstration. The components described below

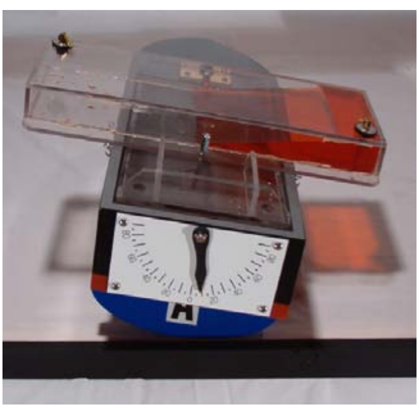

Figure 20: Water on deck setup

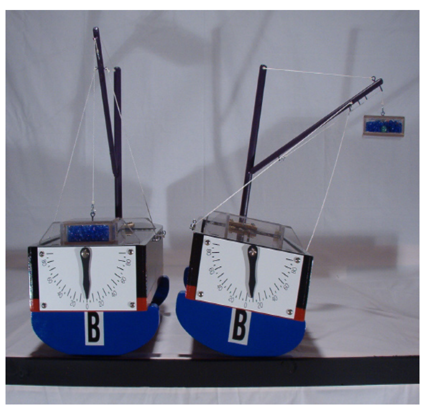

Figure 21: Lifting weights setup

contain sufficient parts to allow for two model setups to be run side by side for direct comparison, although a one-hull model setup produces acceptable demonstrations.

Currently the following principal components have been developed (Figure 19):

Two hulls with heel angle indicator.
Four detachable rocker bases—one type A, two type B, and one type C.
Two removable mainmasts with lifting booms.
Two hold free surface tanks, no centerline bulkhead.
One deck free surface tank, no centerline bulkhead.
One deck free surface tank, with centerline bulkhead.
Two hold dry cargo boxes with two sets of cargo weights.
Two deck dry cargo boxes with one set of cargo weights.
Two lifting weight boxes.

Using these components, the relative effects on a fishing vessel's stability can be demonstrated. These will cover most of the typical fishing situations encountered by crews.

Progressive hull flooding: dry, 10%, and 25% flooding.
Water on deck: dry, 15%, and 30% flooding (Figure 20).
Water trapped in a wide deckhouse: dry, 15%, and 30% flooding.
Overloading.
Overloading with hull flooding.
Lifting weights on centerline.
Lifting weights over the side (Figure 21).
Lifting weights over the side with hold free surface.
Effects of adding a centerline bulkhead.

Descriptions of video and animation slide shows

The presentation can be further enhanced by the inclusion of companion videos and animations of the hands-on demonstration models. These additions make the learning process more interesting, bring the lessons into the real world, and reinforce the concepts discussed regarding the interactions of buoyancy and gravity in the hands-on demonstration models.

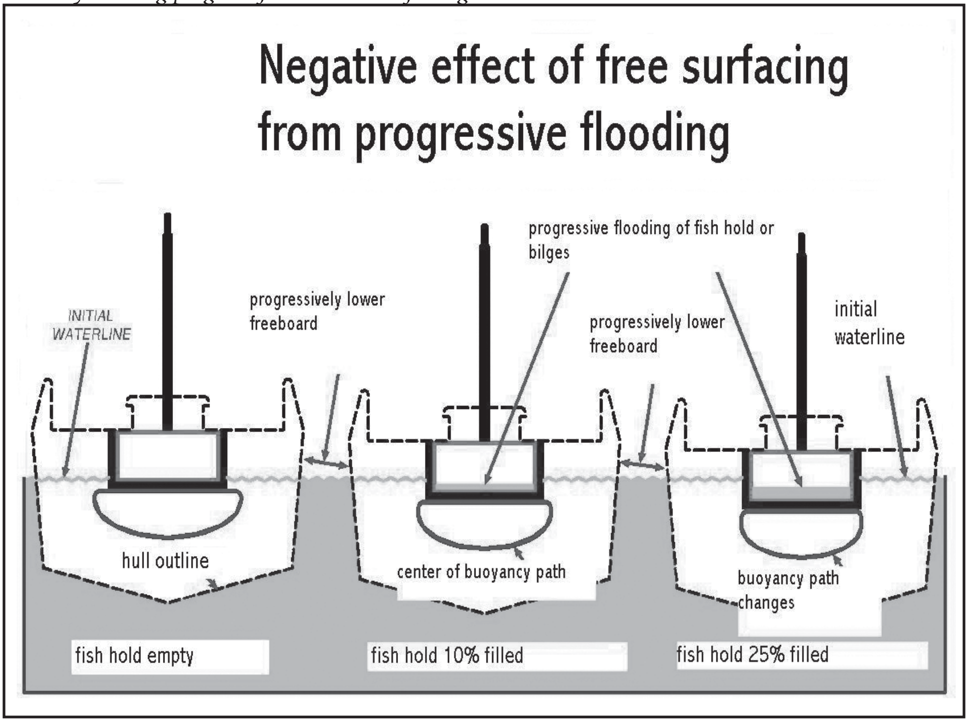

Figure 22: Example of animation for progressive flooding into vessel's hull

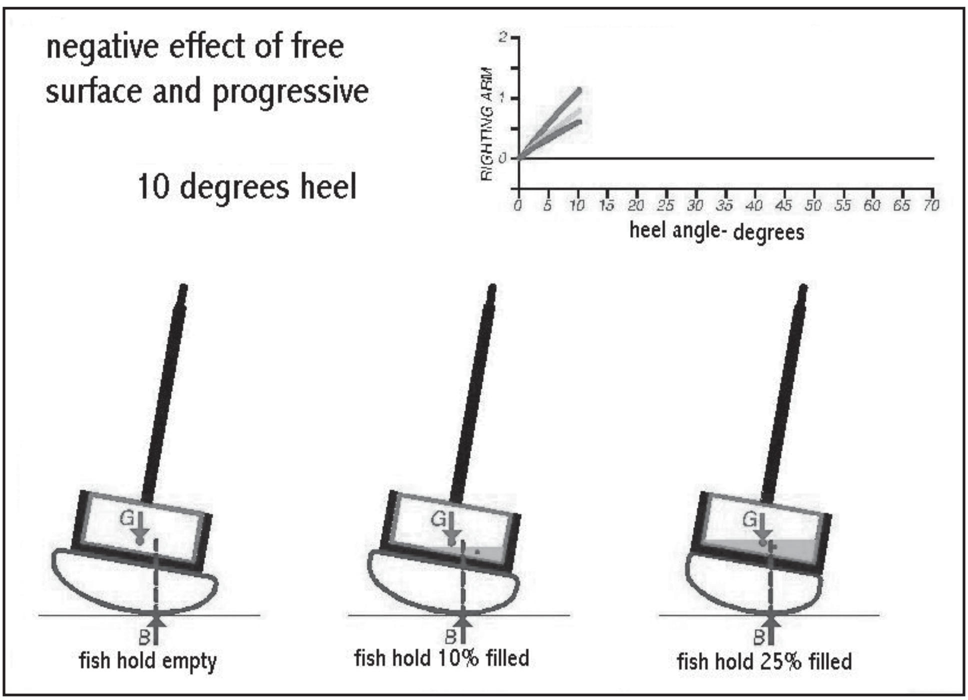

Figure 23: Example of animation for progressive flooding into vessel's hull

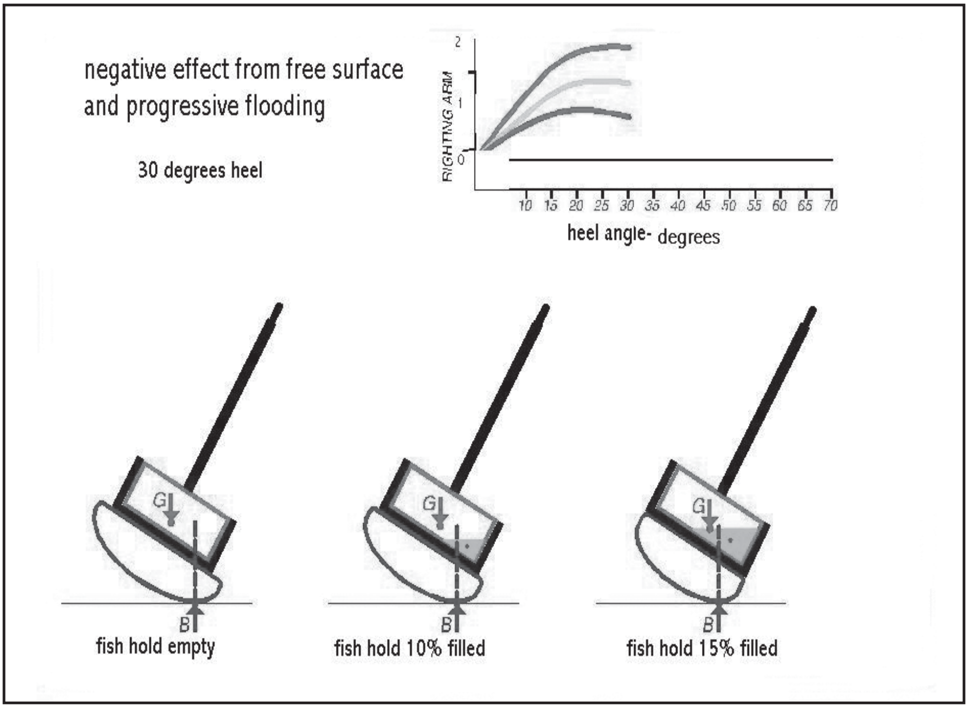

Figure 24: Example of animation for progressive flooding into vessel's hull

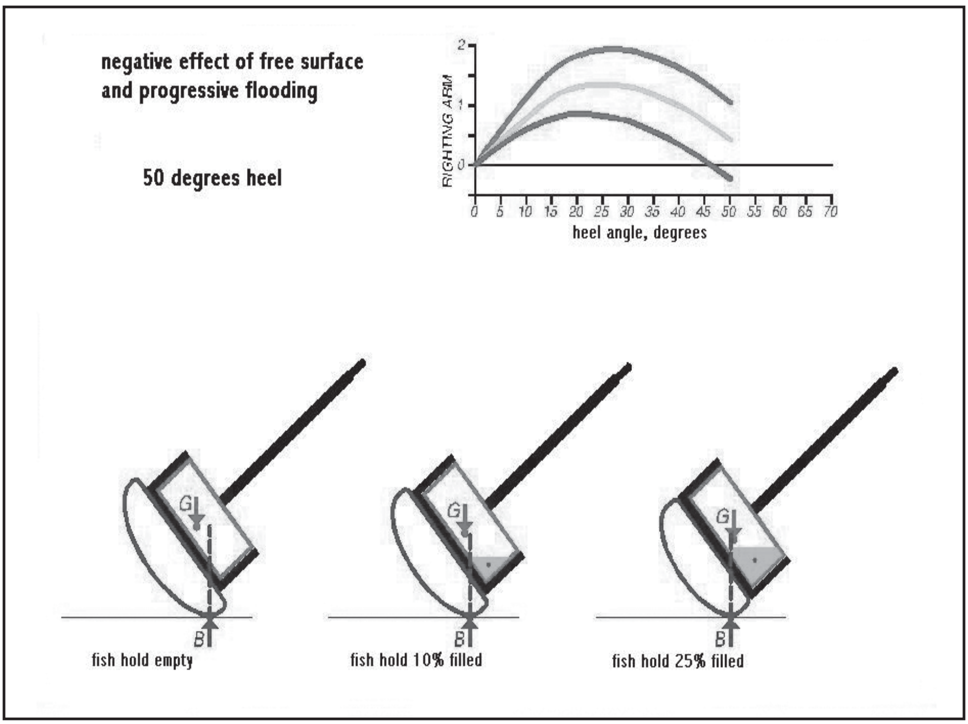

Figure 25: Example of animation for progressive flooding into vessel's hull

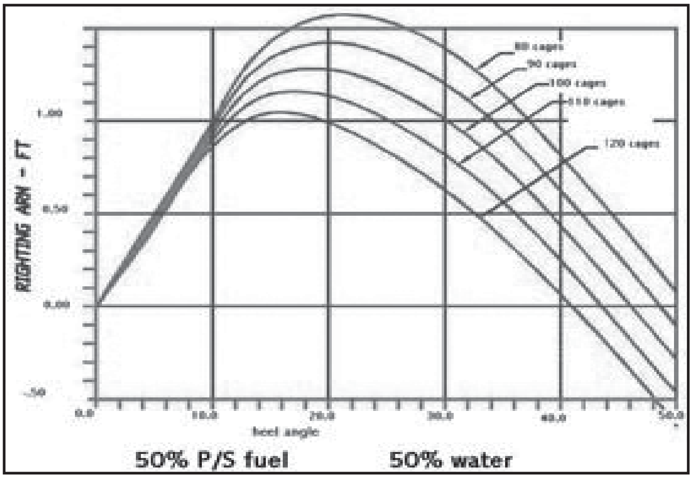

Figure 26: Vessel's righting arm curve

The current videos consist primarily of fishing vessel model tests. These all use free-running models operating in regular and irregular waves. The model tests in regular waves are from the National Research Institute of Fisheries Engineering of Japan (Umeda, Matsuda et al. 1999) and show broaching, loss of stability on a wave crest, and bow diving. The model tests in irregular waves are from a study by the Institute for Marine Dynamics, National Research Council of Canada (Grochowalski 1989). These videos show the full range of fishing vessel operations, including shipping water on deck, broaching, loss of stability on a wave crest, and bulwark tripping. Two videos of real fishing vessels operating in heavy seas are also available. The first shows a fishing vessel being capsized by a stern quarter-breaking wave, and the second shows a fishing vessel bow diving into an unexpectedly large wave face, blowing out the pilot house windows.

The animations of the hands-on demonstration models are used to show the interactions of the center of gravity and the center of buoyancy as the models are heeled over. These animations are done in 5° (0.087-radian) increments. Two or three side-by-side examples are used to show the relative effects on stability directly. Figures 22, 23, 24, and 25 are examples of the animation showing progressive flooding into the vessel's hull. These animation slide shows are particularly effective by having the righting curves, in color, develop in motion as the model heels over.

Flexible approach of SNAME stability training program

The SNAME-developed stability training program uses the Microsoft Powtation medium. This allows the presenter to modify the training program easily to suit the particular needs of the audience. For a specific fishery or a specific boat, potentially confusing parts of the presentation not applicable to the subject audience can be removed. For example, if the vessel or fishery in question does not tow fishing gear, then those slides dealing with towing gear can be quickly removed. And conversely, the presenter can also easily add slides to reinforce topics critical for the target vessel or fishery.

Figure 26 is an example of a slide that can be inserted after the generic overloading slide (Figure 5) is shown to illustrate a vessel's actual righting arm curves as deck load is increased. The slide refers to a specific vessel for which a new set of stability guidelines had been developed. Initial stability was the same throughout the loading range shown, a crucial point as the crew could not notice any change in the vessel's feel, even though loading varied by more than 16% of the vessel's lightship weight. Clearly, this is a stability weakness for this vessel that can only be determined by calculation, not by at-sea experience. By the inclusion of this slide, the crew understood that the vessel's stability had changed significantly.

Laptop computers are a very common tool of the naval architect these days and work well for making the presentation to individual crews. The same computer, coupled with a video projector, will allow presentations at large gatherings such as trade shows. In the event that a computer is not available on site, individual slides can be printed on letter- or ledger-sized paper ahead of time and displayed on an easel. This paper presentation method can be further enhanced by laminating the pages for added durability.

Adaptability

One of the unique features of the SNAME-developed stability training program is that, with minor modifications, it is suitable for many other types of maritime craft, large and small. Container ships, tankers, passenger vessels, and cargo ships all operate under the same underlying principles of physics. All that is required to adapt this training program is to delete fishing-specific parts, such as towing gear, and modify the illustrations to suit the vessel class. The hands-on demonstration models would require no changes, as they are sufficiently generic in their current form. With these changes, the stability training program would make an excellent refresher course for licensed deck officers and an excellent introductory course for naval architects.

Conclusions and recommendations

Improving the safety of fisherman through educating them about their vessel's stability involves three key topics: stability criteria, stability guidance, and stability training. All three are interrelated. The best stability guidance is of no value if crews have not been educated in how to use it safely. If the stability criteria used to create stability guidance information are substandard, then any stability guidance provided will also be inferior.

With the stability training program developed by SNAME's Ad Hoc Panel 12, dangerous misconceptions about vessel stability that have persisted in the commercial fishing industry can be set straight, and the fishing community can receive knowledge critical to understanding vessel stability. This is the first step in improving the safety of fishermen. The next steps that should be undertaken in future projects involve improving (1) the stability criteria used to develop stability guidance and (2) the methods that can be used to present stability guidance to fishing crew. Completion of these projects will enhance the safety of fishermen.

Acknowledgments

The authors wish to thank the following groups for their valued assistance in the development of this stability training program. Without their comments and suggestions, this program would not been able to achieve its goals.

Members of SNAME's Ad Hoc Panel 12, Fishing Vessel Operations and Safety

Members of SNAME's T&R Panel O-44, Marine Safety and Environmental Protection

U. S. Coast Guard, Headquarters, Fishing Vessel Safety Division

U. S. Coast Guard, regional fishing vessel safety coordinators

Members of the Maritime Lawyers Association Fisheries Committee

The crew and owners of the F/V *Christi Caroline,* F/V *Miss Beth,* F/V *Judy Marie,* F/V *Lisa Kim,* and the F/V *Capt Joe*

The various naval architects and shipbuilders both within and outside the fishing community who reviewed our project

References

Francescutto A (2002). Intact stability: The way ahead. Sixth International Ship Stability Workshop. Webb Institute.

Grochowalski S (1989). Investigation into the physics of ship capsizing by combined captive and free-running model tests. Society of Naval and Marine Engineers *Transactions*.

Herbert J (2002). Progress in prevention and response in fishing vessel safety. *In* Proceedings of the International Fishing Industry Safety and Health Conference (Woods Hole, Massachusetts, Oct. 23-25, 2000), Lincoln JM, Hudson DS et al., eds. Cincinnati, OH: National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2002-147.

International Maritime Organization (1995). 1993 Torremolinos Protocol and Torremolinos International Convention for the Safety of Fishing Vessels.

Johnson B, Wallace D, and Savage R (2002). Developing the foundation for an interdisciplinary approach to improving fishing vessel safety. *In* Proceedings of the International Fishing Industry Safety and Health Conference (Woods Hole, Massachusetts, Oct. 23-25, 2000), Lincoln JM, Hudson DS et al., eds. Cincinnati, OH: National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2002-147.

Johnson B and Womack J (2001). On Developing a Rational and User-friendly Approach to Fishing Vessel Stability and Operational Guidance. 5th International Ship Stability Workshop, Trieste, Italy.

Lang JS (2002). Fishing vessel safety: A marine accident investigator's perspective. *In* Proceedings of the International Fishing Industry Safety and Health Conference (Woods Hole, Massachusetts, Oct. 23-25, 2000), Lincoln JM, Hudson DS et al., eds. Cincinnati, OH: National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2002-147.

Turner J and Petursdottir G (2002). Safety at sea for fishermen and the role of FAO. *In* Proceedings of the International Fishing Industry Safety and Health Conference (Woods Hole, Massachusetts, Oct. 23-25, 2000), Lincoln JM, Hudson DS et al., eds. Cincinnati, OH: National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2002-147.

Umeda N, Matsuda A et al. (1999). Stability assessment for intact ships in the light of model experiments. *Journal of Marine Science and Technology* 4: 45-57.

US Coast Guard, Fishing Vessel Casualty Task Force (1999). *Dying to Fish, Living to Fish*. Washington, DC.

Wagner B (2002). Safety and Health in the Fishing Industry: An ILO Perspective. *In* Proceedings of the International Fishing Industry Safety and Health Conference (Woods Hole, Massachusetts, Oct. 23-25, 2000), Lincoln JM, Hudson DS et al., eds. Cincinnati, OH: National Institute for Occupational Safety and Health. DHHS (NIOSH) Pub. No. 2002-147.

Womack J (2002). Small commercial fishing vessel stability analysis: Where are we now? – Where are we going? Sixth International Ship Stability Workshop. Webb Institute.

Appendix: Evolution of stability training

Early stability training

Since the beginning of mankind's venturing to sea, the traditional method of training mariners in ship stability was purely by hands-on experience under the tutelage of experienced captains. Captains were experienced simply because they had survived their previous trips. It was during these long apprenticeships from deckhand to captain that the mariner to-be would learn the proper feel of the sailing ships of the day and thus would be able to command ships.

Although crude, no other practical means of stability training was available. Knowledge of the mechanics of ship stability was in its infancy, and no practical means for the calculation of stability was known. However, given the

Two factors were a key to this success: How ships were propelled and how they were designed. First, sailing ships were always undergoing a simplified inclining, or stability, test while they were underway. Based on the vessel's heel, i.e., freeboard, and current and future weather conditions, sail would be added or removed to maintain an adequate level of safety. Interestingly, the level of safety could be varied based on the weather conditions. In good weather, with steady winds and moderate seas, a lower inclined freeboard would be acceptable and thus higher speeds could be maintained. And when bad weather was encountered, with strong and/or gusty winds and heavy seas, a higher-heeled freeboard would be maintained to enhance safety levels.

Secondly, the design of commercial sailing ships allowed feel to be used to gauge stability. Hull and sail configurations were similar among vessel classes so that the feel of one vessel could be used on another with minimal danger. The evolution of sailing ship design was slow, and any changes typically had small impacts on a vessel's stability characteristics.

Thirdly, with high freeboards and small deck hatches on centerline, the typical commercial sailing ship had relatively high angles of down-flooding. This coupled with a sail's natural tendency for self-dumping the capsizing force as the vessel heeled over, capsizing and sinking from unexpected wind gusts or large rogue waves were rare.

Lastly, only two principal capsizing forces—wind and waves—acted on the typical commercial sailing ship, both of which were reasonably predictable in their effects. Sailing ships did not lift weights or tow heavy gear while under way. They also did not have significant changes in displacement or changes in the center of gravity during their voyages. Free-surface effects were a minimal problem as the sailing ships had inconsequential tankage, nor did they have large deckhouses that might trap large amounts of water high on the vessel. Thus the stability characteristics of a sailing vessel were fairly constant throughout a voyage.

The one class of sailing ship that did not fall into this generalization was large warships. Warships had numerous nontight gun ports near the waterline, which compromised the watertight envelope; they had large weights located high on the hull; and they often pushed the design envelope to meet the grandeur required by ruling monarchs. A few of them were also prone to rolling over in the harbor as well. Interestingly, many of today's commercial fishing vessels have modern versions of these faults with some new ones thrown in.

Why past stability training does not work for today's commercial fishing vessels

Using the stability training methods that were once adequate for sailing vessels for today's fishing vessel is a dangerous proposition. The factors that allowed stability training on sailing vessels through hands-on experience are no longer present on today's commercial fishing vessels.

First and foremost, the use of internal power sources for propulsion removed the continuous inclining test that sailing ship masters could use to gauge their vessel's stability and subsequently make suitable adjustments to its heeling characteristics. Changes in propulsion levels generally do not create noticeable heel changes or changes in a fishing vessel's feel. Neither are propulsion forces self-dumping until severe and often fatal heel angles have been reached.

Second, fishing vessels have been designed with many different configurations to reflect various fishing techniques and local conditions. Safe experience in one fishery cannot be reliably transferred to another fishery having different vessel types and gear. Even within a fishery this problem may exist as some vessels are built to a specific purpose, while others have been converted from other services. An example is the US mid-Atlantic surfclam and ocean quahog fishery, which uses purpose-built vessels, converted Gulf Coast shrimpers, and converted offshore supply vessels. This fishery also uses several fishing methods, side-rigged and stern-rigged dredges, and may carry the heavy catch in fish holds, totally on deck, or a combination of the two.

Third, the general trend in fishing vessel design has been toward making vessels more sensitive to stability problems. Freeboards have been shrinking, making shipping water on deck a more common occurrence. Coupled with numerous openings in the watertight envelope for fish hold hatches and personnel access now closer to the waterline, the danger of down-flooding has increased.

Fourth, numerous and highly variable capsizing forces now act on commercial fishing vessels that were not a concern to sailing masters. Fishing vessels may tow large nets, handle heavy crab pots over the side, or lift heavy weights while fishing. And these capsizing forces do not naturally diminish as the vessel heels over. In fact, it is not unknown for purse seiners to capsize when the fish in the net are spooked and dive en mass, literally pulling the vessel over.

Lastly and most importantly, the stability characteristics of most commercial fishing vessels change significantly throughout a voyage. Fuel and other consumables are burned off, and the catch is brought on board, resulting in significant changes in displacement and the vessel's center of gravity. Since both of these factors are the dominant influences on a commercial fishing vessel's stability, stability characteristics will vary greatly during the voyage. This creates a constantly moving target with regard to the vessel's feel that the crew can not reliably predict. In simple terms, a good feel now may not be correct at a later stage in the fishing trip.

Stability myths and misconceptions

The design and operational characteristics of today's fishing vessel has led to the creation and subsequent handing down of many myths and misconceptions about how stability works and how the feel of a vessel can be used to judge if its stability levels are adequate. Typical misconceptions include that the feel of the vessel will allow a captain and crew to gauge the vessel's stability levels or that the use of paravanes (flopper stoppers) will improve a fishing vessel's stability and its rolling behavior or that adding ballast low will automatically improve stability. Interestingly, many of these misconceptions date back from the sailing days and have been handed down from captain to captain over the decades, if not centuries.

These misconceptions continue to appear in trade journals, books about fishing, and in general talk around the docks. This is not the fault of the fishermen, but the continuing failure of naval architects, safety trainers, and regulators to address stability training adequately to crews. Existing stability training programs generally contain one or more fundamental flaws that limit their use in teaching the basic concepts of stability that would put these misconceptions to rest.

Modern commercial fishing vessels have very complex stability characteristics. With the many different types of fishing vessels, fishing methods, and loading conditions, any stability training program must be carefully developed to cover all potential scenarios crews might encounter. No longer can stability be taught by the traditional method of hands-on experience handed down from captain to crew.