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TOWING OPERATIONS

DIGITAL EDITION

Captain Robert L. Figular

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TOWING OPERATIONS

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Mariners Learning System™
Princeton, New Jersey

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Acknowledgements
This book is designed to provide a wide variety of information on the practice of good seamanship as it pertains to the marine environment. This publication contains data and associated information produced and obtained from the U.S. Department of Homeland Security and the United States Coast Guard (USCG). This title is published by a private company and any appearance of the USCG's name, seal, or initials does not indicate endorsement of this title.

Towing Operations

Safety is always the most important concern when towing. Every towing activity is potentially dangerous. The safety of the crew and the crew of the towed vessel is more important than property, and the primary responsibility in any towing situation is to maintain safety. Towing is a complex evolution. A safe and successful outcome hinges on crew professionalism, ability, and teamwork.

- **Risk Assessment**

  Every boat crewmember is responsible for identifying and managing risks. Towing mishaps can be prevented by honestly evaluating risks involved in every step of any towing evolution. Communicating with the towed vessel's crew who may have important information is essential.

- **Situational Awareness**

  The dynamics of a towing situation continuously change from the time pre-towing preparations begin until mooring at the conclusion of the towing evolution. All crewmembers must stay fully aware of the constantly changing situation at any given time during a towing evolution. It is important that each crewmember knows what goes on in the surrounding environment and how things change. Crew awareness should be reinforced through communication—commenting on what is believed to be happening and involving the towed vessel's crew. The "outside" view could provide information on things not visible from the towing vessel.

  When clues indicate that situational awareness is being lost, a decision must be made whether or not to continue with the towing evolution. A decision takes the form of action/reaction and communication. Everyone in the crew has a responsibility in the decision-making process.

- **Risk Management Planning**

  Realistic towing training based on standardized techniques, critical analysis, and crew briefing and debriefing will contribute to risk management and the development of a towing risk management plan.

  Standard precautions make up the basis for a towing risk management plan, but each towing evolution is unique, and the plan should be revised according to whatever the situation dictates.

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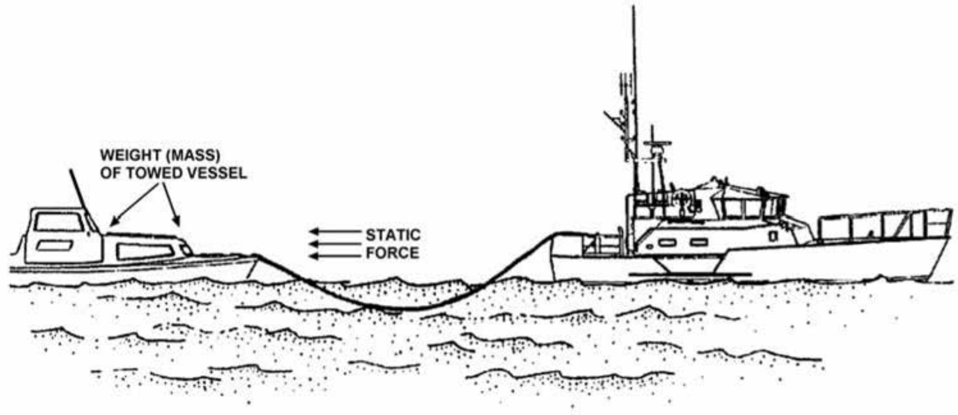
Forces in Towing

Boat crews must understand the forces, or types of resistance, that act on the towed vessel and how to handle the resistance safely. They are the same forces that affect all vessels, but a distressed vessel is limited in how it can overcome them. The towing vessel must provide the means to move the towed vessel. The towline or tow rig transfers all forces between the two vessels. Boat crews must learn to recognize the different forces and each of their effects individually to effectively balance and overcome them when they act together.

Static Forces

Static forces cause a towed vessel to resist motion. The displacement or mass of a towed vessel determines the amount of force working against the vessel. The assisting vessel must overcome these forces before the towed vessel moves. Inertia and the moment of inertia are two different properties of static forces that cause resistance in towing vessels.



Static Forces

- ### Inertia

In this case, inertia is the tendency for a vessel at rest to stay at rest. The more mass a vessel has (the greater its displacement), the harder it is to get it moving.

• Moment of Inertia

The moment of inertia occurs when a towed vessel resists effort to turn about a vertical axis to change the heading. The larger the vessel, the more resistance there will be in turning the vessel. Unless necessary in a case of immediate danger, an attempt to tow a distressed vessel ahead and change its heading at the same time should not be used. Both inertia and the moment of inertia will be involved in the resistance of moving the distressed vessel, which can cause potentially dangerous situations and greater resistance for towing. Both vessels, their fittings, and the towing equipment take much less stress and strain when the two forces are conquered individually.

Overcome the effects of static forces by starting a tow slowly, both on the initial heading or when changing the towed vessel's heading. A large amount of strain is placed on both vessels, their fittings, and the towing equipment when going from dead in the water to moving in the desired direction and at the desired speed. Extreme caution should be used when towing a vessel of equal or greater mass than the assisting vessel. In such situations, the assisting vessel strains the capacity and capability of its equipment, requiring slow and gradual changes.

To start the tow on the initial heading, perform the following procedures:

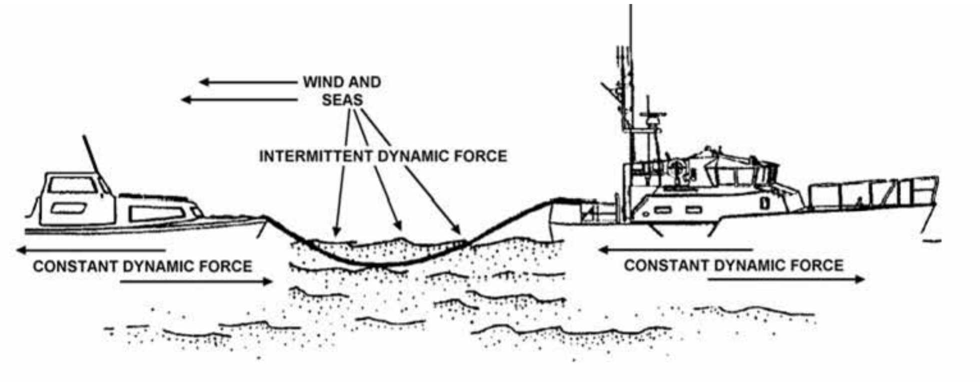
1. Apply the towing force on the initial heading to gradually overcome the towed vessel's inertia.
2. As the towed vessel gains momentum, slowly and gradually increase speed.
3. To change the tow direction, make any change slowly and gradually after the towed vessel is moving.

To change the towed vessel's heading, perform the following procedures:

1. Apply the towing force perpendicular to the vessel's heading. Once the towed vessel starts to turn, resistance will develop.
2. Apply turning force slowly and gradually. It is more difficult to change the initial heading of a heavy vessel (one with a high moment of inertia) than a light one.
3. Now, begin to tow in the desired direction and gradually overcome inertia to get the towed vessel moving forward.
4. Once making way, the effects of static forces lessen.
5. Until the tow achieves a steady speed and direction, apply power or turning force to defeat any remaining inertia or to change the towed vessel's momentum gradually.

Dynamic Forces

Dynamic forces occur once the towed vessel is moving. They are based on the towed vessel's characteristics (shape, displacement, arrangement, rigging), the motion caused by the towing vessel, and the effects of waves and wind.



Dynamic Forces

- ### Momentum

Once a vessel moves in a straight line, it wants to keep moving in a straight line. The greater its displacement or the faster it is moving, the harder it is to stop or change the vessel's direction.

- ### Angular Momentum

Once the vessel's heading begins to change, it wants to keep changing in that same direction. The faster the towed vessel's heading changes, the harder it is to get the tow moving in a straight line.

The towed vessel's momentum will gradually increase with towing speed. Momentum in a straight line will resist effort to change the towed vessel's direction and will tend to keep the towed vessel moving when tension in the towing rig is decreased. If it is necessary to first change the direction of the tow, the towed vessel will develop angular momentum while the vessel's heading is changing. Towing force opposite the swing may need to be applied before the towed vessel achieves the desired heading. The key to dealing with momentum is to anticipate how momentum will affect the towed vessel's motion and apply an offsetting force early and gradually.

- **Frictional Resistance**

As a vessel moves, the layer of water in immediate contact with the hull moves. Due to friction between water molecules, the layers of water close to the hull try to drag along. The vessel appears to move "through" the water. This attempt to drag water alongside takes energy. As speed increases, this action becomes "turbulent." This turbulence takes additional energy, and more speed requires even more power.

Frictional resistance will constantly affect the tow, *normally* keeping some steady tension in the towing rig. Since the shape and wetted surface area of the towed vessel will not change, frictional resistance is managed with towing speed. Higher towing speed causes higher frictional resistance and more strain on the towing rig.

Frictional resistance also varies with hull shape. Greater underwater (wetted) surface area causes greater frictional resistance. Hull appendages, such as propellers, shafts, skegs, keel, and rudders contribute to wetted surface area and frictional resistance.

- **Form Drag**

Form drag plays a large role in the ability to control changes in the towed vessel's movement. Different hull shapes react to motion through the water in different ways. The shape and size of the towed vessel's hull can either help or hinder effort to move in a straight line, when changing heading, and motion changes in response to waves due to buoyancy. The less water a hull shape has to push out of its way, the easier it will move through the water. A deep-draft, full-hulled vessel takes more effort to move than one with a fine, shallow hull. A large amount of lateral resistance, spread evenly over the length of the hull, will hinder effort to change a towed vessel's direction but will help offset angular momentum in steadying up on a desired heading. A towed vessel may be able to help offset form drag by using its rudder.

- **Wave-Making Resistance**

A surface wave forms at the bow while the hull moves through the water. The size of the bow wave increases as speed increases, causing the wave to create resistance for the bow to be pulled or propelled through the water.

Boat crews should keep in mind the different hull types of maritime craft, including the towing vessel. In any towing evolution, the boat crew must be able to recognize a vessel's hull type, as well as its critical capabilities and limitations. Depending on the type of hull, towing vessels must be careful not to tow a vessel faster than the design speed of its hull.

It is not always safe to tow a planing hull type of vessel above planing speed. Going from displacement speed to planing speed, or back, can decrease the towed vessel's stability and cause it to capsize. Also, wave drag (even one large wake) could slow the hull down to displacement speed and cause a severe shock load as the towed vessel tries to get back on plane.

Shock load or shock loading is the rapid, extreme increase in tension on the towline, which transfers through the tow rig and fittings to both vessels.

Wave Drag, Spray Drag, and Wind Drag

The frictional forces of wave drag, spray drag, and wind drag act on the hull, topsides, superstructure, and rigging. They all have a major effect on the motion of the towed vessel, and the transfer of forces to and through the towing rig. These constantly changing forces all vary with the towed vessel's motion relative to the environmental elements and are directly related to the towed vessel's amount of exposure to them. These forces can add up and cause shock loading. Wind and wave drag also cause a distressed drifting vessel to make leeway, which is motion in a downwind direction.

Wave drag depends on the "normal" wetted surface area of the hull and the amount of freeboard exposed to wave action. Wave drag has a large effect on the strain of the tow rig.

- In large seas, be aware of:
  - Combination of wave drag and form drag could overcome the towed vessel's forward momentum and cause the towed vessel to stop and transfer a large amount of strain to the tow rig.
  - Shock load could damage a vessel's fittings and part the towline, endangering both vessels' crews.
- In head seas, be aware of:
  - Towing vessel can control the effect of wave drag only by the speed and angle with which the towed vessel encounters the waves.
  - Limiting speed and towing at an angle to the seas to prevent the head seas from breaking over the bow of the towed vessel.
- In following seas, be aware of:
  - Wave drag causing the towed vessel to speed up as the crest approaches, increasing speed to keep tension in the towing rig, and reducing speed as the crest passes.

Spray drag also provides resistance to the tow. The spray from a wave could slow the towed vessel and increase the amount of shock loading. Spray drag could also adversely affect the towed vessel's motion by imparting a momentary heel, pooling on deck or in the vessel cockpit, and in cold weather, forming ice, thus decreasing stability.

Wind drag can cause shock loading and have a bad effect on the towed vessel's motions and stability. A steady beam wind can cause list and leeway, while a severe gust can cause a threatening heel. List, heel, and leeway may cause the towed vessel to yaw. A headwind increases tow rig loading in a direct line with the towed vessel while the towed vessel crests a wave, causing shock loading.

Buoyancy Response and Gravity Effects

Boat crews should develop a feel for the towed vessel's initial and reserve buoyancy characteristics, overall stability, sea keeping, response to the prevailing environmental conditions, and the response to being towed. Though a distressed vessel may *seem* stable and sound at rest, its response once in tow could be to capsize. A towed vessel's bow may react to an oncoming wave by pitching skyward, or by "submarining." Buoyancy response to following seas could cause the towed vessel to yaw excessively, or gravity could cause it to gain speed and "surf" down the face of a wave.

Once making way, a vessel's buoyancy response or the effect of gravity in a seaway may cause severe shock loading.

Combination of Forces and Shock Load

During a towing evolution, the boat crew rarely deals with only one force acting upon the tow. The crew usually faces a combination of all the forces, each making the situation more complex. Some individual forces are very large and relatively constant. Crews can usually deal with these safely, provided all towing-force changes are made gradually. When forces are changed in an irregular manner, tension on the tow rig starts to vary instead of remaining steady.

Shock loading may cause severe damage to both towing and towed vessels and overload a tow rig to the point of towline or bridle failure. Shock loading could also cause momentary loss of directional control by either vessel and could capsize small vessels.

Even in calm winds and seas, a towing vessel can encounter a large amount of frictional resistance from form and wave drag when towing a large fishing vessel with trawl lines fouled in its propeller and net still in the water. The tow rig and vessel fittings will be under heavy strain, and the tow vessel engine loads will be rather high, but the tow proceeds relatively safely. If suddenly the net tangles and catches on an unseen obstacle, this new "force" acting through the tow rig could immediately increase stress to a dangerous level. This shock load could part the towline or destroy fittings.

(In the example above, the prudent solution would be to make a "safe" tow by recovering the net or marking it and letting it loose before starting the tow.)

Though this example began as a safe and steady tow, a single unexpected incident could have caused a very dangerous situation. Boat crews should always keep in mind that some degree of shock loading can occur during any tow evolution.

Shock Loading Prevention or Counteraction

Because of the potential dangers, the tow vessel must use various techniques to prevent or counteract shock loading, or reduce its effect.

- Reduce Towing Speed:
  - Slowing down lowers frictional resistance, form drag, and wave-making resistance. Reducing these forces will lower the total tow rig tension. In head seas, reducing speed also reduces wave drag, spray drag, and wind drag, lowering the irregular tow rig loads. The total reduction in forces on the tow could be rather substantial. When encountering vessel wake in relatively calm conditions, decrease speed early enough so the towed vessel loses momentum before hitting the wake. A small towed vessel slamming into a large wake will shock load the tow rig, and may even swamp.
- Get the Vessels "In Step":
  - Extreme stress is put on the tow rig in heavy weather when the towed vessel and the towing vessel do not climb, crest, or descend waves together. Vessels in step will gain and lose momentum at the same time, allowing the towing force to gradually overcome the towed vessel's loss of momentum, minimizing shock loading. To get the vessels in step, lengthen rather than shorten the towline if possible.
  - Safety demands emphasis on preventing shock load and reducing its effects. Shock loading presents a definite possibility of damage to vessel fittings or tow rig failure. One of the more feared possibilities is towline snap-back. Think of this as a greatly magnified version of stretching a rubber band until it breaks. Remember, some nylon cordage can stretch up to an additional 40% of its length before parting.
- Lengthen the Towline:
  - A longer towline reduces the effect of shock loading in two ways. The weight of the line causes a dip in the line called a catenary. The more line out, the greater the catenary. When tension increases, energy from shock loading is spent on "flattening out" the catenary before it is transferred through the rest of the rig and fittings. The second benefit of a longer towline is more stretch length. Depending on the type of towline, another 50 feet of towline length will give 5 to 20 feet more stretch to act as a shock load absorber. Remember to lengthen the towline enough to keep the vessels in step and minimize the shock load source. Shortening the towline generally decreases the maneuverability of the towing vessel.

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