FIORENTINO Technical Report FPA-136

Report Prepared for:
Fiorentino Para Anchor

RESULTS FROM STORM DROGUE COMPARISON DRAG TESTS, LONG BEACH HARBOR, CALIFORNIA,

June 15, 2011

Zack Smith

All of the storm drogues and corresponding equipment laid out to dry in the shade after a thorough fresh water rinse.

This report presents data on drag characteristics of seven manufactured drogues deployed from the stern of a 35-foot (10.7 m) sailboat. Test results measure the amount of force placed on equipment, as well as vessel speed with and without a deployed storm drogue and with and without chain weight connected to a storm drogue. All observations were videotaped to help evaluate the negative and positive performance of each drogue. Manufacturers' manuals and websites were also utilized to calculate data and formulate charts.

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1048 Irvine Ave #489
Newport Beach, CA 92660

Please visit us on the internet at www.Para-Anchor.com

Report Photographs by:
Bob Ritner & Zack Smith

** A special thank you to the Fiorentino team members who reviewed my raw notes and video. Your valuable input greatly contributed to the presentation of this report.*

DEFINITIONS

DEPLOYMENT RODE: Fiorentino defines this as a dedicated rope anchored to the boat and attached to a parachute sea anchor or storm drogue for the purpose of deploying the drag device. Anchor rode is currently the standard term used to define rope attached to a drag device, whether it's dedicated rode or not. Either term is accurate and can be used interchangeably for instruction purpose.

DRAG CHARACTERISTICS: Fiorentino defines this as the measurement of a parachute sea anchor's or storm drogue's behavioral traits. These measurements for this report about storm drogues include:

- Recorded boat speeds (with and without a storm drogue deployed)
- Recorded forces placed upon both the boat and drogue
- Observational drogue behavior as it tracks through the water

Observational studies performed by Fiorentino require the data collection of both negative and positive drag traits.

Negative storm drogue traits include:

- Yawing
- Exposure above the ocean's surface
- Erratic spinning
- Tangling in shroud line
- Frequent rising and sinking in the ocean (this behavior may lead to "drogue jumping" as defined in this report)
- The level of difficulty when handling the device (ranging from easy to hard)

***Note**: A device that is too bulky to handle and/or to pack is deemed "user <u>un</u>friendly" by Fiorentino.*

Positive storm drogue traits include:

- Storm drogue tracking directly behind the boat with very little to no yawing
- No erratic spinning
- Storm drogue sinks and remains below the surface

***Note**: A device that can be quickly deployed, retrieved, and packed is deemed "user friendly" by Fiorentino.*

DROGUE/ STORM DROGUE: An underwater device deployed from the stern of a marine vessel to slow, (not stop) its forward motion to improve steerage and stability in large seas. "Drogue" is the most common term used to describe these devices. Fiorentino in recent years has opted to use "storm drogue" as the preferred definition since the term "drogue" is associated with drugs in many countries outside the USA. Either term is technically accurate and can be used interchangeably for instruction purpose.

DROGUE CANOPY: Fabric sewn to dome-or-cup like shapes that capture water.

DROGUE JUMPING: This is defined by Fiorentino as a parachute sea anchor or storm drogue that is pulled partially exposed above the ocean's surface or one that becomes airborne. The following drogue jumping traits may occur with these drogues:

- A speed-limiting drogue that becomes airborne may bounce forward toward a vessel.
- Stopping drogues typically have several cone elements pull out of the ocean's surface when it "jumps" from the water. In such instances, the stopping drogue loses much of its holding power.

Drogue jumping may also occur with drift or parachute sea anchors, but Fiorentino's team has only witnessed this trait during tugboat drag tests. Fiorentino utilizes tugboats that are approximately 100-feet (30 m) in length to measure drag characteristics and component strength of parachute anchors. The large amount of force generated by a tugboat will occasionally cause a para-anchor to partially "jump" out of the water.

DROGUE SHROUD LINES: Sewn lines or webbing that fall away from the canopy and join at a hardware attachment point, usually encompassing a conventional thimble or small swivel.

DROGUE TAIL: This is defined by Fiorentino as a rode that passes through the center of the Shark drogue and out the backside for the sole purpose of attaching a secondary drag device, including (but not limited to) chain, ground anchor, or storm drogue.

PARA-RING: Unconventional hardware invented and defined by Fiorentino as a stabilizing device to prevent shroud tangles for their para-anchors and to be used in place of shroud lines on the Shark storm drogue. The stabilizing hardware replaces traditional thimble and swivel arrangements used on all current drag devices.

SERIES/
STOPPING DROGUE: A long length of anchor rode with multiple cones woven into the rope. A stopping drogue is designed to point the stern into approaching waves by nearly stopping the boat's drift rate. Sometimes referred to as a medium pull drogue.

SPEED-LIMITING/
UNITARY DROGUE: A single, canopy storm drogue made from various patterns of open or solid fabric. Designed to slow, not stop a boat.

TENSION LOAD CELL: A device that measures the amount of force placed on the object to which it is attached. For the purpose of this report, a remote tension link, ending with an eye-and-eye attachment, was used for the drag tests. The load cell was set at 20,000 lbs. (9,072 kg) x 2 lbs. (1 kg) graduations.

TENSION LOAD
INDICATOR: A battery-operated digital indicator required to register load numbers on a small monitor.

INTRODUCTION

Fiorentino's technical report FPA-136 is the result of storm drogue comparison drag tests performed in Long Beach Harbor, California on June 15, 2011. We towed seven different storm drogues in an effort to measure the differences in drag characteristics between the devices. Some of the major differences noted include: vessel speed reduction with the storm drogue deployed and the amount of force placed on the equipment as recorded by load cell instrumentation. All of the tests were recorded on video for the purpose of review to improve the accuracy of this report.

The overall mission for these drag tests was to assess performance. Did the device yaw excessively, set above the ocean's surface, or fail to deploy? Did it spin out of control? We found storm drogues that exhibit these behaviors in calm weather raise important questions about what would happen during a storm when a boat is pitching and rolling out of control.

The report also focuses on what technology is user friendly. We looked at which devices are easy to handle without tangling or injuring sailors during the deployment process. Ease-of-use is a critical element in successful utilization of storm drogues.

All of our tests, as with previous ones, were completed in accordance with proper scientific ethics. One good example of these principles can be viewed in the article entitled *"Scientific Ethics,"* authored by Anthony Carpi, PhD. and Anne E. Egger, PhD. (visionlearning.com). Fiorentino believes these basic principles of science--equality in testing, honest reporting and open testing methods—permit any organization to repeat the experiments on additional vessels to confirm the integrity of said tests. Fiorentino strictly adhered to these ethical standards by testing each storm drogue using the same rigging components, recording instruments, vessel speed, weather conditions and other techniques developed by Fiorentino to ensure that all drogues were tested in the same manner.

Storm Drogues Tested

The seven brands of storm drogues detailed in this report include the Delta, Galerider, Para-Drogue, Seabrake, Seaclaw, Series (Stopping) and Shark storm drogues. The storm drogues chosen for the drag tests are built by companies that have been involved with drag devices for a minimum of twenty years. All seven were pulled through the water using the same tow line and chain weight setup to insure accuracy in recording force readouts and to measure their behavior as they trailed behind the boat. Fiorentino chose to conduct these tests in calm water because we wanted the environment to remain unchanged to increase the accuracy of our observations. Fiorentino has learned from past drag tests that wave conditions and currents can heavily impact test results increasing the level of inaccuracy when comparing different drag devices.

Manufacturers' Instructions Considered

We also considered published manufacturer instructions on how to use their equipment when conducting our tests. Three of the seven manufacturers do not recommend the use of weight with their storm drogues so we decided to test all the storm drogues with and without weights. Previous sea trials by Fiorentino indicate that a range between 20 to 25 pounds (9- to 11 kg) of weight is the optimal amount for sinking storm drogues in heavy weather. For this report we determined that 20-feet x 3/8-inch (6 m x 10 mm) chain weight

weighing approximately 22 pounds (10 kg) would be the best formula to use for sinking the storm drogues. We've learned during our on-the-water training classes that 20-feet (6 m) of chain is about all most sailors can manage when trying to deploy safety equipment because it's so cumbersome to handle. We considered the amount of 8-feet x 3/8-inch (2.5 m x 10 mm) recommended by Seabrake, but previous tow tests by Fiorentino determined this amount was not heavy enough to sink the storm drogues properly (View tech report FPA-124 at Para-Anchor.com for more information about this subject). The Delta drogue manual recommended using 10- to 20-feet (3 to 6 m) of chain, but didn't provide the diameter. And the 35 pounds (16 kg) recommended by the Series drogue is just too heavy and difficult to handle in our opinion.

Rode Used for the Tow Test

The anchor rode used for the test was a 40-foot (12.2 m) length of 5/8-inch (16 mm) rope. The double braid rode developed for Fiorentino after 2000 was woven from a Dacron/nylon mix of fibers in an effort to reduce stretch while maintaining some shock absorption capability. For testing purposes, however, the type of braided rode we used, whether Dacron or Nylon, was irrelevant. Fiorentino has discovered in past sea trials that all braided rode, single, double, 12- plait etc., essentially performs similarly when used with a storm drogue. The 40-foot length was chosen because it was unnecessary to pay out larger amounts of rode in flat calm weather and it made it easier to observe the behavior of these devices since they were closer to the boat.

Importance of Using Weight to Maintain Constant Rode Tension

One of the most important findings in this report is how much the performance of storm drogues improves when chain or anchor weight is added to the devices. This is consistent with other drag tests performed by Fiorentino that show how weight helps maintain "constant rode tension" upon the deployment rode and to sink the storm drogues underwater so the canopy will remain fully inflated (More can be found on the constant rode tension theory at Para-Anchor.com). Additionally, a review of past Fiorentino tow tests and this report demonstrate that drag increases an average of close to 0.5 knots when a chain or mushroom anchor is attached to a storm drogue. Fiorentino has determined from sea trials that extra drag from weight and heavy rode frequently assists with vessel stability.

The manufacturers of the Galerider, Para-Drogue and Seaclaw do not recommend that weight be used with their storm drogues. However, without the implementation of chain weight these devices functioned poorly because they were unable to inflate, yawed excessively, or set above the ocean's surface losing its holding capability. Such issues can easily lead to chafe and shock loading on equipment. It can also result in a storm drogue being pulled out of a wave. This "jumping" affect as Fiorentino refers to it, can be seen on YouTube in the Shark Drogue deployment and tugboat destruction test videos by Fiorentino. In both instances, there were no weights added to the drag devices so they "jumped" out of the water.

When we added chain to these storm drogues the improvement to performance was often remarkable. However, the addition of weight placement didn't always stop the yawing or erratic spinning of some of the devices. Such action is likely the result of undersized swivels or swivels that lock up and are unable to spin freely. It could also be an issue with canopy design. Storm drogue canopies that capture too much water without the proper exit slots tend to yaw excessively. Such storm drogues also exhibit the tendency to sink and

rise in the ocean. Fiorentino experienced all of the above in the initial development of the Shark Drogue in 2005. It took over a dozen prototypes before we finally built a storm drogue that tracks straight behind the boat without any yawing or frequent diving issues. Positive results were only achieved because Fiorentino made the decision to use expensive, heavy-duty stainless hardware essential to the Shark's performance level.

Eliminating the Need for Chain Weight

The specialized hardware developed by Fiorentino permitted us to eliminate the need for chain weight by inventing a "drogue tail" that permits the attachment of a mushroom anchor behind the Shark. Use of a solid anchor condenses the volume of the system and eliminates the nightmare of retrieving 20-feet (6 m) of chain followed by an inflated storm drogue. Sailors retrieving a chain setup can't use their winch once chain is near the surface of the ocean because chain will damage the boat, especially with the downward pull from an inflated drogue as a boat falls and rises upon the waves. For this reason, we conducted an extra tow test with the Shark using a 19.5 pound (8.85 kg) mushroom anchor since that's the correct method for deploying this particular storm drogue. This also permits sailors to use their primary winch to haul in the entire drogue since the device permits the use of all rode in front of the device. Chain was also used during the test, but for comparison purpose only.

***USCG Report and the Jordon Series/Stopping Drogue**

There is one other report that supports the importance of using weights with a drag device. In 1987, Donald Jordan authored a USCG report entitled "Investigation of the Use of Drogues to Improve the Safety of Sailing Yachts." Jordan tested his series drogue, originally conceived and patented by E.J. Pagan, both with and without the use of weight. He found that without weights attached to the Jordon Series drogue that many of the cones connected to the towline were pulled out of the water reducing its overall performance. Jordon added weight to the Jordon Series drogue and concluded that a "30-35 lb (14 to 16 kg) weight attached" would insure the proper performance of his device by keeping "all the drogue elements fully underwater."

Since Jordan understood the importance of using weight to improve the performance of his storm drogue, it's unclear why he didn't add weight to the cone-style drogues he tested when completing the comparison portion of his report. It's also unclear why he chose to use homemade cone-style drogues versus actual storm drogues or parachute anchor models available at the time his comparison tests were underway. In an effort to avoid similar mistakes, Technical Report FPA-136 uses the same test equipment and includes all the major market storm drogues in an effort to provide up-to-date information on storm drogue performance with and without the use of weights.

Fiorentino hopes you will find this report useful when selecting and using a storm drogue for your vessel. Feel free to visit us at www.para-anchor,com if you would like more information or if you have any questions.

***Note:** There seems to be some confusion related to the USCG's role in the 1987 Jordon Series drogue report on a few sailing blog and forum websites. The USCG wrote to your author in an effort to clarify any misconceptions. The USCG stated its job was strictly a supportive role in an effort to provide an "economical platform" for the test. There was no endorsement of the Jordon series drogue and they never claimed the apparatus was better than a para-anchor as indicated in some books, online videos, and websites.

ON-THE-WATER DRAG TEST

06-15-11

Seven different storm drogues were towed behind a 35-foot (11 m) monohull sailboat to complete 15 drag tests outside Long Beach Harbor.

In the first series of tests, each storm drogue was attached to a 40-foot (12.2 m) length of 5/8-inch (16 mm) deployment rode developed for Fiorentino. The double braid rode is woven from a Dacron/nylon mix of fibers. The second series of tests included the same deployment rode, but with the addition of 20-feet x 3/8-inch (6 m x 10 mm) chain weight weighing approximately 22 pounds (10 kg).

The 5/8-inch (16 mm) deployment rode has a spliced eye with a stainless thimble on both ends. A 5/8-inch (16 mm) bow shackle secured the rode to a load cell capable of measuring storm drogue strain up to 20,000 lbs. (9,072 kg). The load cell was attached to a cleat located on the port stern near the transom. Storm drogues were deployed after the sailboat reached an approximate speed of 7.0 knots. The engine and single prop produced approximately 2,750 RPMS for each trial.

From left to right: Bob Ritner, Zack Smith, and Gerrard Fiorentino as they prepare to conduct tow tests outside Long Beach harbor, California.

SPEC. SHEET—MONOHULL SAILBOAT

Length (loa):	35’ (10.7 m)	Weight:	6 tons
Length (wl):	31’ 1-in. (9.5 m)	Draft:	5’
Beam:	12’6-ins. (3.8 m)	Cruising speed:	6-7 knots
Load Cap:	5 tons	Maximum Speed:	8 knots
Fuel Cap:	28 gal	Engine HP:	27 HP diesel engine
Water Cap:	120 gal.		

STORM DROGUES TESTED

Delta

Galerider

Para-Drogue

Seabrake

Seaclaw

Series (stopping)

Shark

PROJECT OBSERVATIONS

Weather Conditions

During the course of the test, the ocean was calm with an average of 1 to 3 knots of wind (sea state 1). This pattern of calmness persisted through the entire test with the Ocean's surface remaining flat.

Deployment Procedure

Storm drogues were all deployed from the stern of the monohull sailboat. Attached to each storm drogue was a 5/8-inch (16 mm) braided rode that was secured to a single eye located on the tension load cell. On the opposite side of the load cell was another eye that was shackled to a port cleat. Both the deployment rode and each individual storm drogue were tossed overboard at the same time after the monohull sailboat reached a speed of approximately 7.0 knots.

Tension Load Cell

The tension load cell resting on the port stern quarter demonstrated no unusual pattern of registering force and there were no wave conditions, including boat wakes, to affect force readouts.

Braided Rode Length

40-feet (12.2 m) of braided rode was deployed because the ocean was calm with a sea state of 1. The shorter length of line also made it easier to observe storm drogue behavior. Typically, extreme weather conditions require an average of 300 to 600-feet (91 to 182 m) of rode for storm drogue use (the same recommended formula for parachute anchor deployment by Fiorentino). This rode length formula developed by Fiorentino in the late 1940's, equals out to approximately 10-feet (3 m) of rode to every foot (0.31 m) of boat (LOA—Length Overall, excluding bow sprits).

Storm Drogue Effect on the Helm

There was no noticeable pull on the helm until the deployment of the Para-Drogue that yawed severely during its tow tests.

Storm Drogue Retrieval

All the storm drogues were pulled in by hand, as the weather was calm.

Test 1: No weight added to the storm drogues

In the first series of tests, each storm drogue was attached to a 40-foot (12.2 m) length of 5/8-inch (16 mm) deployment rode designed for Fiorentino. The double braid rode is woven from a Dacron/nylon mix of fibers. The 5/8-inch (16 mm) deployment rode has a spliced eye with a stainless thimble on both ends. A 5/8-inch (16 mm) bow shackle secured the rode to a load cell with the opposite end shackled onto the storm drogue.

No chain weight was added to any of the storm drogues during the first series of tow tests.

Delta (by Para-Tech Engineering)
No chain weight

Model 48”	For boats up to 35-feet (10.7 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	5.4 to 5.5
Speed Reduction (kts)	1.5 to 1.6
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	138 lbs. (63 kg)—low 176 lbs. (80 kg)—high 158 lbs. (72 kg)—average

Delta (by Para-Tech Engineering)
No chain weight

Observations:

Deployment: The Delta is deployed twice. In the first instance the Delta skips across the surface, similar to the Seaclaw (p. 22), failing to inflate. In the second instance the Delta continues to skip on the surface until the speed of the vessel is lowered to two knots. While the Delta behaves erratically, spinning abnormally and yawing a little, it is minimal when compared with the yaw of the Para-Drogue (p. 18).

Concerns: The failure of the Delta to inflate when a vessel exceeds two knots is a significant problem. Without proper inflation sufficient drag will not be created for slowing the vessel down. The erratic spinning behavior of the Delta combined with some yawing could damage the Delta due to shock load of the device. The 3/8-inch (10 mm) bolted swivel used to prevent the webbed shroud lines of the Delta from twisting might be too small for storm use. Fiorentino tug tests demonstrate that small swivels tend to break rather quickly and can lock up when placed under continued force. Dependent on the supplier, the swivel on the Delta has a working load of approximately 1,500 lbs. (680 kg) and possible break strength of 6,000 lbs. (2,722 kg). Frequently, the 3/8-inch (10 mm) swivels have broken at 4,500 lbs. (2041 kg) of force during Fiorentino destruction tests. The bolt itself tends to bend sooner.

Galerider (by Hathaway, Reiser, & Raymond)
No chain weight

Model 30” x 36”	For boats up to 10,000 lbs. (5 tons)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	5.5 to 5.6
Speed Reduction (kts)	1.4 to 1.5
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	156 lbs. (71 kg)—low 260 lbs. (118 kg)—high 160 to 170 lbs. (73 to 77 kg)—average

Galerider (by Hathaway, Reiser, & Raymond)
No chain weight

Observations:

Deployment: The Galerider deployed without surface skipping. Approximately 1/4 to 1/3 of the Galerider was exposed above the surface during most of the tow test. The Galerider has less drag than other speed-limiting drogues given how open webbing allows more water to pass through it.

Concerns: With 1/3 of the storm drogue exposed above the surface, drag is reduced. This increases the likelihood of it being pulled out of a storm wave. Drag reduction can also collapse the cable and/or the canopy.

Para-Drogue (by Para-Anchors Australia)
No chain weight

Model MK 2	For boats up to 50-feet (12.8 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	4.3 to 4.4
Speed Reduction (kts)	2.6 to 2.7
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	228 lbs. (103 kg)—low 610 lbs. (277 kg)—high 276 to 296 lbs. (125 to 134 kg)—average

Para-Drogue (by Para-Anchors Australia)
No chain weight

Observations:

Deployment: The Para-Drogue deployed without surface skipping. However it displays an inability to track straight as well as frequent back and forth yaws as it rises and sinks in the water. However, the parachute-like canopy shape did create substantial drag to slow the boat. The Para-Drogue is currently available in only one size. The manufacturer recommends using two storm drogues in tandem for vessels over 50-feet (15.24 m).

Concerns: Yawing is a significant issue as a primary cause of rode chafe, knocking a boat off course and increasing weather helm. One concern is that the Para-Drogue may have too much holding power for smaller boats in the 20- to 30-foot (6.1 to 9.1 m) range. If the boat slows too much, waves can overtake it and potentially cause cockpit flooding. Of equal concern is the idea of towing tandem storm drogues as recommended by the manufacturer to handle larger vessels. Fiorentino discovered during sea trials that such setups tend to function poorly and are not user friendly.

Seabrake (by Burke)
No chain weight

Model GP24L	For boats from 10- to 35-feet (3.1 to 10.7 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	4.4 to 4.6
Speed Reduction (kts)	2.4 to 2.6
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	196 lbs. (89 kg)—low 420 lbs. (191 kg)—high 230 lbs. (104 kg)—average

Seabrake (by Burke)
No chain weight

Observations:

Deployment: The Seabrake deployed without any surface skipping. However, the Seabrake's frequent spinning is likely one reason for its cavitation issue. Cavitation occurs when the canopy alternates between collapse and inflation which can cause a storm drogue to lose its grip in the water. While some sinking and yawing was evident it was much less than the Para-Drogue brand (p. 18). The parachute-like canopy does create substantial drag.

Concerns: Cavitation may result in shock loading that can break either the rode or the storm drogue. The four webbed shroud lines placed over a light duty thimble are served with ordinary sewing machine thread. Therefore, the easy removal of the thimble by hand is an indication that it could fall out of its splice during use, creating a potential chafe issue. Fiorentino destruction tests indicate that heavy-duty thimbles when served tightly are not only less likely to fall out of the splice, but also less likely to split open.

SeaClaw (by W.A. Coppins)
No chain weight

Model S2	For boats up to 42-feet (12.8 m)
Boat speed without storm drogue (kts)	7.1
Boat speed with storm drogue (kts)	4.5 to 4.6
Speed Reduction (kts)	2.5 to 2.6
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	256 lbs. (116 kg)—low 342 lbs. (155 kg)—high 310 lbs. (141 kg)—average

SeaClaw (by W.A. Coppins)
No chain weight

Observations:

Deployment: The Seaclaw is deployed twice. In the first instance the Seaclaw skips across the surface of the water and does not inflate. In the second instance although the Seaclaw is deployed with its built-in flotation facing upward it skips across the water's surface for almost 30 seconds before it inflates. A video review indicates that both webbed lines connected to the canopy had become twisted. This may have been a contributing factor affecting canopy inflation.

Concerns: The 5/16-inch (8 mm) bolted eye and eye swivel used to prevent the webbed shroud lines of the Seaclaw from twisting might be too small for storm use. Tug tests conducted by Fiorentino demonstrate that small swivels tend to break rather quickly and can lock up when placed under continued force. Dependent upon the supplier, the swivel on the Seaclaw has a working load of approximately 1,100 lbs. (499 kg) and possible break strength of 4,400 lbs. (1996 kg). The Seaclaw's large size, combined with the fact that the built-in flotation device must remain facing upward during deployment, may present some handling challenges.

Series – Stopping Drogue (by Ace Sailmakers)
No chain weight

Model 103 Cones	For boats up to 10,000 lbs. (5 tons)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	3.3
Speed Reduction (kts)	3.7
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	228 lbs. (103 kg)—low 320 lbs. (145 kg)—high 280 lbs. (127 kg)—average

Series – Stopping Drogue
(by Ace Sailmakers)
No chain weight

Observations:

Deployment: Part of the drogue was on the surface which can influence drag. There was little to no yawing.

Concern: Setting on or above the surface can reduce drag. The stopping drogue can be increasingly difficult to handle as more cones are deployed. Essentially, as more cones are deployed more force is then exerted on the rode until retaining a solid grip becomes impossible. This is the manufacturers recommended method of deployment. Use of a winch is possible, but Fiorentino sea trials indicate that the cones tend to tangle around the winch and substantial caution must be employed to prevent tearing.

Shark (by Fiorentino)
No chain weight

Model Small	For boats from 32- to 49-feet (9.8 to 14.9 m) And 50,000 lbs. (25 tons)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	5.0
Speed Reduction (kts)	2.0
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	178 lbs. (81 kg)—low 300 lbs. (136 kg)—high 190 lbs. (86 kg)—average

Shark (by Fiorentino)
No chain weight

Observations:

Deployment: The Shark deployed without any issue of surface skipping. The Shark set on the surface the entire time without spinning as well as tracked straight without yawing.

Concern: A storm drogue that sets too close or above the surface can lose some of its holding power.

Test 2: Weight added to the storm drogues

In the second series of tests, each storm drogue was attached to a 40-foot (12.2 m) length of 5/8-inch (16 mm) deployment rode designed for Fiorentino. The double braid rode is woven from a Dacron/nylon mix of fibers. The 5/8-inch (16 mm) deployment rode has a spliced eye with a stainless thimble on both ends. A 5/8-inch (16 mm) bow shackle secured the rode to a load cell with the opposite end of the 40-foot (12.2 m) rode shackled onto the storm drogue.

The second series of tests included the same deployment rode, but with the addition of 20-feet x 3/8-inch (6 m x 10 mm) chain weight weighing approximately 22 pounds (10 kg). All seven storm drogues were tested with the chain weight. Only one additional tow test included a 19.5 pound (8.85 kg) mushroom anchor attached to the backside of the Shark drogue. Previous sea trials by Fiorentino indicate that a mushroom anchor significantly improves the drag results of the Shark versus the use of chain which made it relevant to incorporate the mushroom anchor into the drag test. The Shark is specifically designed for attaching an anchor like a mushroom to its backside to improve its angle for grabbing more water.

The second series of tests included the addition of 20-feet x 3/8-inch (6 m x 10 mm) chain weight weighing approximately 22 pounds (10 kg). All the storm drogues performed better with the added weight.

The Shark drogue was specifically designed for anchor weight attachment behind the device. For this reason a 19.5 pound (8.85 kg) mushroom anchor was attached to the backside of the Shark drogue for an additional tow test.

Delta (by Para-Tech Engineering)
20-feet (6 m) of chain weight

Model 48”	For boats up to 35-feet (10.7 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	5.4
Speed Reduction (kts)	1.6
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	160 lbs. (73 kg)—low 254 lbs. (115 kg)—high 190 lbs. (86 kg)—average

Delta (by Para-Tech Engineering)
20-feet (6 m) of chain weight

Observations:

Deployment: The chain weight deployed the Delta storm drogue immediately. It never skipped on the water surface as it had in test 1 without weight placement (p. 14). While there was still some yawing, it was minimal when compared to test 1 when no weight was deployed with the storm drogue. While the Delta drogue‘s erratic spinning was still present it was likely caused by force locking up the swivel.

Concerns: The erratic spinning behavior of the Delta drogue combined with some yawing could damage the Delta drogue due to shock load of the device. The 3/8-inch (10 mm) bolted swivel used to prevent the webbed shroud lines of the Delta from twisting might be too small for storm use. Fiorentino tug tests demonstrate that small swivels tend to break rather quickly and can lock up when placed under continued force. Dependent on the supplier, the swivel on the Delta has a working load of approximately 1,500 lbs. (680 kg) and possible break strength of 6,000 lbs. (2,722 kg). Frequently, the 3/8-inch (10 mm) swivels have broken at 4,500 lbs. (2041 kg) of force during Fiorentino destruction tests. The bolt itself tends to bend sooner.

Galerider (by Hathaway, Reiser, & Raymond)
20-feet (6 m) of chain weight

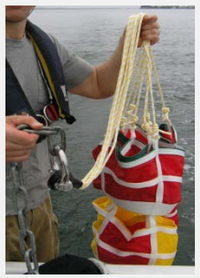
Model 30” x 36”	For boats up to 10,000 lbs. (5 tons)
Boat speed without storm drogue (kts)	6.9
Boat speed with storm drogue (kts)	5.2 to 5.3
Speed Reduction (kts)	1.6 to 1.7
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	130 lbs. (59 kg)—low 203 lbs. (92 kg)—high 140 lbs. (64 kg)—average

Galerider (by Hathaway, Reiser, & Raymond)
20-feet (6 m) of chain weight

Observations:

Deployment: The Galerider performed much better with the extra chain weight attached to it, no longer sitting above the surface. Less force was placed on equipment by using the chain weight. The manufacturer does not recommend the use of chain with their storm drogue.

Concerns: The cable that holds the mouth of the Galerider open is partially folding in half, which can cause the canopy to collapse and lose its holding power. This behavior has been noted in several other drag tests, including tests published in *"The Sea Anchor & Drogue Handbook,"* written by Daniel Shewmon.



Para-Drogue (by Para-Anchors Australia)
20-feet (6 m) of chain weight

Model MK 2	For boats up to 50-feet (12.8 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	4.1
Speed Reduction (kts)	2.9
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	256 lbs. (116 kg)—low 520 lbs. (236 kg)—high 256- to 284 lbs. (116 to 129 kg)—average

Para-Drogue (by Para-Anchors Australia)
20-feet (6 m) of chain weight

Observations:

Deployment: Although the chain weight reduced the yawing along with the sinking and rising issue evident in Test One when no chain weight was utilized (p. 18), the problem was not resolved. However, the parachute-like canopy shape did create substantial drag to slow the boat. The Para-Drogue is currently available in only one size. The manufacturer recommends using two storm drogues in tandem for vessels over 50-feet (15.24 m). Para-Anchors Australia does not recommend the use of a chain with their storm drogue.

Concerns: Yawing is a significant issue as the primary cause of rode chafe, knocking a boat off course and increasing weather helm. One concern is that the Para-Drogue may have too much holding power for smaller boats in the 20- to 30-foot (6.1 to 9.1 m) range. If the boat slows too much, waves can overtake it and potentially cause cockpit flooding. Of equal concern is the idea of towing tandem storm drogues as recommended by the manufacturer to handle larger vessels. Fiorentino discovered during sea trials that such setups tend to function poorly and are not user friendly.

Seabrake (by Burke)
20-feet (6 m) of chain weight

Model GP24L	For boats from 10- to 35-feet (3.1 to 10.7 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	4.2 to 4.3
Speed Reduction (kts)	2.7 to 2.8
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	224 lbs. (102 kg)—low 420 lbs. (191 kg)—high 240- to 270 lbs. (109 to 123 kg)—average

Seabrake (by Burke)
20-feet (6 m) of chain weight

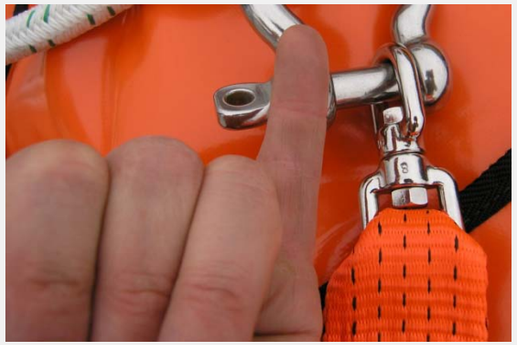
Observations:

Deployment: Neither the frequent spinning or the cavitation issue were eliminated by the Seabrake's chain weight. Cavitation occurs when the canopy alternates between collapse and inflation which can cause a storm drogue to lose its grip in the water. Unfortunately, the frequent spinning of the storm drogue resulted in badly twisted shroud lines. Interestingly, the canopy didn't collapse, but maintained its grip in the water. While some sinking and yawing was evident it was much less than the Para-Drogue brand (p. 18). Although a swivel might have the effect of reducing a portion of the twisting it would be negated given that force placed on a swivel has a tendency to lock it up and prevent it from spinning freely.

Concerns: Cavitation may result in shock loading that can break either the rode or the storm drogue. The four webbed shroud lines placed over a light duty thimble are served with ordinary sewing machine thread. Therefore, the easy removal of the thimble by hand is an indication that it could fall out of its splice during use, creating a potential chafe issue. Fiorentino destruction tests indicate that heavy-duty thimbles when served tightly are not only less likely to fall out of the splice, but also less likely to split open.

SeaClaw (by W.A. Coppins)
20-feet (6 m) of chain weight

Model S2	For boats up to 42-feet (12.8 m)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	4.5
Speed Reduction (kts)	2.5
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	230 lbs. (104 kg)—low 468 lbs. (212 kg)—high 250- to 270 lbs. (113 to 123 kg)—average

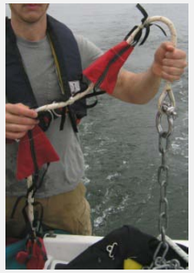


SeaClaw (by W.A. Coppins)
20-feet (6 m) of chain weight

Observations:

Deployment: The chain weight deployed the Seaclaw immediately. It never skipped or surfaced above the water as it had during the drag test without the chain (p. 22). The sharp downward pull on the anchor rode illustrated how quickly the chain sunk the Seaclaw deep below the ocean's surface. W. A. Coppins does not recommend the use of a chain with their storm drogue.

Concerns: The 5/16-inch (8 mm) bolted eye and eye swivel used to prevent the webbed shroud lines of the Seaclaw from twisting might be too small for storm use. Tug tests conducted by Fiorentino demonstrate that small swivels tend to break rather quickly and can lock up when placed under continued force. Dependent upon the supplier, the swivel on the Seaclaw has a working load of approximately 1,100 lbs. (499 kg) and possible break strength of 4,400 lbs. (1996 kg). The Seaclaw's large size, combined with the fact that the built-in flotation device must remain facing upward during deployment, may present some handling challenges.



Series – Stopping Drogue (by Ace Sailmakers)
20-feet (6 m) of chain weight

Model 103 Cones	For boats up to 10,000 lbs. (5 tons)
Boat speed without storm drogue (kts)	7.0
Boat speed with storm drogue (kts)	3.2
Speed Reduction (kts)	3.8
Single Propeller Vessel (Rpms)	2,750
Load Cell Readout with Storm Drogue Deployed	104 lbs. (47 kg)—low 630 lbs. (286 kg)—high 362- to 376 lbs. (164 to 171 kg)—average

Series – Stopping Drogue
(by Ace Sailmakers)
20-feet (6 m) of chain weight

Observations:

Deployment: The series (stopping) drogue set deeper in the water with chain weight assistance. However, the stopping drogue became partially tangled which had an adverse effect on its ability to slow the vessel by as much as an estimated 0.5 to 1.0 knots. The tangle occurred when the last 25’ (7.62 m) of the storm drogue entered the water all at once.

Concern: While the manufacturer recommends paying out the stopping drogue slowly, it proves to be problematic in that the drogue’s pull becomes increasingly stronger as more cones are deployed. This is especially true with the addition of chain weight. The test vessel did not have a cockpit winch to assist with deployment. Even if it had, it would have been impossible to utilize as the cones tend to tangle around such devices. In addition, we wanted to drop the last portion of the storm drogue all at once for the purpose of measuring the initial shock load created by the device itself. Such action maintains consistency during a comparison test.


Shark (by Fiorentino)
20-feet (6 m) of chain weight
19.5 lb. (8.85 kg) mushroom anchor

Model Small	For boats from 32- to 49-feet (9.8 to 14.9 m) and 50,000 lbs. (25 tons)	
Weight deployed with drogue	Chain	Mushroom Anchor
Boat speed without storm drogue (kts)	7.0	7.0
Boat speed with storm drogue (kts)	4.8	4.5 to 4.6
Speed Reduction (kts)	2.2	2.4 to 2.5
Single Propeller Vessel (Rpms)	2,750	2,750
Load Cell Readout with Storm Drogue Deployed	178 lbs. (81 kg)—low 300 lbs. (136 kg)—high 190 lbs. (86 kg)—average	238 lbs. (108 kg)—low 344 lbs. (156 kg)—high 300 lbs. (136 kg)—average


Shark (by Fiorentino)
20-feet (6 m) of chain weight
19.5 lb. (8.85 kg) mushroom anchor

Observations:

Deployment: The Shark storm drogue set deeper in the water in test 2 as compared with test 1 (p. 26) when no weight was added to the device. Of notable interest is that chain weight attached to the drogue tail failed to register a higher amount of force on the load cell indicator versus no weight attached to the tail. The drogue tail was designed by Fiorentino to place weight behind the storm drogue (specifically a mushroom anchor or other ground tackle) rather than in front of it. This is an effort to avoid the use of chain which can be difficult to handle. Chain was used in test 2 solely for providing consistency with the testing process for comparison purposes.

Subsequently, a mushroom anchor was attached to the Shark as the correct method for weighing down the storm drogue. The amount of force and extra drag created by the anchor attached to the drogue tail during the tow was normal. While the mushroom anchor was lighter in weight than the chain, it has a wider surface area, thus creating extra drag. The small mushroom anchor was more successful at inflation of the canopy and achieving a better angle by simultaneously pulling the backside of the Shark in deeper water while tilting the mouth toward the surface.

DRAG SPEED CHARACTERISTICS
35-foot Monohull Sailboat Deployment--Single Rode Set-Up (No Chain Weight)

*5/8-inch (16 mm) x 4**0-feet (12 m)** Double Braid Dacron/Nylon mix, 16,000 lbs. (7,258 kg) break strength.*

Test Parameters	Delta 48”	Galerider 30” x 36”	Para-Drogue	Seabrake GP24L	SeaClaw 2	Series (103 cones)	Shark Small
Recommended Boat Size	Up to 35’	To 10,000 lbs.	Up to 50’	10’ to 35’	Up to 42’	To 10.000 lbs.	32’ to 49’ and 50,000 lbs.
Boat speed without drogue (in knots)	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Boat speed with drogue (in knots)	5.4 to 5.5	5.5 to 5.6	4.3 to 4.4	4.4 to 4.6	4.5 to 4.6	3.3	5.0
Speed reduction (in knots)	1.5 to 1.6	1.4 to 1.5	2.6 to 2.7	2.4 to 2.6	2.4 to 2.5	3.7	2.0
Vessel rpm’s with one propeller	2,750	2,750	2,750	2,750	2,750	2,750	2,750
Load Cell Readout with drogue deployed	138 lbs. (63 kg)—low 176 lbs. (80 kg)—high 158 lbs. (72 kg)--average	156 lbs. (71 kg)—low 260 lbs. (118 kg)—high 160 to 170 lbs. (73 to 77 kg)--average	228 lbs. (103 kg)—low 610 lbs. (277 kg)—high 276 to 296 lbs. (125 to 134 kg)--average	196 lbs. (89 kg)—low 420 lbs. (191 kg)—high 230 lbs. (104 kg)--average	256 lbs. (116 kg)—low 342 lbs. (155 kg)—high 310 lbs. (141 kg)--average	228 lbs. (103 kg)—low 320 lbs. (145 kg)—high 280 lbs. (127 kg)--average	178 lbs. (81 kg)—low 300 lbs. (136 kg)—high 190 lbs. (86 kg)--average

DRAG SPEED CHARACTERISTICS
35-foot Monohull Sailboat Deployment--Single Rode Set-Up (20’ x 3/8” Chain Weight—22 pounds)

*5/8-inch (16 mm) x 4**0-feet (12 m)** Double Braid Dacron/Nylon mix,16,000 lbs. (7,258 kg) break strength.*

Test Parameters	Delta 48”	Galerider 30” x 36”	Para-Drogue	Seabrake GP24L	SeaClaw 2	Series (103 cones)	Shark Small
Recommended Boat Size	Up to 35’	To 10,000 lbs.	Up to 50’	10’ to 35’	Up to 42’	To 10.000 lbs.	32’ to 49’ and 50,000 lbs.
Boat speed without drogue (in knots)	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Boat speed with drogue (in knots)	5.4	5.2 to 5.3	4.1	4.2 to 4.3	4.5	3.2	4.8
Speed reduction (in knots)	1.6	1.7 to 1.8	2.9	2.7 to 2.8	2.5	3.8	2.2
Vessel rpm’s with one propeller	2,750	2,750	2,750	2,750	2,750	2,750	2,750
Load Cell Readout with drogue deployed	160 lbs. (73 kg)—low 254 lbs. (115 kg)—high 190 lbs. (86 kg)—average	130 lbs. (59 kg)—low 203 lbs. (92 kg)—high 140 lbs. (64 kg)--average	256 lbs. (116 kg)—low 520 lbs. (236 kg)—high 256 to 284 lbs. (116 to 129 kg)--average	224 lbs. (102 kg)—low 420 lbs. (191 kg)—high 240 to 270 lbs. (109 to 123 kg)--average	230 lbs. (104 kg)—low 468 lbs. (212 kg)—high 250 to 270 lbs. (113 to 123 kg)--average	104 lbs. (47 kg)—low 630 lbs. (286 kg)—high 362 to 376 lbs. (164 to 171 kg)--average	178 lbs. (81 kg)—low 300 lbs. (136 kg)—high 190 lbs. (86 kg)--average

DRAG SPEED COMPARISON---With and without Weight + added force with weight attachment

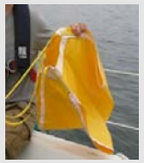
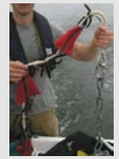
Test Parameters	Delta 48”	Galerider 30” x 36”	Para-Drogue	Seabrake GP24L	SeaClaw 2	Series (103 cones)	Shark Small
Recommended Boat Size	Up to 35’	To 10,000 lbs.	Up to 50’	10’ to 35’	Up to 42’	To 10.000 lbs.	32’ to 49’ and 50,000 lbs.
Boat speed reduction with drogue (no weight)--in knots	1.5 to 1.6	1.4 to 1.5	2.6 to 2.7	2.4 to 2.6	2.4 to 2.5	3.7	2.0
Boat speed reduction with drogue (weight placement)--in knots	1.6	1.7 to 1.8	2.9	2.7 to 2.8	2.5	3.8	2.2
Extra speed reduction because of weight—in knots	0 to 0.1	0.3 to 0.4	0.3 to 0.4	0.1 to 0.4	0 to 0.1	0.1	0.2 with the chain 0.4 to 0.5 with a 19.5 lb. mushroom anchor
Extra force measured on Load Cell Readout Because of weight attachment to drogue	22 lbs. (73 kg)—low 78 lbs. (115 kg)—high 32 lbs. (86 kg)--average	26 lbs. (59 kg)—low -57 lbs. (92 kg)—high -20 to -30 lbs. (64 kg)--average	28 lbs. (116 kg)—low -90 lbs. (236 kg)—high -12 to -20 lbs. (116 to 129 kg)--average	28 lbs. (102 kg)—low 0 lbs. (191 kg)—high 10 to 40 lbs. (109 to 123 kg)--average	-26 lbs. (104 kg)—low 126 lbs. (212 kg)—high 60 to 80 lbs. (113 to 123 kg)--average	-124 lbs. (47 kg)—low 310 lbs. (286 kg)—high 82 to 96 lbs. (164 to 171 kg)--average	0 lbs. (81 kg)—low 0 lbs. (136 kg)—high 0 lbs. (86 kg)—average **Mushroom Anchor:** 44 lbs. (81 kg)—low 44 lbs. (136 kg)—high 48 lbs. (86 kg)—average
Notes		Negative numbers equals less force on equipment because of chain.	Negative numbers equals less force on equipment because of chain.		Negative numbers equals less force on equipment because of chain.	Negative numbers equals less force on equipment because of chain.	Odd that the force measured with the chain deployed was zero. The mushroom anchor added force appears normal vs. past drag tests.

COMPARING THE TOP 7 STORM DROGUES

Storm Drogue Specs	Delta 48”	Galerider 30” x 36”	Para-Drogue	Seabrake GP24L	SeaClaw 2	Series (103 cones)	Shark Small
Boat Size	Up to 35’	To 10,000 lbs.	Up to 50’	10’ to 35’	Up to 42’	To 10.000 lbs.	32’ to 49’ and 50,000 lbs.
Retail price (04-2012)	$219	$595	$618	$238	$450	$1,161	$789
Item Weight (using same scale)	4 lbs. (1.81 kg)	9.5 lbs. (4.3 kg)	6 lbs. (2.72 kg)	4 lbs. (1.81 kg)	13 lbs. (5.9 kg)	35 lbs. (15.9 kg)	14 lbs. (6.4 kg)
Hardware	3/8” (10 mm) swivel	1/2” (12 mm) swivel	light-duty thimble	light-duty thimble	5/16” (8 mm) swivel	Soft rode eye with no serving	Para-ring® & 3/4” (19 mm) swivel
Stowage Bag	Draw string bag	Draw string bag	Zipper enclosed bag	Velcro enclosed bag	Buckle snap enclosed bag	Not included	Packs inside the para-ring®, bag not required
Shroud Line Type	Webbing	Braided	Braided	Webbing	Webbing	Cone into rode	Stainless steel para-ring
Shroud Line Quantity	3	5	8	4	2	1 rode	1 para-ring

Rode & Chain Recommendations for Storm Drogue Use

Information acquired through 2011 manual purchases and 2012 website reviews

Manufacturer Recommendation	 Delta	 Galerider	 Para-Drogue	 Seabrake	 SeaClaw	 Series/ stopping	 Shark
Rode Length	Minimum 200 ft. (61 m)	Minimum 350 ft. (107m), *"and more maybe useful."*	263 ft. (80 m)	3 x Boat's length, plus 30% surplus	177 ft. (54 m)	Rode length is based upon boat weight. Recommendations can vary between suppliers. Rode lengths average between 250-600 ft. (76- to 183 m)	10 ft. (3 m) of rode for every foot (0.31 m) of boat (bow sprits not counted). Fiorentino's team usually won't carry more than 600-ft. (183 m). See *"Short or full rode deployment"* pp. 47.
Rode Diameter	1/2- to 5/8-inch (13- to 16 mm)	5/8- to 3/4-inch (16- to 19 mm)	1/2- to 5/8-inch (13- to 16 mm)	9/16- to ¾-inch (14- to 19 mm)	1/2- to 5/8-inch (13- to 16 mm)	Boat end 5/8-inch (16 mm) second half of line is ½-inch (13 mm) Rode diameters increases to 3/4- to 1-inch (19 to 25 mm) as vessel weight increases.	5/8- to 3/4-inch (16- to 19mm)
Weight Placement	10-20 ft. (3- 6 m) chain	Recommends not to use chain	No recommendation on the website or in the user manual	8-14 ft. (2.4- to 4.2 m) chain	Recommends not to use chain	15-50 lbs. (7 to 23 kg) of chain	Mushroom anchor, 10 lbs. (5 kg) (for gales and 25 lbs. (11kg) for storms.
Rode Fiber	Nylon	Nylon	Nylon	Polyester (Dacron)	Nylon	Nylon	Nylon/Dacron Mix

Rode & Weight Recommendations for Storm Drogue Use by Fiorentino

Fiorentino

Drogue Tension Guideline:

The following chart explains the recommended rode lengths and sinking weights required to properly deploy a storm drogue from the stern of a boat. You may choose to deploy shorter increments of rode or the full recommended length, based on various actual conditions (current weather, future weather forecast, your experience with the vessel, etc.). The average length of rode to deploy in severe weather is 10-feet (3 m) of rode per every foot (0.31 m) of boat length.

Weather conditions	Calm Weather	Gale Force	Heavy Weather	Severe Weather
Wind speed in knots	< 28	28-47	48-65	66 >
Option 1: Short rode deployment	N/A	150 ft. (46m)	300 ft. (91m)	90% of rode
Amount of weight required	N/A	10 lbs. (5kg)	25 lbs. (11kg)	25 lbs. (11kg)
Option 2: Full rode deployment	10 ft. x boat length	10 ft. x boat length	10 ft. x boat length	10 ft. x boat length
Amount of weight required	25 lbs. (11kg)	25 lbs. (11kg)	25 lbs. (11kg)	25 lbs. (11kg)

DISCLAIMER: The chart above was compiled following the completion of a 15 year study involving drag device performance, with and without the use of load cell equipment, under varying weather conditions. Developed by Fiorentino Para Anchors, these guidelines are provided to the boating community for education only. Until further research has been completed the data in these charts should be used with prudence. Due to the dynamics of the relationship between a boat and the ocean, these guidelines cannot be claimed as an exact science. Unusual currents and wave patterns and even boat design can affect the results of these guidelines. (Excerpt from *"Shark Drogue Manual, 2nd edition."*)

Conclusion

This technical report from Fiorentino is the result of comparison storm drogue drag tests performed in Long Beach Harbor, California on June 15, 2011. Seven different storm drogues were tested measuring the differences in each drogue's drag characteristics. Each test was recorded on video to show the behaviors of each storm drogue as they were towed. Major differences identified from these tests include:

- Vessel speed reduction with the storm drogue deployed.
- Amount of force placed on the equipment recorded by load cell instrumentation.

The purpose of this report is to determine storm drogue performance by recording the following:

- Whether or not the device encountered excessive yaw
- Did the device set above the ocean's surface
- Did the device fail to deploy
- Did the device spin out of control

Devices that experienced any of these behaviors raise major questions concerning what would occur under storm conditions while a boat is pitching and rolling.
Along with the performance tests, Fiorentino recorded the ease of use for each device. It is important to determine which device will not only perform optimally under severe weather conditions, but also which storm drogue will be easy to handle without tangling or injuring sailors during the deployment process.

Proper scientific ethics are used by Fiorentino for each test. An example of these principles may be found in the "*Scientific Ethics*" article authored by Anthony Carpi, PhD and Anne E. Egger, PhD online at the website visionlearning.com. The principles of testing equality, honest reporting, and open testing methods allow other organizations to repeat these tests and verify their validity. Fiorentino adhered to ethical standards by testing each storm drogue using the same rigging components, recording instruments, vessel speed, weather conditions, and other recorded techniques developed by Fiorentino to ensure that each drogue was tested equally.

To recap, the following seven storm drogues were used in these tests:

- Delta
- Galerider
- Para-Drogue
- Seabrake

- Seaclaw
- Series (Stopping)
- Shark

Each of these storm drogues are built by companies that have been involved with drag devices for a minimum of twenty years. Each was pulled through the water utilizing the same tow line and chain weight setup to ensure accuracy in the force readouts and to record their trailing behavior. Wave conditions and currents may heavily impact test results which causes increased levels of inaccuracy. These tests were conducted in calm water to ensure an unchanged environment for increased accuracy in results.

The published manufacturer instructions for the correct use of each device were used while conducting Fiorentino's tests. The manufacturers of the Galerider, Para-Drogue, and Seaclaw do not recommend the use of weight with their storm drogues. To be equal, each storm drogue was tested with and without the addition of weight. Fiorentino's previous sea trials indicate that a range between 20 to 25 Lbs. (9 to 11 Kg) of weight is the optimal weight for sinking storm drogues in heavy weather. For this report it was determined that 20 Ft. x 3/8 In. (6 m x 10 mm) of chain weighing approximately 22 Lbs. (10 Kg) was the best formula used for sinking storm drogues. This was also the peak amount of chain that can be safely managed during deployment.

The deployment rode used for these tests was 40 Ft. (12.2 m) in length and 5/8 In. (16 mm) in diameter of rope. Fiorentino developed a double braided rode woven from Dacron/Nylon mix of fibers. The type of braided rode used for these tests was irrelevant due to Fiorentino's discovery that all braided rode (i.e., single, double, 12-plait) all essentially perform the same when used with a storm drogue. Also irrelevant was whether a Dacron or Nylon fiber rope was used due to the short rode deployment limiting stretch as defined in Fiorentino's constant rode tension theory. The 40 Ft. (12.2 m) length was chosen for these tests to provide clear observation to the behavior of each device in flat calm weather while close to the boat.

A key finding within this report is the improved performances of storm drogues when chain weight or anchor weight is added. This finding is consistent with previous tests performed by Fiorentino which determined that weight aids in maintaining "constant rode tension" upon the deployment rode and in sinking the storm drogues underwater, thus keeping the canopy fully inflated. Refer to information regarding the constant rode tension theory at Para-Anchor.com. Reviewing the previous Fiorentino tow tests and this report demonstrate that drag increases on average 0.5 knots when a chain or mushroom anchor is attached to a storm drogue. These sea trials show that extra drag from a weight and heavy rode will frequently assist with vessel stability.

The devices of the three manufacturers that do not recommend the use of weights were found to not inflate, excessively yaw, or set above the ocean's surface losing their holding capability. These issues can lead to chafe and shock loading on equipment. It may also result in the storm drogue being pulled out of a wave. This "drogue jumping" affect as defined by Fiorentino can be viewed from YouTube in the Shark Drogue deployment and tugboat destruction test videos by Fiorentino. In both instances the devices "drogue jumped" out of the water since no weights were added.

The added chain to these storm drogues displayed remarkable improvement to performance in many cases. However, the addition of weight placement did not always stop the yawing or erratic spinning of some devices. This is likely the result of swivels that are undersized or which lock up and are unable to spin freely. Canopy design may also cause this. Storm drogue canopies may capture excessive water and yaw due to improper exit slots for the water to escape. These storm drogues exhibit a tendency to sink and rise in the ocean. All of these characteristics were experienced by Fiorentino during the initial development of the Shark Drogue in 2005. Fourteen prototypes were built prior to designing a storm drogue that tracks straight behind the boat without yawing or frequent diving issues. These positive results were due to Fiorentino utilizing quality heavy-duty stainless steel hardware now patented by the company.

The quality of the hardware has directly contributed to the performance level of the Shark Drogue. This specialized hardware allowed for the elimination of the need for chain weight by inventing a “drogue tail” which permits the attachment of a mushroom anchor behind the storm drogue. The use of a solid anchor condenses the volume of the system and eliminates the difficulty of retrieving 20 Ft. (6 m) of chain followed by a storm drogue. A winch may be used when retrieving the Shark Drogue since there is no chain setup in front of the storm device. Damage is especially a risk when there is a downward pull from an inflated storm drogue as the boat falls and rises with the waves. For this reason, the Shark Drogue was tested using the recommended 19.5 Lb. (8.85 kg) mushroom anchor. This was an extra test compared to the two tests performed for each storm drogue. Another benefit of using the mushroom anchor with the Shark Drogue is that the primary winch can be used to haul in the entire device since all the rode can be utilized.

Fiorentino hopes that you have found this report to be useful in selecting a storm drogue for your vessel. If you would like further information or if you have any questions please visit us at www.para-anchor.com.

Drag Device Manufacturer and/or Distributor Information

This report is based on the most up-to-date information available from the manufacturers at the time the report was written. However, manufacturers can change their data in their manuals, video, and websites at any time. To date, no safety regulations or standards for testing procedures exist for the manufacturing of storm drogues. Companies that no longer manufacture domestically, but import their products from other countries are not required to notify the public of their status change from manufacturer to importer. In some countries, a person or company is considered a manufacturer by simply putting their name on the product even though they played no part in its construction.

Fiorentino Para Anchor
1048 Irvine Ave #489
Newport Beach, CA 92600
USA
Para-Anchor.com
Para-Anchors.com

Para-Tech Engineering
1580 Chairbar Road
Silt, CO 81652
USA
seaanchor.com

Hathaway, Reiser, and Raymond
184 Selleck Street
Stamford, CT 06902
USA
hathaways.com

Ace Sailmakers
3D Colton Road
East Lyme, CT 06333
USA
acesails.com

Burke Marine
1/5 Clyde Street Rydalmere
NSW 2116
Australia
burkemarine.com.au

Para-Anchors Australia,
PO Box 1377,
Sale, Vic. 3850
Australia
paraanchors.com.au

W.A. Coppins
255 High Street,
Motueka
New Zealand
paraseaanchor.com

Online Video from this Test is located on YouTube under the title of “Storm Drogue Comparison Tests.” It can also be viewed on “The Complete Para-Anchor Set-Up 2nd edition” DVD.