Safety At Sea Studies - 1994 San Francisco Anchor Tests

West Marine Sand Anchor Test

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Background

Vendors frequently send anchors to West Marine to see if we want to carry them. Sometimes the anchors are similar to anchors we now stock, e.g., a less expensive fluke anchor, while other anchors are completely different designs. While we are very satisfied with our existing anchor selection, we are always interested in designs that may be the next Danforth, CQR, or Bruce. Before we take on a new anchor line, we test the new models against existing models in actual on the water testing.

Over the course of two days, we tested over a dozen new and established anchor styles in several sites. Anchors tested on 4/22/94 included the following:

Manufacturer	Model	Weight (lbs.)	Comments
Digger	15	15	Spring loaded Releasable anchor
Chuck Ford	New Concept	15	Inverted V shaped anchor
West Marine	Performance 12	14	Similar to Danforth 12-H
FOB	FOB Light	14	Aluminum pivoting fluke anchor
Hans-C	Hans-C 15	15	Pivoting diamond fluke anchor

On May 20, we once again tested using similar methods, although the winds were light compared to 4/22, and we only tested at Site B and C. Included in the test were the following anchors:

Manufacturer	Model	Weight (lbs.)	Comments
West Marine	TRAD 8	8	Similar to Danforth 8-S
Hooker	Economy 13	13	Slip ring shank
Danforth	H-960	12	Formerly called the 12-H
Danforth	S-920	13	Formerly called the 13-S
Creative Marine	Max 15	15	Like a Delta shank on a Bruce fluke
Danforth	DeepSet D-1150	10	Thin shank Danforth anchor
Bruce	5 kg.	11	One piece cast steel anchor
Tie-Down Eng.	Super Hooker M-740	13	Similar to Danforth 13-S
Paul Luke	3 Piece Storm	40	Fisherman style anchor
Simpson Lawrence	Delta 6	14	New style of plow anchor
Digger Anchor Co.	Digger 15	15	Spring loaded releasable anchor
Rule Ind.	Mushroom	12	Vinyl coated
Rule Ind.	River Anchor	12	Like a mushroom with
Rule Ind.	Navy cast anchor	20	Pivoting fluke cast anchor

Test Methods

The West Marine powerboat, ***Showtime***, was used for pulling the anchors. It is a Fortier 26 with a single Yanmar 170 HP diesel driving a four bladed propeller. Lines were attached to strong points on each side of the cockpit to form a bridle to which we attached a Dillon 2,000 lb. dynamometer. This device has markings every 20 lbs. and can be read 10 lbs. of tension. The anchor rode consisted of 220' of 1/2" New England Ropes Caprolan nylon line spliced to 30' of 1/4" ACCO proof coil chain, and was attached to the dynamometer. For safety considerations, we limited the line tension to 1,000 lbs., which corresponded to 1,500 engine RPM. Our engine RPM versus tension was as follows:

RPM	Tension
700 (idle)	250 lbs.
1000	550 lbs.
1200	700 lbs.
1400	900 lbs.
1500	1000 lbs.

Since each shank was different, we needed to use different attachment devices at the anchor shank. Some, like the PERF 12, used standard 5/16" anchor shackles, while the FOB Light required the use of a large stainless carabiner due to its 1" shank width.

Some anchors were adjustable in fluke angle, and were tested in all configurations, even if the angle was inappropriate for the known bottom conditions.

NOTE: We were able to pull most, but not all, anchors to our predetermined limit of 1,000 lbs. In some cases, we pulled anchors to a lesser tension, but the anchors showed no signs of dragging. It is very difficult to terminate a test at precisely 1,000 lbs. Tensions in excess of 700 lbs. should be interpreted as similar **unless it is specifically noted that the anchor dragged or released**. Put another way, anchors which withstood 1,000 lbs. of tension may have been capable of more tension, just as anchors that withstood 700 lbs. may have been capable of more tension.

Test Location

Site A was east of Santa Cruz Wharf and west of the mouth of the San Lorenzo River. Depths varied from 20 to 24 feet, with a very hard dark gray sand bottom. We generally used 120 feet of anchor line, measured to the water surface.

Site B was west of the wharf in an area known to surfers as Cowell's Beach. Depths varied from 16 to 19 feet, in a dark sand with very fine particulate size. The material appeared to be silt or clay particles.

Site C was inside the Santa Cruz Small Craft Harbor, on a sandbar which forms in the lee of the west jetty. The bottom is white beach sand, and was awash at low tide. This allowed us to observe the anchors under tension, although some of the observations were made with the anchors in unsaturated sand, a condition which is not found in practice.

Summary of Results on 4/24/94

Each anchor was pulled at least two times in each location. If the anchor did not set, we tried anything we could think of (more or less scope, slow or fast pulls, different chain) to get it to set.

FOB Light

The FOB Light anchor weighed approximately 14 lbs. and was constructed out of cast aluminum. It is similar to a Danforth-style anchor, with adjustable fluke angles like the Fortress brand anchors. Its manufacturer's designation was E14.

The FOB worked extremely well in Site A and B in the sand configuration. We were unable to break it free at 5:1 scope in either location at tensions up to 925 lbs. We also veered the angle of pull through approximately 90° after the anchor was firmly set, and were unable to damage the anchor or get it to drag.

When reassembled in the mud orientation, the FOB would not engage in sand.

At site C, the FOB set quickly and plowed a wide trench in the sand. In each case, however, the FOB rotated in the sand until one of the stock tips protruded, whereupon it popped out of the sand and flipped onto its back. It then re-engaged the bottom and dug it. This occurred at 760 lbs. This instability appeared to be due to the short stock length relative to normal Danforth-proportioned anchors.

The FOB would not set in the mud orientation on the beach, but dragged with its crown in the air.

Digger Anchor (4/22/94)

The Digger, a self-releasing 15 lb. anchor, which can be made to release its flukes to a 180° angle if the anchor gets trapped under a snag. It is primarily sold as an inland anchor for pontoon and fishing boats.

The Digger did not set in any location, and attained tensions of no more than 160 lbs. It tripped to its 180° setting on the first pull, which made it difficult to trust since we were never sure if it was in "tripped" mode when we pulled on it.

When tested at site C, the failure mode became obvious. The anchor fluke tips quickly engaged the sand, causing the anchor to rear up with its crown up in the air. The anchor was relatively stable, dragging at about 80 lbs. of tension, on its fluke tips and the end of its shank. Then the anchor fell over and repeated this process. Had the shank been longer, thus forcing the flukes in

at a shallower angle, it is possible that the flukes would have penetrated.

New Concept Anchor

The New Concept anchor, invented by Oakland resident Chuck Ford, has two flukes arranged in an inverted V shape, and a shank made from links of chain. It weighed approximately 15 lbs. This was a modified version of an anchor which we had tested approximately two years ago. It is patented, but has yet to go into production.

The New Concept did not set in any location, either using the chain which was included, or the chain on the test rode. We recorded a maximum of 110 lbs. of tension, due to its skidding on the bottom.

At site C, the New Concept began to engage with its fluke tips, then reared up and fell over. At this point, the anchor was rotated about 135° from its intended orientation and continued to drag on the sand in this orientation. The anchor appeared unstable in sand, although it is possible that it would work in soft mud.

Hans-C Anchor

The Hans-C anchor has two flukes on opposite sides of an adjustable, pivoting shank. It can be set to one of three different fluke angles.

We were not able to develop more than about 350 lbs. of tension on the 15 lb. Hans-C anchor, and this tension was recorded while the boat was making headway of about a knot. The anchor could be felt skipping by placing a hand on the anchor line. When retrieved, the pivot point was jammed with sand, and it was not obvious that the anchor would orient itself "flukes downward" on the bottom. We cleared the sand and tried several times to get the anchor to hold. As with other tests, the scope as approximately 5:1. From the boat, it felt like the central fluke point was scraping a shallow trench in the bottom.

We also tried the anchor at its other fluke angle settings, although the difference between them was hardly noticeable.

At site C, the Hans-C engaged quickly, but did not penetrate more than 3-4 inches below the surface. Sand which was caught in its fluke opening extruded through the rear of the anchor. The anchor was stable, but did not bury deeply enough to produce substantial resistance.

A source of concern was the Hans-C angle adjustment bolt, which could easily be tightened so that the anchor shank hinge was immobilized. When finger tight, it began to squeeze the shank halves together. In general, the hinge of the shank seemed problematic since the tight clearances could cause jamming. We understand that the anchor has been modified since this version was produced, so this problem may have been rectified.

West Marine Performance 12 Anchor

The PERF 12 West Marine Performance anchor was used as a benchmark for the test. It is very similar to the original Danforth 12-H anchor, and has T shaped flukes and a normal 32° fluke angle. Its actual weight is 14 lbs.

We were not able to explain the results of the Performance 12 lb. anchor. At site A and 5:1 scope, the anchor would not register tensions of over 340 lbs. without breaking free. When we increased the scope of 7.5:1, the anchor would not engage. However, when the scope was reduced to 3:1 (70' of line in 22' of water), the anchor dug in and held to 900 lbs. of tension. After it broke free,

it reset and held 500 lbs.

At site B, the Performance anchor held at 4:1 scope to 940 lbs. of tension and did not release. When fully engaged, the boat was maneuvered 90° with a slack anchor line, then load was applied in an attempt to break the anchor free or damage the anchor. It did neither, and recorded a load of 1,020 lbs. in the new direction. The shank appeared unbent by this sideways pull.

At site C, the Performance anchor engaged the sand quickly, and rapidly buried until it was not visible. It was pulled to a tension of 940 lbs. and continued to dig deeper.

We suspect that the dense sand at Site A prevented the anchor from burying, but the softer sand of Sites B and C facilitated burying.

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West Marine Traditional 8

This was the lightest anchor tested in the second round of test. It is similar to the 8-S Danforth Standard anchor.

The Traditional 8 engaged after some dragging, and held to 550 lbs and 1200 RPM. We then pulled it a second time to 760 lbs., and when it was retrieved the shank was bent to the side approximately 30°. We did not veer on the anchor so the damage was not due to our purposely pulling sideways on the shank. The anchor did not drag, however, even with the bend.

We were able to straighten the shank and continue testing at Site C. It dragged across the sand in the typical "tripod" fashion, with one fluke tip, stock tip, and shank touching. When we flipped the anchor over, it set immediately and held to 1080 lbs. When it was dug out of the bottom, it was found to be about 8" under the surface, and had rolled about 30°.

Hooker Economy 13

This is a variation on the Danforth anchor type, using flukes bent in the center for stiffness, and a shank made from rod stock. The hollow shank lets a ring to be used as an attachment point, which allows the anchor to be withdrawn crown first should the anchor become stuck.

In our tests, however, the anchor showed no interest in sticking in anything. At Site B, we were unable to get it to engage the bottom, and registered 60 lbs. of tension as it bounced along the bottom. At Site C, the anchor reared up and scraped along the surface. When the anchor was forced into the sand in a normal digging attitude, it popped out at 95 lbs. of tension.

We could not find any positive attributes of this anchor, other than price.

Rule/Danforth H-960

This is a slightly modified version of the 12-H anchor that Danforth has made for years. This version has had its stock width reduced from the original 21-1/2" to 17-1/2", which the engineers at Rule indicate has no effect on its performance. Like other H series anchors, it has T section flukes, is made from high-tensile steel, and has a forged shank.

At Site B, the anchor engaged immediately and held to 1000 lbs. of tension. We then weighed and re-set the anchor, and it registered 960 lbs. After engagement, we turned the boat 90° to see if we could bend the shank, but the anchor continued to hold and was undamaged.

At Site C, the anchor engaged quickly, and buried until it was 8" under the surface. We pulled it to 920 lbs. and it showed no signs of dragging.

Rule/Danforth S-920

This is a slightly modified version of the original 13-S anchor. It has a shorter stock than the original, and it now uses a plate shank rather than the original forged shank.

At Site B, the S-920 dug in immediately and held to 940 lbs. On the second pull, it held to 880 lbs. where it let go suddenly. The anchor was able to reset, and showed no signs of distortion when retrieved. We did not test the S-920 at Site C.

Creative Marine Max Anchor

The Max appears to be a combination of the curved shank of the Delta so that it is self-launching, combined with a large scoop-shaped fluke like the Bruce. It has a reinforcing rib which runs down the length of the shank, terminating about 4" above the fluke. It appeared to be "light" to the testers, meaning that it has a lot of surface area in the flukes compared to the structural, non-fluke components.

After some dragging, the Max engaged the bottom at Site B and held to 720 lbs. of tension. At this point it released, and we could not get it to set again. When retrieved, the shank was bent about 30° about 2" above the fluke surface. We could not bend the shank back, so the testing at Site C was attempted with the bent shank. This made the anchor unstable so that it would not engage the sand. A new, modified Max was requested from Creative Marine, and will be tested in a future test.

Rule/Danforth D-1150

The Deepset® style of anchor was introduced in the mid-80s as an improvement to the Standard and Hi-Tensile designs. It uses a spring steel shank which is much thinner than the normal steel shanks, and a smaller crown assembly with parallel crown plates. These changes are said to reduce penetration resistance, and allow the anchor to dig deeper and engage higher sheer strength soils. This design philosophy has also been used in the Deepset Hi-Tensile®, Deepset® VSB® mud anchor, Deepset® Plow.

The 10 lb. D-1150 was pulled to 940 lbs. at Site B, where it released suddenly. We suspected that the anchor might have been damaged, and retrieved it, only to find a knot in the chain about 15' from the anchor. It was not obvious whether the knot could have caused the release, so we redeployed the anchor. It held the second time to 980 lbs.

At Site C, the D-1150 was pulled to 840 lbs. and buried 7" under the surface. After retrieval, the anchor was jammed and the flukes would not pivot. We then placed the anchor on the sand with the flukes up, and the anchor showed no signs of digging into the bottom. It seemed that if a boat were to pull hard on the Deepset anchor, then upset the anchor due to tide or wind, the anchor might not ever reset.

Bruce 5 KG, 11 lb. Anchor

This is currently the smallest Bruce anchor that is imported into the U.S. It is a cast one piece anchor, with a three-palmed fluke. Bruce anchors have a reputation of engaging the bottom quickly, staying embedded when veered, and having only moderate holding power.

At Site B, the Bruce engaged immediately, then began to drag at a constant 300-350 lbs. of tension. We lengthened the scope from 5.3:1 to 8.2:1 to see if it would help the anchor, and its holding power increased to 580 lbs., although the anchor continued to drag slowly.

Disappointed by this performance, we tested it again before we left the site. At 5.3:1 scope it held 260-450 lbs., but the anchor was dragging the entire time. It would seem to hold for a moment, then release, then re-engage. While we were able to get a reading of 800 lbs. of tension, the boat was dragging the anchor at substantial speed and could not be said to be anchored.

At Site C, the Bruce plowed a perfectly straight furrow while at a 15° angle of attack to the seabed. We pulled it at tensions from 200-380 lbs., but it would not dig deeper or pop out. Its performance was very consistent and stable.

Super Hooker M-740

This is a very similar anchor to the Rule/Danforth S-920, but marketed by Tie-Down Engineering, who manufacturers the Danforth line of anchors for Rule. It has a very short stock protruding from each fluke, leading us to surmise that it would be rotationally unstable. While we saw evidence that this design rotated more than other similar anchors, it did not disengage due to rotation.

During the two pulls at Site B, the M-740 held 850 and 860 lbs. without dragging. At Site C, it held tensions of up to 1,060 lbs. and was found to have rotated 45° when it was eventually dug up. During the next pull, the anchor popped out of the sand due to having picked up some welding rod between the flukes and shank, which was not interpreted as being the fault of the anchor. It does point out, however, that the Danforth-type of anchor has a tendency to snag on items on the surface or in the seabed, and can be made to disengage when it hits something.

Luke 40 lb. Fisherman Anchor

This was the oldest design, and heaviest anchor, that we tested. At Site B, we were unable to attain a tension greater than 300 lbs. and the anchor seemed stable dragging at between 100 and 200 lbs. Even at idle RPM, our test boat caused the anchor to drag. Additional anchor line did little to increase its holding power.

At Site C the Luke simply plowed ahead slowly with only 200 lbs. of resistance. When we pushed the fluke into the sand with body weight, the tension increased to 390 lbs, only to relax to 200 lbs. again. We were very surprised by the limited penetration in either sand bottom.

The geometry of the anchor held the flukes in a steep angle of attack, and it looked as if they would quickly dig in. However, the small surface area and rounded edges of the flukes did not provide a sharp bite into the bottom.

Delta 6 KG, 14 lb. Anchor

The Delta is a modern version of the plow anchor, with sharper sections and no shank hinge. We tested the second smallest anchor.

It engaged immediately and held up to 1000 lbs. with no apparent movement on the first pull at Site B. On the second pull, it again reached 1000 lbs., but did so while dragging slightly.

At Site C, the Delta quickly righted itself from several different attitudes and dug in. In the unsaturated sand above the tide line, the Delta held about 500 lbs. while slowly creating a furrow in the sand. This tension increased to 790 lbs. as the sand got wetter, but still with some perceptible movement.

It was the opinion of the testing crew that the Delta has the best overall performance of any of the anchors tested on May 20.

Digger 15 Anchor

We tested the Digger for a second time, after careful instructions from the manufacturer to use exactly 5:1 scope and no chain. It did not dig in perceptibly in Site B, and we could only register 30 lbs. of tension.

At Site C, the Digger repeated reared up, fell over, and reared up again. It was completely unstable and did not register any tension. Even when we pushed its flukes into the sand, it popped out and fell over.

Mushroom 12 lb. Anchor

According to the manufacturer, this anchor is "a very popular anchor for the ardent fisherman." We believe that this reputation is based on its unlikely tendency to snag on bottom debris in reservoirs or rivers. It also exhibited no tendency to snag on a sand bottom. It dragged on its side with one edge partially imbedded, and produced no more than 40 lbs. of resistance.

River style 12 lb. Anchor

According to the manufacturer, this anchor is "ideal for fisherman frequenting waterways with sand, weed, gravel, or stone bottoms. Recommended for strong current areas." From our observations, it is appropriate for a paperweight, at most. This anchor behaved similarly to the Mushroom, and developed no more than 40 lbs. of tension.

Navy type 20 lb. Anchor

This anchor looks like a large ship's anchor, with bulky cast flukes and a pivoting shank. It has aluminum paint for protection, which corroded after one use in salt water, even after rinsing. It did not penetrate into sand at all, and produced a momentary tension of 60 lbs.

Conclusions

1. Our test looked at the ability of popular anchor designs to penetrate and hold in a sand bottom. We attempted to measure the tension that an anchor could withstand without perceptible dragging. This is difficult, however, since it is hard to measure the point at which an anchor begins to drag without observing it underwater. It is even difficult when the anchor can be observed, since it is frequently so deep in the seabed as to make observation impossible.

2. It is difficult to surmise the failure mode of an anchor from the surface. Either observation by SCUBA diving or shallow water testing is necessary to determine what happens.

3. Similar bottom conditions may have widely varying results, based on our experience with the Performance anchor. It is difficult to explain why it would not set on one side of the wharf, yet is set easily on the other side, nor is it possible to explain why it set better with reduced scope.

4. Anchors which come highly recommended, even those which are successful in the marketplace, may not perform in the real world. The most confusing results were those of the Hans-C, which seems like it should work, yet never has in our tests. Perhaps we should test a larger version.

5. Anchor stability, once the anchor has engaged, is as important as high tension ratings. The FOB rotated out of the bottom after recording loads over 800 lbs. This might cause a false sense of security when an anchor appeared to be set securely. The Max anchor bent after withstanding 740 lbs. and would not re-set.

6. An anchor needs to meet various criteria to work well for boaters. Most anchors have some strengths and some weaknesses, and an anchor that works well in one application may fail in another. For example, we did not credit anchors for their ability to be retrieved in snag-prone bottoms like reservoirs. Anchors like the Mushroom, River, Economy, and Navy might be better suited to this use than the higher holding power yachtsman's anchors.

7. An anchor should also engage the bottom quickly, every time it is deployed. It should not set on some occasions and not on others. It should also be capable of remaining in the seabed as the vessel veers in the wind and current. And anchors should not be upset by minor debris in the seabed.

8. One area where we need to do more testing is the effect of anchor weight on consistency of performance. Some anchors appeared to skid along the bottom without getting initial penetration, and we suspect that the larger version of each of these anchors might engage much more consistently. In other words, the holding power to weight ratio may not be a smooth relationship, but may have a discontinuity in the curve at a particular weight.

Other anchors, like the Delta, grabbed every time they were used, even though they were small sizes. We suspect that this might be due to the central fluke tip, which can exert high localized pressures on the bottom due to the small surface area.

9. The Danforth-type anchors, as a class, appeared to hold tenaciously and continue digging as load was applied. Several demonstrated roll instability, and appeared that they would have popped out of the bottom had we continued to pull on them with increased tension.