

27.4.1999

JUNK RIG AND ADVANCED CRUISING RIG ASSOCIATION



NEWSLETTER 34

af
Wergelands Venner - forening af pligt i det
stava di der gode lesere og sløst endige

JUNK RIG



AND ADVANCED CRUISING RIG
ASSOCIATION

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Contents - Newsletter 34 - April 1999

3	From the Secretary
4	A.G.M. June 1997
6	Summer Rally
7	Beaulieu Classic Boat Festival
8	East Anglian Rally
9	Falmouth Classic Rally
11	Scottish Rally
12	News and Letters
24	"Nymph"
27	Research and Development Report
51	For Sale

Cover photo: Yacht Duma of Bertrand Devos at the Scottish Rally, Sept. 1998. LOA: 12m, LWL: 10.20m, Beam: 4.20m, Draft: 1.10/2.20m, Displ: 12 ton, Sail area: 802m, Designer: D. La Forestier, La Rochelle.

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From the Secretary

February 1999

As no doubt you will have noticed, it is a long time since you received the last newsletter. This has come about as Gavin Dalglish, who was combining his duties as Chairman with newsletter editor had to let go of the editorship due to his business commitments.

We are very grateful to Gavin for guiding the newsletter into print for 10 years during which the quality of the newsletter has risen enormously and he deserves a rest.

Anyway, it all landed on the Hon. Sec's. desk, who unable to find another volunteer to be editor has had to leave it until now, during the UK's winter yachting hibernation period to progress this newsletter.

I am now delighted to tell you that member Alan Mayne has volunteered to take on the editorship, so hopefully we shall be able to return to our target of two newsletters a year.

Although Ariel, our junk rigged dayboat has up to a point satisfied the demand for a junk rig boat that can be chartered, to enable members to really get to know the rig, it cannot offer overnight accommodation, so has to return to base every day. I have now purchased for myself a Coromandel 21 with hinged mast, Hasler junk rig, 3/4 berths, road trailer and launching trolley. My intention is to offer it for charter to "JRA members only" from the summer rally, June 20th onwards.

If any member is interested in chartering their boat to other members through the JRA please let me know and we can discuss the procedure. One of our members has chartered his 28 junk rigged yacht through a commercial charter company with success in the past.

However it is not my personal intention to make a big business of it and my boat will not be chartered on the terms and to the specification of a commercial charter and consequently the rates will be considerably lower.

The rallies I am organising this year are:-

Summer Rally/AGM	Warsash S.C., The Solent	June 19th/20th
European Rally	Dieppe Y.C., N. Coast of France	July 17th/18th
Scottish Rally	Solway Y.C., Kippford Nr. Dumfries	Aug 28th/29th

We will also be at the Beaulieu Boat Jumble on April 11th, as usual, sharing Geoff Turton's "Tomjo Marine's" stand, with the working model rigs.

JUNK RIG ASSOCIATION

Annual General Meeting

21st June 1997

AGENDA

1. Apologies: Jock McLeod (President), Ken Taylor, Pete Galliène, Brian & Jan Whear, David Tyler.
2. Adoption of Minutes of AGM of June 15th 1996.
3. Hon. Secretary's report of financial statement (see below) and adoption.
4. R & D Secretary's report on his R & D and research at Exeter Uni. by students & Joddy Chapman.
5. Association Boat *Ariel*.
6. Any other business.

1996 Income & Expenditure of the J.R.A.

	Income	(1995)	Expenditure	(1995)
Rallies	£1,125.90	(862.00)	£1,198.47	(853.40)
Subscriptions	£4,753.62	(3630.23)	£	
Shop	£2,724.45	(2668.11)	£1,310.44	(1996.50)
Newsletters & Members List Costs	£		£1,351.50	(2626.14)
Stamps, Stationery & Copying	£		£1,196.81	(974.12)
Research & Development	£ 194.00		£1,052.00	(1010.00)
Publicity of Association	£		£ 125.00	(235.54)
Association Boat <i>Ariel</i>	£		£3,604.14	()
Banking - Interest/Charges	£ 184.71	(200.18)	£	(14.39)
Petty Cash in Hand @ 31.12.96			£ 106.78	
	£8,982.68	(7360.52)	£9,945.14	(7710.09)

(1995)

Opening Balance at 1.1.1996	£5,603.75	£5,953.32
Net Loss for 1996	£ 962.46	£ 349.57

Balance in Banks at 31.12.1996	£4,641.29	£5,603.73
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Value of Junk Shop Stock (at cost) at 31.12.96	£1,245.00	£1,505.70
Foreign currency in hand at 31.12.96	\$ 100.00	\$ 128.00

Minutes of the AGM held on June 21st 1997 at the Warsash S. C.

1. Chaired by Gavin Dalglish
Supported by Robin Blain, Maurice Donovan, Geoff Turton.
Present 42 Members
Apologies Jock McLeod, Ken Taylor, Pete Galliène, Brian & Jan Wear, David Tyler.
2. Minutes of the AGM of June 15th 1996 were taken as read and adopted.
3. Secretary's report.
Following last years successful rally at Plymouth in which a record 100 members took part, and rallies at Falmouth with special guests Pete & Annie Hill and at the Solway Y.C., we were inspired to organise 4 rallies this year and include one in East Anglia for which we are hoping for better weather than today.
a) Subscriptions: We can maintain our present rates for another year against slowly rising postage and printing costs.
b) Publicity: After attending several Classic festivals and local boat shows, we have decided that attendance at the Beaulieu Classic Festival and Jumble are sufficient for our publicity and can be coped with successfully with our resources. Following a talk to the Amateur Yacht Research Society given by Robin Blain & Gavin Dalglish, they offered to give us publicity and hand out our information and membership application forms at their London Boat Show stand this year and in future. Gavin produced a very professional poster for the J.R.A. free of charge by his Company for display at the AYRS show stand.
c) Junk Shop: The Junk Shop had a reduced turnover last year, but the Loan Library is still well used and new books are being added as they become available, as can be seen in Fact Sheet 4.
d) The R & D Fund: This stands at £194= and is banked in our Lloyds Bank Instant Savings Account which benefits from a monthly interest credit.
4. Research & Development by Maurice Donovan, R & D Secretary.
Joddy Chapman is continuing his good work at Exeter University this year without having the handicap of organising the students researches at the same time, and general reports will appear in the newsletter with detailed reports available from the Hon. Sec. Dr. Francis Chiu the director of the Engineering Department, is sadly leaving to take a post in Industry but Joddy is confident that his researches will continue to make good progress.
5. Association Boat *Ariel*
The Hon. Sec. went through his report as submitted in the Newsletter 33 and members at the rally were able to see *Ariel* themselves during the rally and read the report on a display board.
6. No other business was discussed.

Summer Rally - June 1997

The day dawned with bright sunshine but strong SW winds which resulted in only two members sailing to Warsash.

Keith Topley having come from Cowes found that his 30' yacht was getting such a pounding on the SW facing club jetty that he returned home before damage was done. Matthew Barnes came from Southampton in his deep keeled Warsash O.D. and bravely took several members for sailing only to be admonished by the harbour master for being fool hardy - such is the misunderstanding of the ease of handling the junk rig.

Meanwhile other members amused themselves with the three Sunbird working model rigs, and rigging Ariel our new 18' dayboat which the weather prevented us launching.

The evening was enlivened by Rex Warner giving us an excellent talk and film of Tim Severins "China Voyage" in which Rex was a crew member. The JRA has the book in the library and for sale.

On the Sunday the rough weather persisted and threw in some thunderstorms, so we took ourselves to the Royal Southampton Y.C. on the Beaulieu river for a barbecue lunch by road and later in the day said our goodbyes from this very hospitable club.



Matthew Barnes and members about to board his Warsash OD 27, which carried his land transport on the pushpit rail!

Beaulieu Classic Boat Festival - June 1997

The Hon. Sec. and his wife represented the J.R.A. at this two day festival for the second year, in the lovely surroundings of Bucklers Hard on the Beaulieu River, which was a busy warship yard in 1780, as the picture below depicts.

The weather was perfect and this popular festival was well attended by many classic boats of all sizes from Welsh coracles to old trading schooners.

A mock battle was re-enacted between French and English warships in the days of sail with much firing of canons and clouds of smoke sent the local wild life scattering for cover.

As you can see in the photo of our stand, we displayed poster photos of junk rigged boats, books and the 3 working model rigs that were borrowed from Sunbird Marine, all created plenty of interest and the kids love operating the model rigs and



The JRA display at the Festival of Sail



A model showing the frigates "Swiftsure" (foreground) and "Euryalus" being built at Buckler's Hard

consequently get their elders involved.

(Sunbirds have built and supplied a model junk rig for Bruce Roberts in the U.S.A. so members going to boat shows in the States should see it on display)

East Anglian Rally - July 1997

We were most grateful for the local knowledge supplied by Digby Hall and Ken Taylor, and most of all for the Bradwell Quay Yacht Club for hosting our rally. We virtually took over their clubhouse for the weekend and they catered for us magnificently.

The weather was kind to us and the sun shone throughout, although we could have done with a little more wind, but on



"Ariel" doing her duty as a water taxi.



Kris Catteceur's Trident 24 "Blue Moon"

Saturday we were able to give everyone a sail from the Bradwell Marina.

In the evening we retired to the Yacht Club for an excellent meal and video of Tim Serverins 'China Voyage' presented by Gavin Dalglish.

On the Sunday due to the lack of wind we abandoned sailing to Maldon and went to West Mersea where the Y.C. served us a sumptuous lunch and *Ariel* did great service as a water taxi, after which we cruised gently back to Bradwell, in Tom Wallace's Virgo Voyager, Don Howard's Trident 24, Roy Riley's Coromandel, Jill Godfrey's Navigator, *Ariel* and Kris Catteceur's Trident 24 who had come over from Ostende, a noble effort.

Falmouth Classic Rally - August 1997

This rally was organised to coincide with the annual event of the Falmouth Classic weekend, which this year included the visit of the replica of the *Endeavour* Captain Cooks ship in which he discovered Australia.



"Water Bear" beating accross Carrick Roads

We were also joined by Jim Melcher in his unique Bolger 40 barge yacht that had crossed from N. America. The rest of our fleet was made up of Gary Griffin in his Chance 37, Martyn & Margaret Aldis in their Sunbird 32, Brian & Jan Dye in their Hermes 26, Scot and Robin Gilchrist in *Water Bear* and our own *Ariel*.

Saturday gave us sailing in light winds and clear skys before joining in with the evenings local festivities and Pasty dance that ended with a tremendous fireworks display.



Jim Melcher under full sail in his Bolger 40



The Bolger 40 at anchor in St. Mawes

On Sunday we all sailed in company to St. Mawes where *Ariel* ferried us ashore for a first class pub lunch that lasted so long that *Ariel* was high and dry on our return, so we released the water ballast and carried her down the shore, so that she could display her versatility again as a water taxi.



"Ariel" and the Chairman awaiting the launching party's return from the Pub

Scottish Rally - September 1997

The Kippford Estuary greeted us with plenty of wind, and the rain kept away, so sailing was boisterous and enjoyable. Members were taken aboard by Alastair Maxwell in his Colvic 29, Alan & Gloria Parsons in their Eventide 28, David Tyler in his Lone Gull 28, Ralph Yates in his Coribee and Ariel that Gavin Dalglish trailed up from Southampton.

Gavin again presented the story of the China Voyage with a video report of the expedition.

30 members came from far and wide and had a hearty weekend with plenty of Scottish fresh air and good food from the local hostelrys.

Mark Thompson later wrote the following in a letter to the Hon. Sec.

'I was very much stimulated by my first JRA meet in Kippford, such a relaxed bunch of people, all seemed intent on avoiding the rat race and enjoying the simple pleasures of life.

I was impressed by the hardware as well - such ease of control. As a keen windsurfer I was surprised to note how similar the current bendy batten rig is to a windsurfer sail. The producing and controlling of shape appear to be the current areas of development. I did note that looking along the sail, as the wind increased the centre of bend (pressure) had moved well aft. This was quite a problem in early windsurfer sails - normally leading to spectacular wipe-outs! Current sails with full tapered battens and stiff sail cloth, lock in the shape and are vast improvement. Perhaps there are some lessons to be learned



David Tyler's "Ivory Gull" joined us while en passage from the Western Isles of Scotland. She is now for sale as an ideal cruising home for two and guests.

News and letters from around the World

... from

Bo Starborg

December 1996

Hello!

I'm a Swedish Junkie, and I have a warning to all of you who are thinking about changing to a junk rig. Don't you get Hooked and when your sailing friends are going to the expensive part of the chandlery talking about rigging screws, two speed winches, high tec. ropes, rigging tension and furling headsails and mainsails and so on, you are left all alone down at the bargain counter buying marine lines for your junk rig. And at sea your job is to keep the crew busy when the boat more or less is sailing herself.

I found a Vega 27 hull and built the rest myself and fitted a second hand Hasler/McLeod rig. The sail was too small for light winds and the battens too long, so I had a lot of weather helm. I moved the rudder aft and added two panels at the bottom of the sail, but I still had a excessive weather helm, at this point I found out that the biggest problem

with a junk rig is that there is nobody around to ask, but what the hell it's my boat I'll do what I want with it, so I took the sail down and cut off 35cm of the leech with a pair of household scissors right there on the jetty. I could see the other boat owners move further and further away. I taped the edge and took the sail home and sewed it on my old pedal powered Singer sewing machine.

The next weekend I had a boat that had perfect balance and is a dream to sail.

Next season I will have a batten parrel on the boom and a mast lift that goes from the top of the mast under the boom and back to the top of the mast.

Then I will have a tiller for sale!



... from

Stu Stebbings

October 1997

(Owner/operator of Island Junkets)

This was my second season in our 46' junk rigged ferro-cement ketch "Pralines & Cream" (our favorite family ice cream flavor).

As you can see from the enclosed photo it doesn't take much wind to stir up some foam. A true single-hander, I can be telling my passengers sea stories while "Pralines & Cream" finds her own way through our San Juan Islands in Washington State. Our jib does detract but tacking through the wind becomes a breeze.

See you on the water.



*"Pralines & Cream" showing her stuff
on Bellingham Bay, Summer 1997
- & the crows nest works!*



... from

Henry Piggot

October 1997

"Glory" now rests well on her trailer in my hay barn. After twelve hundred mile voyage around Britain, last summer, including a month exploring the Shetland Islands. My four anchors came in useful!! The diesel heater paid for itself!!

I did enjoy the islands, lots of open spaces, and anchorage's all to oneself.



"Golden Wind No. 2" with the
Kykladic Pan sail

water mirror) as a reminder of our voyages. This is very nice to look at, when sailing and remembering the circumstances connected with the pictures but also it works as wind-scale. We call the wind strength according to the last visible panel picture. Much fun!

When we had finished the 2½ month trip with *Golden Wind*, we left her at home and took *Fukes Sarg* behind the car and drove to Brest and Douarnenez. What a wonderful meeting! We were very pleased to meet *Badger* and *Water Bear* and others, 8 J.R. boats in all. But to live in tiny *Fuke* was some challenge! We are too old now. Next time - if we are able to go there again in 4 years we will certainly be in *Golden Wind*.

We finished our long inshore trip on *Golden Wind*, some 2500 km and 80 locks, and some nautical miles also on the Baltic Sea, where we met the old "Golden Wind", with the colourful (Buddhist) sails. I was pleased that the new rig could well get along with the old despite one third less of sail area!

To lengthen the mast I have been considering moving the pivot-point higher, to form a tabernacle and so gain some additional panel space and a better mechanism for mast lowering. As you can imagine on our trip we had to lower and set the mast frequently and in the end this was done in minutes (with sails on).

Golden Wind is now much more perfect. And more beautiful, since I painted the sails. On each panel I drew a certain symbol or figure, i.e. a so called Kykladic pan (old



"Golden Wind No. 1" with the sails in the Buddhist colours

July 1997

I enclose you a little map of our trip this year.



We liked it much more than the one last year, which also started from Breisach but went North and was all cold and rain. We just love the South. Never the less we had also some ice over the boat at the beginning and used the pansy charcoal stove for several weeks. But for some reason the French canals are much more fun than the German ones. The villages are so nice, people friendly.

We met 2 big wooden junks and the owners, who had built them themselves were very pleased to see us. They were of that Dimitri Forrestier, who is only known in France. His designs are rather aesthetic, probably not so good sailing. But I do not know for certain, as although I have met 6 of these yachts so far, I have never seen one sailing. Somehow the J.R.A. should try to contact Forrestier and have a look to that strange tradition in France.

In Avignon we met several English boats who on their way south had been stuck there. The place is so nice near the famous bridge, I can well understand that one stays there for years.

We went on and reached Port Saint Louis at the Med. in 2 weeks, after 130 locks and 2 tunnels and a river bridge.

In Port Grimaud we met another Junk, this a China built one. But in a state of destruction, no one to ask, and left alone.

Around Italy we sailed long stretches, twice 8 days and nights with a storm in the Tyrrhanian sea, which we managed well hoving to for 6 hours.

The little island of Strophades 50 n.m. west of Greece was a big experience, 2 men live on it in the huge old monastery.

In the Aegean we visited only 3 places, where we have good friends as we visited there many times over 13 years. It was our 10th visit there and the first one coming all the way by boat. All the other visits we had towed the boat there by car.

The highlight were the dolphins. Only around Greece you find them. First time I was able to touch several on the back from the bow. I just held my hand in the water and they deliberately came very close (while the boat was doing about 5 knots) until I could touch and hold the back fin!

We also saw many turtles and many birds came to the boat, sitting on my hand, coming into the cabin, searching some food in the galley. Swallows, dove and very small ones. One dove stayed with us for 2 days and nights. The others usually for a night.

The Korinth Canal was not as expensive as we expected, about £25 sterling. This is the first time we have visited the Ionian Islands. They were very crowded and windless, like the Adriatic except for one day, when we sailed 100 n.m. in 24 hours.

Venice was another highlight. We moored in the little harbour at St. Georgio just opposite St. Marks square. But when in pouring rain I met 2 Englishmen at the railway station packing their folding kayak who had just completed a self-made tour of Venice in their own boat, I wanted to do the same. Impossible to find out if permitted or not. So we lowered our mast and just went through all Venice despite the incredible heavy boat traffic there. Several boats of Carabinieri (police) met us but they just smiled. It was a big experience!

Another highlight of Venice: The huge collection of junks of all kinds (donated by a Frenchman) in the Maritime Museum.

Then we went home by train, got the trailer and brought the boat safely home after 2400 nautical miles, 870 river kilometres, 130 locks, some railway and street k.m. and several k.m. on our bicycles (Cromptons).

Again we found it so practical in having a small boat with shallow draught! From a bigger boat you can not reach down to the dolphins, you can not travel the canals of Venice, the Korinth canal is much more expensive and so on.

Only these huge Forrestier junks do have less draught. Incredible 35 cm (14") centreplate up!! But beautiful as they are (with their sliding windows, shearline and long overhangs bow and stem), we prefer our little boat which is so much easier to handle and maintain.

Dear Robin

Many thanks for your kind letter and package. For many years I have suggested to other people that they join your organisation but, for some reason or other, I guess I never have. As you know, for 17 years we were at sea sailing a junk, and receiving mail was one of our major problems.

To bring you up to date, Seven Seas Press died years ago. Last year, I republished *CRUISING WRINKLES* and updated the text in italics without changing any of the original wording. It is so easy

for someone to say something twenty years ago and then republish a completely revised edition which refutes about half of what was originally said. Anyway, I added more chapters to the book, part of them from *CRUISING AS A WAY OF LIFE*, and added many photos. This book is available from me for \$30 which includes postage in the U.S. plus \$5 more to send it priority airmail overseas. (also in the J.R.A. Library)

Prior to that, I wrote a book, *SAILMAKING; Making Chinese and Other Sails; Sailing Chinese Junks and Junk-Rigged Vessels*, which has been well-received. In the second printing, I added more particulars for making Western sails. This is also available from me for £28 plus \$5 for overseas. I am enclosing my "blurb" on my newest books. (Also in the J.R.A. Library)

I realise that since Newsletter 30 came out, probably much added knowledge has been acquired concerning the junk rig. I personally have little interest in why it works. I am more concerned in making it work better. Briefly, after about 35 years of designing, building, owning, sailing, and making sails for junks, I do have some general observations I would like to pass on.

1. The shape of the sail must vary according to the type of hull to which it is attached. For heavy displacement hulls, in order to get sail area with reasonable mast heights, the sails must be broader than ones used on light displacement hulls.
2. Except in the very smallest of hulls, the Chinese lug rig masts should be stayed. When I was in China (prior to WWII), I did not see any ocean-going cargo junks that did not have stayed masts. The one on which I sailed had stayed masts. I have had occasion



Tom Colvin

to rerig several European junk-rigged hulls where they had frequent mast breakage and, on a couple of occasions, hull damage caused by the mast whipping because it was unstayed. Once they were stayed, the problem ceased to exist. The stays should be set up as a restraint rather than on Western hulls where you can play "The Flight of the Bumblebee" on the taut rig.

3. In making sketches while in China, I made the mistake of using the draftsman's convention of drawing parallel battens because my sketch was not so much to indicate the shape of the sail as to indicate the reeving of the sheetlets. I was informed by the holding up of a hand the way battens should go. If the thumb is parallel to the horizon and the fingers spread apart, this is the shape of the battens and their convergence at the luff. I have tried the parallel battens, i.e., JESTER, and found the sail shape to be wanting.

4. On the junk on which I sailed, the mainsail was mat and the fore and mizzen were canvas. In tacking, the fore and the main have a sailor who tossed the lines around the leech and rehooked the sheet to the weather rail. The hook was S-shaped about 2' in length of 1" diameter iron. The sheet and sheetlets all led to the weather rail and forward of the aftermost part of the leech. The mizzen was double sheeted.

5. I find that the better sail is of heavier material. On the Gazelle 42' type of hull, we used 10oz. cloth, and on K'UNG FU-TSE 48' and others of her type, we used 13oz. cloth. I do not use Dacron but have used it.

6. Re Battens: At one time I had thought I could improve the Chinese rig by using batten pockets. It was one of the worst mistakes I ever made. The breaking of a batten requires a replacement of identical size; whereas, in the real world of cruising, this is not always an option. The absolutely best batten was of bamboo. But there are only a few types of bamboo that are suitable for battens. I have tried wood, aluminium, PVC which is an absolute failure, and pole vaulting poles which I consider second to bamboo. We bought the rejects which were quite reasonable in price; however, we have used up the entire North American supply and the cost of the good ones is out of this world. I am now using spun epoxy fiberglass pipe which, though slightly heavier than pole vaulting poles, seems to be holding up.



Jean Colvin

7. The idea that the lowermost batten (boom) needs to be any different from the other battens is erroneous.

8. As to the effects of the sail being on one side of the mast or the other, MIGRANT had sails that were made in Hong Kong and were on the port side of the masts; I made the sails for GAZELLE, and they were on the starboard side of the mast. We sailed in company and could not discern any difference whatsoever in the ability to sail to windward, regardless of which side of the mast the sails were on. In recent years, I hang the foresail on one side and the main on the opposite side of the masts. This requires one to make a left-handed sail when sewing on the rope. If I have a mizzen, it is located on the same side as the foresail. In China and even here, the advantage of doing this is that there is more clearance between the sails when tacking, and they certainly don't interfere with each other when down as far as passage between the fore and the main is concerned.

9. Most the of the Western junk-rigged vessels do not sail really well to windward because the sails are sheeted in too tight and there is too much downward pull on the leech. My children, when asked by a junk owner how they determined the proper sheeting on a sail, said: "When in doubt, let it out". As a matter of interest, my youngest son, Kenn, has his own Gazelle lug-rigged steel hull named SILHOUETTE which he occasionally sails single-handed without any problems.

10. Again, on the shape of sails, it is imperative that the centers of effort of each panel be determined and should present a smooth S-shaped curve, the upper one being the most forward but also forward of the total center of effort of the whole sail. In too many of the rigs designed, the center of effort of the upper panels move aft and the sails sag badly - worse than on a gaff rig.

11. Regarding area, unfortunately, most of the junk rigs today are put on yacht hull forms and also, unfortunately, very few of the yachtsmen have any experience in commercial ocean voyaging. Therefore, it is prudent to restrict the sail area to about +10% of what it would have been with a regular Western rig. For the few who have had professional sailing experience in commercial vessels, I normally make the sail area 35% more than the Western rig. We had a recent comment from an owner of one of my junk-rigged schooners that another of the same design seemed to have a greater amount of sail area and was much faster. I pointed out that the owner had about 50 years of sailing experience, part of it in commercial sail, and that his vessel had no engine. Today we see more powering than we do sailing with very nice looking sail covers over the sails. My own steel schooner, ANTELOPE, which has a 5-ton cargo hold, is 36' on deck, 29'3" on the water, carries 854 sq.ft. of sail with a lug rig on a six tone displacement in ballast. She, of course, has no engine or other auxiliary power.

12. In case you have not heard, Peter Ludwig and ANDREW DORIA have been posted missing. We were informed by the family that he is presumed lost on a voyage from

Bermuda to the U.S. ANDREW DORIA was designed with a 13.3 ton displacement. I think Peter was optimistic in stating that he was sailing at 22 tons. He was closer to 25 tons when I sailed aboard her a few years ago. He was still adding weight. He was a very fine gentleman, but he was wont to make continual changes, usually five or six at a time, so he was never sure whether any one or all of them helped or hindered.

13. On the making of sails, I have found that the flatter the sail is, the better the vessel sails. One of the biggest problems is in obtaining battens that are sufficiently stiff. Any curvature in a Chinese sail seems to slow it down.

14. After all these years - over 35 - about the only improvement I have made or think I have made is the use of electrical ties to secure the batten and backing strip to the sail. It is sure easier than shoving baling wire through the sail and much easier on the hands than passing five turns of marline around each batten and certainly superior to using bolts.

15. Having sailed Chinese junks in China at the same time I was sailing professionally on a sailing cargo schooner, at that time I did not notice nor can I recollect any peculiarities in wind conditions that make one favor one rig over the other. The Chinese rig was certainly less expensive to make and replace than one for a three-masted schooner of the same size. The Chinese rig was labor intensive to set. Where 10 of us could get the schooner under way, it took about 20 to get the junk under way.

16. The ability to reef quickly and simply, whether it be up or down, certainly favors the Chinese rig. For commercial purposes, there is a disadvantage to the rig in that you have no way, without carrying extra spars, to load and unload cargo. On a regular schooner, we can use both the gaff and the boom for lifting and transferring cargo from the hold to the dock. This is especially true today where much of the cargo coming aboard is on pallets.

17. Re model sails and model hulls and model testing, I have done this and the results are very unsatisfactory and open to many fudge factors. In towing tests of sailing hulls, it is not unusual for the test to indicate that one hull is superior to the other when, in actual sailing of the full-size hulls, what appeared to be inferior was actually the better sailer of the two. Scale effects are always an iffy proposition and the results are always trying to prove a fad. For example, the latest one is reinventing the large mainsail and small headsail as being more efficient than vice-versa, proving what all of us knew back in the 30's. Nobody ever asked how come a catboat could sail without a jib.

18. Lastly, I am not wedded to any one particular sail shape. I keep toying with different shapes. Unfortunately, I do not have those many thousands of £s at my disposal to play harder! If the Chinese ever did scientific research on their sails and rigs, I have never heard it mentioned.

With kindest regards, I am

Sincerely

Thomas E Colvin

... from

Thomas E Colvin, N.A.

December 1997

Dear Robin

Many thanks for your letter and all the goodies you enclosed.

One of the problems that you may want to investigate concerning the junk rig is the air flow across the sail when the hull is pitching and yawing. Years ago, I did such a test with rather crude facilities and was able to induce both yaw and pitch or heave and discovered that, in parallel battens, there was a tremendous amount of turbulence, and in the ones that were splayed, there was less turbulence. The method that I used was smoke and I had no means of doing any further testing. At one time when I was with one of the larger shipyards, I did have access to their towing tank and was able to do testing of different hull forms approximating normal leeway in a sea. It was quite enlightening.

On K'UNG FU-TSE I was able to try out camber between battens. this was done with a very simple rig with a halyard to the yard and a lizzard on each batten. Everything was knotted to give a predetermined camber. There was a halyard at each end of the yard, thus a controlled amount of camber was possible. I found that when camber was induced it destroyed the windward capabilities. If close winded ability was essential, I used a downhaul on the lowermost batten to keep the sail as taut as possible. This was a significant benefit as the vessel pointed about 5° closer to the wind versus not using the downhaul. However, the downhaul should never be used except when this type of performance is necessary because in heavy wind in a gybe we have had the lower battens climb up the mast as much as 7' or 8' and, of course with impunity.

My latest rigs up to 15m on deck have been using the tube of 51mm on all except the main on the larger hulls where it is 82mm battens. My battens, being external to the sail, leave a good space between them and the spar.

Enclosed are three photos - one of myself sitting at the wheel, one of Jean steering, and one of ANTELOPE



"Antelope" 37' Junk Schooner designed and built by Tom Colvin

departing in ballast for the Bahamas. There was not much wind. ANTELOPE is a cargo carrying commercial schooner. She carries approximately 5 tons of package freight in the hold and can carry another 5 tons on deck. Because of our laws, she is not allowed an engine of any sort if she carries third party freight foreign or coastwise, except she could have a engine to carry freight only to contiguous states. The netting all around is to keep our dog, a Schipperke named Dory, from jumping overboard when she sees some dolphins. She loves the water.

Also enclosed is a sample of a materiel we are using for our junk rigs sails and for others up to around 20m. It is called Top Gun. It is quite inexpensive and does not require covers except for prolonged stays in port.

On a couple of junk-rigged hulls, the owners tried straight PVC pipe that is used here in water pipes in houses. I think ours is probably softer than yours because they would take a terrible bend and, if we got them large enough to reduce the bending, the sails became too heavy for most of the owners to set without the use of a winch. The best battens I have ever used are still bamboo.

After I get a chance to carefully read all the newsletters you sent, maybe I will see something that I have experimented on also that is either in agreement or disagreement. In all the years I have been sailing junks, every time I go out I still learn something new.

News of Pete & Annie Hill

For those that have been reading Annie Hill's 'Blue Water Letter' in Yachting Monthly, you will be up to date with their travels in *Badger*. But since we last heard from then in Newsletter 31 in 1996, they left South Africa and headed for the Caribbean, to find it was not changing for the better and then on to Newfoundland. Here the remote beauty of the coastline was understandably appealing, especially when they found water shallow enough for anchoring, usually near the mouth of a river, and enough wind to give them sufficient peaceful progress without the iron horse.

The polar bears by all accounts also found *Badger* and crew appealing and worth close inspection, as you will appreciate from this photo to which Annie added "He seemed more like a big, gentle dog than one of the most feared and unpredictable animals of the world" Newfoundland is as far south as polar bears venture I believe and are known to swim 100 miles at a stretch, so they were indeed honoured by this visit.



Hon Sec.

... from

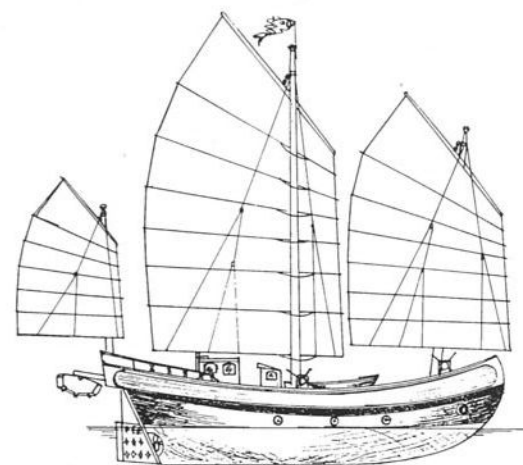
Capt. Mike & Paddy Briant on Junk *Chi Lin* October 1997

I have been involved with junks since I first arrived in Hong Kong in 1955, I am a student of Junks. My first junk '*Ying Hong*' was built on the island of Aplichau in Aberdeen, H.K., in 1961 and was my cruising home for six years. She was a Horgaujai (round-sterned shrimp trawler) 42' L.O.A. of teak on yacal, built in the traditional manner. She had an aversion to going to windward but otherwise served us well. On that boat I survived a typhoon in the China Sea, marriage in South Africa and the acquisition of two sons in the Caribbean. There were many other less harrowing adventures, we finally sold '*Ying Hong*' in N. Carolina, USA and have recently tried to track her down without success.

Our present junk '*Chi Lin*' we built ourselves in South Africa. she is 50' L.O.A. 15' beam, 5'6" draft. The hull is ferro-cement and I have only myself to blame for her design faults. She is based loosely on the Foochow Stock Junk, see drawing. Like '*Ying Hong*' she is a floating home, very heavy, very roomy but friendly. Launched in 1982 she was used only for day sailing until we departed Cape Town in 1995. Since then we have been bumbling around the South Atlantic, Caribbean, Venezuela and the East Coast of North America and encountering more than our fair share of hurricanes.

We plan to spend the winter here in Halifax and with some trepidation are busy preparing the boat for the experience.

Now I would like to refer to an enquiry from Pete and Annie Hill in Newsletter 33. The boat in the picture is '*Ahoy*'. She is, or was, owned and built by Ray Cruickshanks, shipwright and boatbuilder extraordinary. I long ago lost count of the number of boats Ray has built or rebuilt. In '*Ahoy*' he has taken a standard G.R.P. dinghy shell produced for the local (Cape Town) fishing industry, raised the freeboard and done many innovative



things to create a little, self-sufficient cruising ship with all mod. cons. Information from here on may be faulty for although I have known Ray since Pontius was a pilot we have now lost touch. '*Ahoy*'s' finished L.O.A. is, I think, 18' and she sets a single Chinese, fully-battened lugsail. Ray shipped her to Australia and sailed her back to S. Africa, Ray's skill as a boatbuilder is only surpassed by his unconventional and intuitive ability to get things right.

'Chilin'

"Nymph"

by *Bunny Smith*

In the 2½ season's sailing with "Nymph" I have established several quite important handling features and some which should influence future designs. These are:-

- (a) Sheeting systems
- (b) Batten and yard loading
- (c) Mast and yard stiffness
- (d) Need for batten hinges

Sheeting

Initially a double sheeting system was installed. I did this solely because I could see no advantage in such a system on a single sailed rig but as I had never tried it I was against condemning it without a trial: An expensive trial at that because it is a hopelessly clumsy system to operate and particularly so for a boat which needs to short tack as I do when coastal cruising. Double sheets may have a place on a true ocean cruising yacht which tacks but rarely and then at leisure. Therefore, my advice is not to touch it unless you are going ocean cruising.

A sheeting horse was designed and installed on Nymphs' duck tail and the sheets led to a rail around the aft end of the cockpit. The Fenix main sheet system was fitted to suit a new sail which was also needed. These changes were beneficial and so much so that I was able to get down to trying to establish optimum sail sheeting angles and twist control. Please refer to George Chapmans' article titled "Wind Shears and their effect on sails" JRA Newsletter 32.

The Fenix sheeting system allows a small degree of control of twist but it is not precise and relies on friction to keep the sail shape required. The friction slowly bleeds off and the sail should be continuously retrimmed. Four or five years ago I decided to reverse the course of the mainsheet through the sheet span blocks giving a closed loop in the cockpit. The two ends being knotted to becketts on the appropriate block on the mainsheet horse. This to allow separate control of the two halves of the sail and so control twist. Other affairs prevented this being tried on Fenix. It is now on "Nymph" and is a great success. I have replaced the single rope and I now have two separate sheets one for each half of the sail. (see sketch)

When Christopher Scanes first tried it he cried "I love it, for the first time in my life I can see what I am doing and I can control the twist". This from a professional sail trimmer of vast experience. I too have grown to love it and I recommend it to all who can profit from it. Out of all this drops the following figures:-

- (a) Sheeting Angle (Applicable to all JR) The bottom of the sail should be sheeted at approx. 20° to the fore and aft line of the sail for best results when sailing to windward.

- (b) Apparent Wind Angle Nymph now sails to windward to best advantage at between 32° & 34° to the apparent wind.

The above figures are those extracted by Joddy Chapman from his recordings of the Nymphs performance. The boat was helmed exclusively by George and Joddy and all recordings made on their instruments in a steady light wind and on a smooth sea. He wrote "I am sure it will do better with more experience and a better shaped sail..." I agree.

Yard & Batten Loading

Nymph's yard and mast are carbon fibre painted white with the hardest paint existing to prevent the resin from heat absorption and U/V light degradation. The Yard and all battens had cork glued on half circumference to act as fendering between these spars and the mast. A system tested and used without fault for 6 - 7 years on Fenix. No faults were initially noted until mid 1996 when abrasion of the paint finish on the mast was evident in the way of all the seven battens except for No. 1 and the yard. The abrasion increased in severity descending down the mast and reached its peak at No. 4 batten and then diminished but was still discernible at No. 7 (boom).

A silage sheet joining tape, the toughest and best tape I have ever found and used for years without failure, was applied over all the cork fendering to offer a smoother surface to the mast paint finish. Except for the yard this taped solution failed in two hours sailing starting at No. 4 and spreading in degree up and down the sail. The yard tape still has not failed at the end of 1997.

All the cork was removed from the seven battens and replaced with plastic tube for 1997 except for No. 7 batten where shrink wrap was applied as a trial. It too failed after 2 hours sailing and so this material was also replaced by plastic tube. No further damage to the mast finish has occurred.

I give all this tedious detail so that my conclusions may make sense to the reader. These are:-

- (a) The pressure and therefore load of the yard and battens on the mast is least at the top of the sail and steadily increases down the sail and reaches a peak at the middle approx. when it is severe. The loading then starts to diminish but not by very much.
- (b) The loading of the yard on the mast is astonishingly light.

Added support for the above conclusions is lodged in the fact that all batten and hinge failures in 1996 occurred initially in Nos. 4 & 5 battens. Those above and below showed the first signs of eventual failure or overloading in diminishing degrees except for No. 1 batten which survived undamaged.

Mast & Yard Stiffness

Nymph's mast is the same length as Fenix's but is ½" greater diameter for the bottom two thirds and the top third is tapered to a much lesser degree. The mast is 80% stiffer than Fenix's and 60% lighter than the aluminium one. The C. of G of the Carbon mast is

10'6" above deck and this mast confers an increase in hull stability of between 30 & 33%.

The yard is also carbon fibre & it is Carbospars standard "Boss" dinghy mast lopped at each end. It is installed upside down with the foot at the peak and the head at the throat. It is only a fraction lighter than Fenix's aluminium yard but it is so wonderfully stiff that no sign of flexibility or bending has been observed, and therefore no slackening of the leech.

Together, the stiffness of these two spars have shown their value in the integrity of the sail shape and so far I have not found it necessary to fit leech or luff lines because the sail does not start to go out of shape and distort until the battens are overloaded and the sail cloth starts to take the sheeting loads. I will fit these additional lines next year to see if I can increase still further the apparent wind speeds when full sail can be used with advantage to performance.

These two rather expensive spars support the argument that for best results the stiffest possible mast and yard should be the choice for any junk rig.

Batten Hinges

This section is written in support of Maurice Donovan's article "Batten Developments" Newsletter 33.

In a genuine ocean cruiser, integrity in the rig is of overriding importance and windward performance is of low value. Up to now we have had to choose which end of the performance envelope we need to sacrifice to achieve the performance we require of our boats. The ocean cruiser has an easy choice: Stiff battens.

The small light coastal cruising boat has a more difficult choice since a reasonable windward performance is of prime importance but not over-riding and a compromise can be achieved as in the Fenix case which boat could work to windward in a channel gale yet still sail well in light airs but steadily less well as the true wind fell below 8/9 knots and the camber ratio steadily decayed until the sail was flat. The perfect compromise is difficult to achieve with battens of uniform scantlings and flexibility. In fact, I think it is impossible.

Batten hinges will solve any difficulty of choice for all types of rig for all applications and priorities since stiff battens may be used to provide integrity and the hinges the camber ratio needed for windward performance at all practical wind speeds.

So come on all you clever chaps get down to developing a reliable hinge which will suit all rigs for all applications and publish your ideas in the newsletter as some have already done.

I.S.Smith. Oct. 1997

[In this connection, some may be interested to learn that Fenix is in my grandson's hands, now in the Canaries waiting to cross to the Caribbean after a hard 7 day slog to windward to get out of the Channel and across the Bay of Biscay in all the bad weather in late August, that saw two yachts lost there, until abreast Cape Finisterre when it was all plain sailing down to Madeira. He averaged 90 miles a day. That is a good performance for such a small boat.]

Research and Development

from the Editor/Hon. Sec.

We have some catching up to do due to the lack of a newsletter in 1998. So the following are three reports submitted by Joddy Chapman and a critical letter concerning Joddy's work from Bunny Smith. So, as they say in the advert "now concentrate because here comes the technical bit"!

J.R.A. R & D Meeting

Exeter 1 October 1997

from Bunny Smith to Maurice Donovan (R&D Sec.)

8 Nov. 1997

Dear Maurice

As you know I made my views plain to the J.R.A. in 1989. The following year Victor Winterthun answered some of the questions I asked.

See his letters in Newsletter No. 21, Summer 1990.

- 1) To summarise he stated:- (relevant selection)
 - (a) "Battens do work as vortex generators" (NOTE since confirmed by Exeter 3rd year students)
 - (b) "Efficiency increased with battens on both sides of the sail and it works better if the wind reaches them at an angle". He used 20°. (NOTE this confirmed the Fenix result)
- 2) At our 1st October 1997 meeting Joddy Chapman stated that "battens have no aerodynamic function at all". This contradicts Winterthun's findings above and mine with Fenix. Both independently confirmed views.
- 3) He has to prove to us in the face of the above that:-
 - (a) His half scale sail & its battens mimic exactly the aerodynamics of the full scale rig & its battens.
 - (b) Winterthun is wrong and why
 - (c) I am wrong and why
 - (d) His measurement methods and results are made available for use by us if we wish for further proof.
- 4) I now regret not getting to my feet and blowing him apart for putting across such a finding without a scrap of supporting evidence or an answer to the findings of others and particularly so as he had formed a contrary view. He treated us casually to say the least. This is not a matter to take on trust.
- 5) He appears to have put his personal ambitions, whatever they may be, ahead of the J.R.A. priorities. The University may be getting value for money but that is for them to judge. But the other equal paymaster - the J.R.A. - appears, so far, to have been taken for a ride. In three years Joddy has not moved at all to answer,

even in part, properly the task set him in our 1995 programme. (15 Oct. 1994 meeting refers)

- 6) He should not have needed any further direction and in fact, I would be against it as a researcher should not be closely controlled except financially.
- 7) If any one uncharitable enough to think I am taking this line because I am invaled, think again, I do not care if I am right or wrong. I use this batten example as a perfect one of a thoroughly unacceptable result from our financial support for this young man.
- 8) Left to me I would cease to support him forthwith and if we have already parted with funds for 1998 I would ask Exeter to return them. And I propose this.
- 9) If that proposal fails to be carried, then I propose we give him 6 months grace to answer para 3 above. In which case, I suggest we call a special meeting in April 1998 to hear his explanation and justification for his view that "battens have no aerodynamic function".
- 10) I have sent a copy of this to Robin and Chris Scanes and Joddy too, he must know what I am saying. Further copies are enclosed so you can send them to other members. I lack their addresses.

Research at Exeter University for the JRA

by Joddy Chapman

"More hot air has been talked about the aerodynamics of yacht sails than ever came out of a wind tunnel" – Practical Junk Rig, H G Hasler and J K McLeod, Adlard Coles, 1988, p.18.

Introduction

The delay in publication of Newsletter 33 means that readers are unlikely to have had the chance to send off for my previous report, which was summarised by Maurice Donovan in that issue. Following the November 1997 meeting of the JRA technical committee, and Gp Capt Smith's comments in particular (which may or may not have been published in this newsletter – I hope they have) it has become clear that there is a communication problem between me and some members of the committee. This article is an attempt to address this problem. Also, the committee will meet every six months in the future, Robin Blain has found a publisher who can assist in getting these newsletters out on time and Maurice has agreed not to précis my contributions.

Because I have received a number of comments saying that not all members are familiar with concepts such as lift and drag coefficients, I will show how to interpret a simple lift/drag curve and sail boat performance polar. I will then summarise what I have done to date, especially since January 1997, which I described in my presentation to the JRA committee. The two discussion sections explain how I see the JR in relation to other sails and the keep batten problem. Finally, I will outline my intentions for the next stage

of this project and explain why I think it could enhance the JRA's reputation. First, I wish to describe the nature of a research degree and the research process.

"Never do a part time PhD"

-I was warned after starting this project. Why indeed do a PhD, and what is a PhD? A useful book from the Open University ("How to get a PhD", E M Phillips and D S Pugh, OU Press 1994) describes the nature of the qualification in relation to other degrees. Traditionally, a bachelor's degree is a general education, a master's is a licence to practice (theology, initially, but now all sorts of things) and a doctor's degree a licence to teach. Having said that, of course nowadays you don't have to become a lecturer, rather the idea is that the degree recognises that the holder is an authority in their chosen field in full command of the subject and able to extend the boundaries of current knowledge. In Britain, the PhD is a 20th century import from the US and represents a more restricted achievement than, say a LLD (Law) or MD (Medicine). It might be added that most family GPs are given the honorary title of doctor after gaining two bachelor's degrees, although arguably they should have a master's as a licence to practice.

The aim then is to become a professional researcher, recognised as an authority by an appropriate university faculty or organisation, in full command of the subject by being up to date with developments world wide, yet with the astuteness to discover where a useful contribution can be made. One could go on. The book goes on for another couple of hundred pages, but this is the idea, and it is what I want to do.

The scientific process

Scientific "breakthroughs" are rare. More often than not the process is a slog or even "just a job" for those who work in research, battling against poor funding, disinterested superiors, isolation and low social standing. Not that this applies to me! Anyway, I feel I should answer those critics who think that a PhD student should produce a breakthrough of Nobel Prize significance by briefly describing the scientific process as I see it as a way of introducing my approach to the problem of establishing the merits of the Junk sail.

The system works like this: a theory or hypotheses is created, which may be a follow on from some other work or based on observations of some phenomenon. This may be published as a "paper" in a reviewed journal. An experiment is devised to test the theory and the results of this are also published in a reviewed journal together with the theory if it hasn't already been so. Other researchers read the journals and devise their own experiments to test the theory or repeat the original experiment. This may require the theory to be changed a little or a lot, or absorbed into a bigger theory. It then gets published and so on until everyone is happy with it. Gravity is a good theory – it has been tested by many experiments and is useful enough to work out how to get spacecraft around the solar system. Cold fusion has not been so successful – many experiments around the world have failed to reproduce the originally claimed results.

The process of review is important. Before a scientific paper is published it is scrutinised by a panel of experts who may be senior members of university faculties and experienced researchers in their own right. They make suggestions as to how the paper might be improved or clarified, and provide a check on quality for the benefit of other researchers who may read the paper as well as the reputation of the journal. This Newsletter is not reviewed (so far as I know!) since it does not set out to publish scientific papers, and this article is not a scientific paper.

For a trainee researcher new to a subject, or an experienced researcher extending their work into a new field, the scientific process begins with a thorough review of the literature in that field (to make sure that they stand a good chance of making an original contribution). The actual research, especially for a student, may be of the type where some existing plant or process or device is tried out in some new way or on some new materials, for example. Usually this would be carried out using existing methodologies in a lab or in the field. Sometimes the work may involve devising new methodologies if it is perceived to be required. My project involves both elements.

The starting point for me was an approach by Alan Boswell in early 1995 who was seeking equipment to measure the performance of yachts with Chinese sails. I had developed a measurement system for a small catamaran, as a hobby, and was working on a second system that would offer higher resolution. During the summer of 1995 I heard about the undergraduate projects at Exeter, Gp Capt Smith's experiments with *Fenix*, and that the JRA were looking for someone to carry the work forward. After an interview with Dr Francis Chiu, who would become my supervisor, I applied to be a part time research student at Exeter's School of Engineering and the JRA offered to pay the annual fee of £900.

Lift and Drag

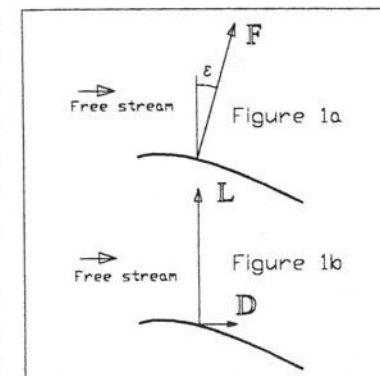
Gp Capt Smith's experiments with *Fenix* (Newsletter 20) had shown that by fitting "keep" or dummy aerodynamic battens to the side of the sail opposite the mast (Port side in this case) he could sail at least 10 degrees closer to the wind than before, on starboard tack. Since this implies a 10 degree reduction in aerodynamic drag angle, it is a claim that sounded very interesting and readily measurable with my instrumentation. So what does this mean?

A body in motion through a real fluid, like a sail or a cricket ball or an aeroplane, is subjected to forces as a result of that motion which can be added together to produce a net or resultant force. The unit of force is the newton (symbol N - it is convenient to remember that an apple weighs about 1N on the surface of the Earth). Force also has a direction, so it is called a vector quantity. You don't need to worry about how this force is developed yet.

Figure 1a shows our body (which happens to look like the cross section of a sail) and the resultant force vector F . Figure 1b is a similar diagram but shows two force vectors L (lift) and D (drag). The vector sum of L and D is equal to F , i.e. if you follow the length and direction of L and then the length and direction of D you arrive at the same place as

you would if you just followed F in the first place. You will also notice that L is at right angles to the direction of the free stream of the fluid and that D is in line with it. This is simply a convention: the resultant force F is resolved into two components to describe its magnitude and direction. Lift is *always* perpendicular to the free stream and drag is *always* parallel with it by definition.

The other way to describe the direction of F is by writing down the angle between F and, by convention, the perpendicular to the fluid free stream. This angle, which I shall call e , is the drag angle and is shown in Figure 1a. The free stream direction is the direction of the flow far upstream of the body, or the direction of the flow if the body wasn't there.



Balance of forces on a yacht

For a yacht sailing along at a constant speed in a steady wind on flat water there is a perfect balance between the forces acting on everything above the water line (the aerodynamic forces) and everything below the water line (the hydrodynamic forces). If for some reason there is an imbalance, such as an increase in wind speed, the yacht will obey Newton's Laws and accelerate until balance is restored. The aerodynamic forces can be summed to produce a resultant F_s , as can the hydrodynamic forces F_h . These must be equal and opposite for the motion of the yacht to be steady and this is shown in Figure 2. Also shown in this figure are the directions relative to the boat of the air free stream and the water free stream. The angle between these directions is termed the apparent wind angle b . The angle between the centre line of the boat and the water free stream is the leeway angle l . This diagram is completed by highlighting the aerodynamic drag angle e_s and the hydrodynamic drag angle e_h .

Although it may not be obvious unless you try it with a protractor, the sum of the two drag angles is equal to the apparent wind angle ($b = e_s + e_h$). This was first realised by F. W. Lanchester in 1907 and is known as Lanchester's course theorem.

Since Gp Capt Smith's yacht could sail 10 degrees closer to the apparent wind after he fitted keep battens, and making the *assumption* that there was no change to the hydrodynamic drag angle of the hull, we can say that he experienced a 10 degree reduction in aerodynamic drag angle. Why is this significant?

Lift-Drag curves and coefficients

Returning to figure 1, we can mark the end of the resultant force vector with a dot. By changing some property of the body such as its angle of attack to the free stream we get another resultant and we can mark the end of this with another dot and so on over, for

example, a range of angles of attack. Join the dots up and we get a curve describing how the lift and drag vary with angle of attack. This is a lift-drag curve. One could plot lift and drag separately against angle of attack, as I did in my article in Newsletter 32, but the lift-drag curve is the usual practice since it relates directly to what is happening.

The one problem with plotting the resultant force in this way is that we cannot easily compare sails of different sizes or in different wind speeds. So that we can, the forces are reduced to coefficient form by dividing the force by the sail area and the dynamic pressure of the apparent wind:

$$C_l = L / (S * 0.5 * r * V_a^2)$$

and

$$C_d = D / (S * 0.5 * r * V_a^2)$$

where

C_l and C_d and the lift and drag coefficients, S is the sail area in square meters, r is the density of the air and V_a is the free stream (apparent wind) speed in m/s. The 0.5 is there by convention because $0.5 * r * V_a^2$ is the dynamic pressure of the fluid, i.e. that which would be measured with a pitot tube. These coefficients are dimensionless. If you know the area of your sail and the speed of the apparent wind (in metres per second) you can quickly calculate the forces. Because the denominator in the above equations is the same a $C_l - C_d$ curve has the same shape as the $L - D$ curve from which it was derived.

It should be pointed out here that coefficients of this type can only be used for bodies fully immersed in a fluid, and then only provided some specific conditions are met to ensure that the dynamic conditions are similar. For a boat hull it would be necessary to plot a whole series of lift - drag curves for different boat speeds because the shape of the curve changes with speed. This is especially true for short fat hulls which hit a "brick wall" of drag at modest velocity.

Newsletter 20 contains an example of a $C_l - C_d$ curve, reproduced here in figure 3. This is for a 1:12 scale model of Dr Moran's three masted *Cocachin* tested at the Wolfson unit in Southampton, and is of the complete vessel heeled at 10 degrees in 8.1 m/s tunnel speed. The model was set at different angles to the wind and the sails sheeted as Dr Moran thought best. The three curves are for three different positions of the truss, a line that pulls the forward end of the boom aft and raises the height of the peak. On to this graph I have drawn two lines of the same length from the origin to points on curves B and C that typically correspond to windward sailing. The angle between these lines, which

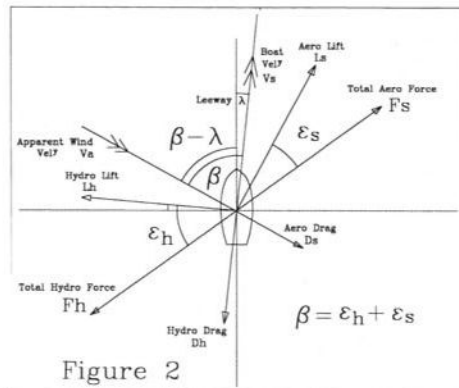


Figure 2

are the resultant forces in coefficient form, is the change in aerodynamic drag angle associated with hauling on the truss for a constant resultant coefficient of 1.4. It is 5 degrees.

All of this should explain what a lift-drag curve is and show by comparison with the *Cocachin* tests that the 10° reduction in drag angle reported by Gp Capt Smith is very significant. However, there are difficulties with interpreting these curves. Why, for example, did I choose the lines I did on the *Cocachin* curves? How do I know that they correspond to best windward performance? I am happy to admit that they are just best guesses for illustrative purposes only. The only way to find out for sure (other than sailing the real vessel!) is to marry up this aerodynamic data with the hydrodynamic tank test data in a velocity prediction program (VPP) to produce a polar diagram of boat speed against true wind speed. More on this later.

(For completeness, it should be explained here that an alternative to the $C_l - C_d$ curve is the $C_x - C_y$ curve. This is a graph of forward drive force coefficient C_x against side force coefficient C_y , and is the presentation preferred by Tony Marchaj and others. These are usually obtained by "sailing" a complete model in a wind tunnel and sheeting the sails for maximum forward drive whilst maintaining an acceptable heeling moment, with the aid of an on-line display of some kind. The problem I have with this is that it pre-supposes a known maximum heeling moment. Although useful in some circumstances where the hull characteristics are known and only one wind speed is of interest, I do not feel that it is appropriate here where only the sail is in the tunnel and the results need to apply to a range of wind speeds).

Sailing craft polar diagrams

Whether derived from on-board measurements or wind tunnel and tank tests via a VPP, a polar diagram is the accepted way to display the results. Readers of Newsletter 32 will have seen a number of polars, mostly for Maurice Donovan's *Capricorn*. Here I shall show by example how a point on a polar is calculated from on-board measurements and how to identify velocity made good to windward (VMG) from such a diagram.

For this example it seems appropriate to use the data for *Fenix* (Gp Capt Smith's Sadler 26 with a much modified Sunbird rig) from page 17 of Newsletter 20. The second case is chosen where the sail was sheeted to windward, a kicking strap and flexible battens

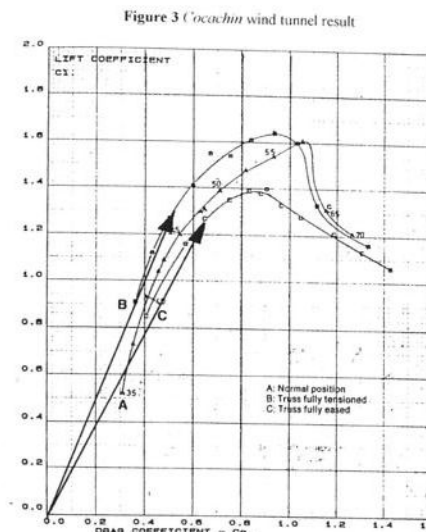


Figure 3 *Cocachin* wind tunnel result

were in use, but no keep battens. The yacht was sailed in an apparent wind of 12 – 15 knots on a smooth sea or one with a slight chop. Boat speed was measured with a Walker trailing log and apparent wind with a Seafarer instrument mounted on the pulpit. The data was presented thus:

(1) Port Tack. Angle 35-40 degrees, speed 4.7 – 5 knots.

(2) Starboard Tack. Angle 50 degs approx., speed 4.7 – 4.9 knots.

It is necessary to assume that the leeway angle is small enough to be neglected, which I believe is justifiable for this yacht under these conditions, and that it is reasonable to take average values of the figures reported. This gives us the following:

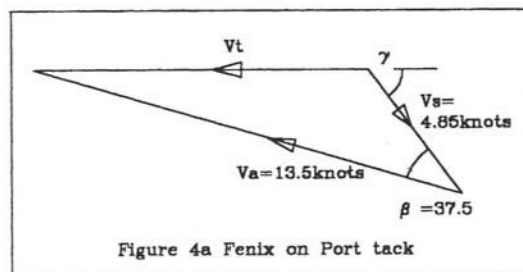
(1) Port Tack. $b = 37.5$, $V_s = 4.85$, $V_a = 13.5$

(2) Stbd Tack $b = 50$, $V_s = 4.8$, $V_a = 13.5$

where b is the apparent wind angle, V_s the boat speed and V_a the apparent wind speed. Units are degrees and knots. To calculate the true wind speed V_t and the yacht's course relative to the direction of the true wind another vector diagram is used, much like those you draw on your navigational chart to calculate EP if in tidal waters. This is shown in figure 4a for the Port tack case.

As a vector sum, $V_t = V_a + V_s$. Start by drawing a line of length equal to V_s in any direction you like. Draw a second line of length equal to V_a at an angle b to the first line. The line between the open ends of these lines represents the true wind speed vector V_t , its length is the true wind speed and its angle relative to the V_s line is the true wind angle (symbol γ). Try it for the Starboard tack case yourself.

Figure 4 has been drawn the way round it is so that the true wind is blowing from right to left. This is the convention I use, some prefer to have the wind blow down from the top of the page. The "position" of the yacht can now be plotted on a polar diagram using true wind angle and boat speed.



Both Port and Starboard cases are drawn on the same side of the diagram (in this case Port tack side) to ease comparison. Different symbols can be used to distinguish them and I have drawn a circle for the Port tack point and a square for Starboard on figure 4b.

Also on figure 4b are two arrows which depict the velocity made good to windward for each case. This is the component of boat speed resolved in the direction from which the true wind is coming from, and is the recognised measure of windward performance.

If the yacht had been sailed on a number of different headings on each tack, and the figures from the instruments recorded for each, a number of points could be plotted on

the polar diagram and then joined up to produce a curve like that for lift-drag. Different curves for different true wind speeds, of course, and from these it is very easy to identify best VMG. This whole process can be automated and this is what my measurement system does. For *Fenix*, VMG was almost twice as much on Port tack over Starboard, despite V_t working out a knot higher for the latter case. After keep battens had been fitted performance was pretty well equal on both tacks, although Port still had a very slight advantage. This highlights the significance of such a large reduction in drag angle.

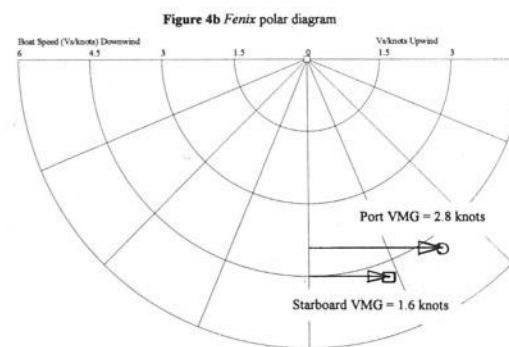
I hope that all this will help your understanding of the next section of this article, which is a summary of what I have done to date. Most of it is taken from progress reports to the university, so it makes rather dry reading but it shows my line of thinking.

Progress Reports

October 1995 — June 1996

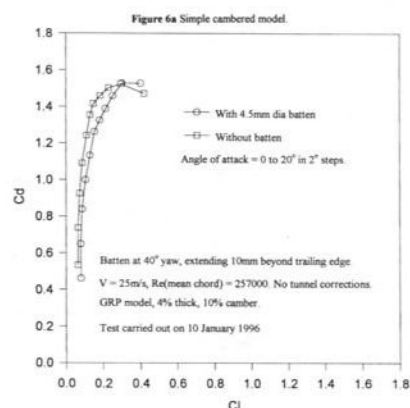
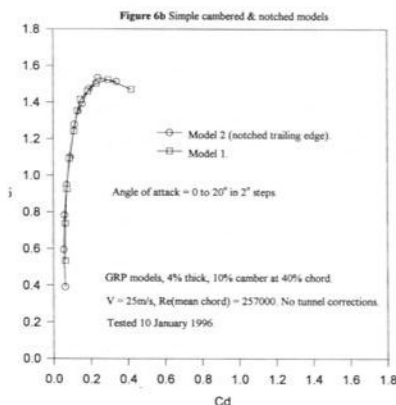
Background reading revealed controversy surrounding the reported improvement in windward performance of a 26ft monohull yacht with inclined external 'keep' battens fitted to the opposite side of its Junk sail's structural battens. Previous undergraduate projects at Exeter (see Newsletter 30) had investigated through flow visualisation the generation of vortices along the lee side of yawed cylindrical battens. No quantitative measurements of their effect had been made. An MSc student at Cranfield was investigating the effect of yawed battens on a 0.25m² model JR as part of a wider investigation of sail plans. Initial results at the time suggested no significant difference to the aerodynamic characteristics of the model. I have plotted the relevant final results in figure 5. (Data courtesy of Ian Hannay, from M G Licops, "The comparative efficiency of different sailing rigs: the Bermudan, Chinese Junk and Crab Claw rigs", Cranfield University College of Aeronautics, MSc thesis, 1996).

The opportunity was taken to carry some instrumentation on three yachts fitted with Junk rigs. The aim of these initial trials was to gain some familiarity with the JR and to see if the instruments could detect a difference between tacks. With the JR being asymmetrical a difference was expected. The results were inconclusive but from the logistical lessons learned a decision was made to build a 10m² JR for a 14' dinghy. This sail is a 1/2 scale model of that fitted to Maurice Donovan's *Capricorn* in Plymouth.



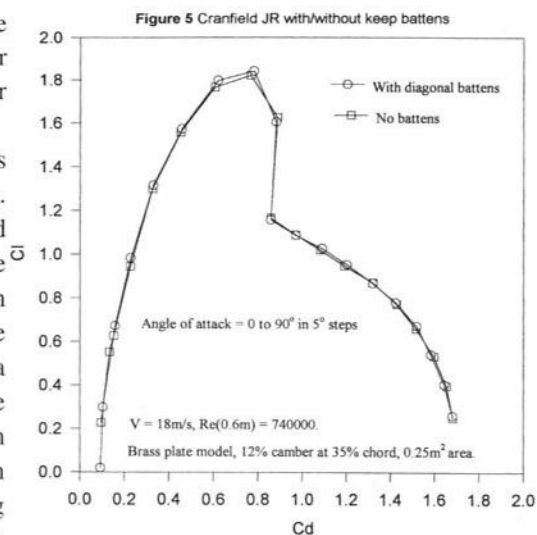
Adjustable hinged battens were designed to permit the effect of camber to be measured (Newsletter 33 for details).

The closed circuit wind tunnel was used to test a number of simple models. Initially, 5 models were made and tested. They were all of a simple trapezoidal plan tapering from ~190mm at the root to ~100mm at the tip over a span of ~300mm. Two had a notched trailing edge and the other three were tested with and without a 4.5mm diameter batten yawed at 40 degrees on the low pressure and side extending 18mm beyond the trailing edge. These were tested up to and just beyond the stall, since windward performance was the principal interest. The results of some of these tests, which were shown at the JRA's AGM in June 1996 and Newsletter 32, are re-drawn as standard lift-drag curves in figure 6.



Note how the presence of the batten degrades the drag angle before the stall. There was no difference between the notched and un-notched models. The notched models and the overhanging batten were to test Ian Hannay's "polyfoil" theory ("Natural Aerodynamics", AYRS 117, ISSN 0144-1396, 1995).

After an initial outing afloat the 10m² JR was made available to a 4th year undergraduate group project. They attempted to measure the forces developed by the sail on a static test rig built on high ground near the School of Engineering at Exeter. They were hampered



by unsuitable winds and instrument problems, which really only served to highlight the difficulties of this approach.

Progress July 1996 — June 1997

Performance Measurement

During the summer of 96 the dinghy was sailed in a range of conditions in Plymouth with a crew of two. Instrumentation consisted of one or two data loggers, wind speed/direction sensors fitted to the masthead and/or bowsprit, towed log, stethoscope and bubble generator.

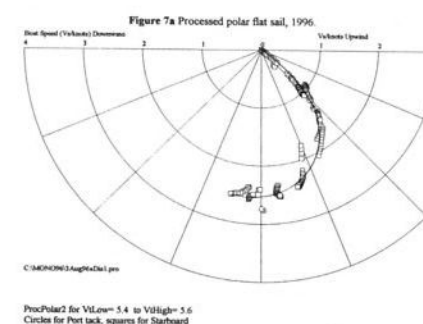
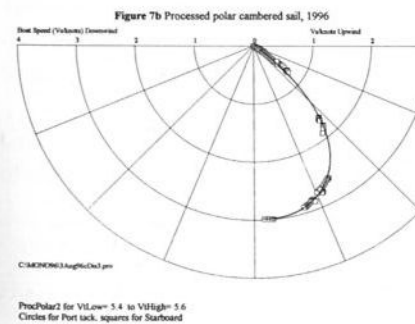
Observations of tuft behaviour and with the stethoscope revealed that for the sail set flat and sheeted for best speed there was reverse flow over most of the lee side with a turbulent, separated shear layer curving aft from the leading edge and enveloping the mast when on Port tack.

With the sail set to flat, 5% and 10% camber a number of 'polars' were sailed and observations of the tufts, with the stethoscope and soap bubbles were made. Unlike the case for the sail set flat, when cambered the tufts generally streamed aft and no leading edge separation was evident except at large angles of attack. Performance measurements and stethoscope observations were also made on *Capricorn*.

Data Processing

The aim was to produce reliable polar diagrams for a given true wind speed for each of the different rig configurations. In the spring of 97 new software was written in Visual Basic to apply a more rigorous analysis and handle the larger file sizes created. Previously, consecutive averages had been calculated and maximum boat speed Vs binned according to its corresponding true wind angle g. For the new approach the three basic parameters Va (apparent wind speed), Vs and b (apparent wind angle) are filtered to be within specified standard deviations over a given sampling period. For the dinghy 20s was used for the example here.

The values from this initial filtering are then saved to build up a database of the boat's performance. This data can then be filtered a second time by applying a limit to



true wind speed V_t to allow comparisons between rig configurations. Figure 7 shows some results for the dinghy with the sail set flat and with 10% camber in 5.5 knots true wind.

Tethered Testing - 1

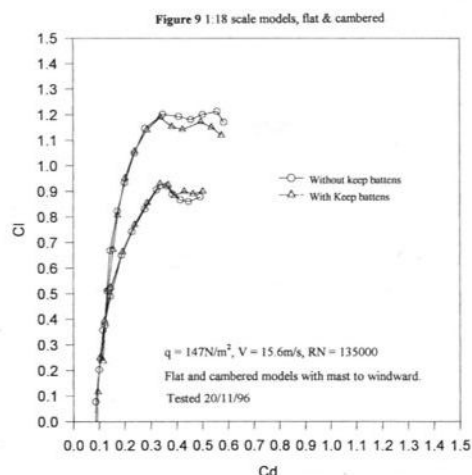
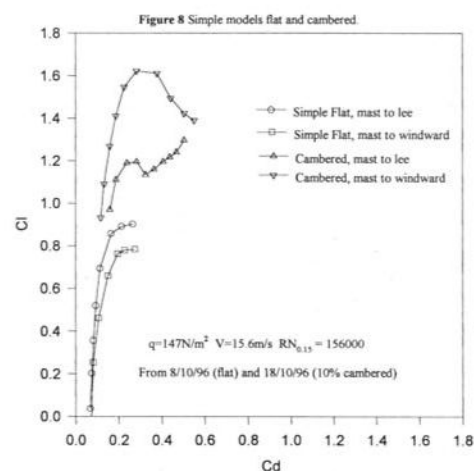
To complement and compare with the wind tunnel models (see below), direct measurement of sail forces on the dinghy rig was attempted using the single line tether method in the autumn of 1996. This involves securing the boat to a buoy with a single line and moving the line fore and aft in the boat until a representative sail angle to the apparent wind is found and balance achieved. The various angles, wind speed and tension in the tether are then noted, the tether moved and the process repeated.

This method was not successful: a steady balance condition could not be achieved in practical conditions afloat. A second method, involving mooring the dinghy with three lines inside a floating breakwater, was tried, albeit without instruments. This showed considerable promise.

Wind Tunnel Testing

Following the flow visualisation observations on the dinghy JR a further series of wind tunnel tests were conducted. Initially using the simple trapezoidal models used earlier in the year, the experiments were extended to include 1:18 scale models of the dinghy rig.

With the simple flat model suitably tufted, leading edge separation and re-attachment could be observed. The stethoscope revealed an almost immediate transition to turbulent flow from the sharp leading edge. With a 5mm rod representing the mast mounted on the lee side of the model the flow pattern was similar to that without the mast at angles of attack greater than 6 degrees. Stethoscope observations confirmed that above this incidence the separation bubble from the leading edge enclosed the mast, and measurements of lift

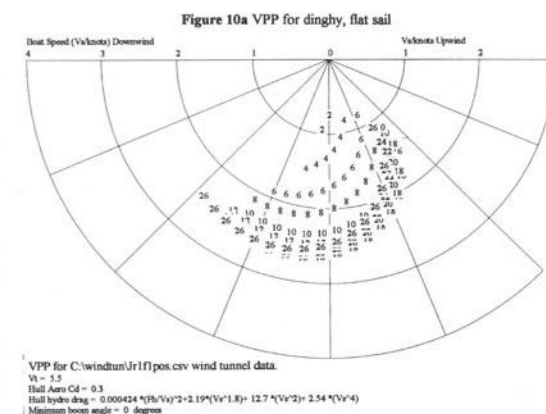


and drag showed significantly higher Cl_{max} and smaller drag angle with the mast to leeward than to windward, as shown in figure 8.

For the simple 10% cambered model the flow pattern was somewhat different. Trailing edge separation worked its way forward as angle of attack increased, in the manner of a conventional stall. The extent of the leading edge separation was less than for the flat model such that it could not envelop the mast, when mounted on the lee side, resulting in a lower Cl_{max} than for the mast to windward. None the less the cambered model performed better than the flat model.

Three 1:18 scale models the 10m² JR were made, the first flat and the second and third cambered 10% for Port and Starboard tacks. Additional 'keep' battens could be fitted opposite the structural battens.

Figure 9 shows the effect of fitting the keep battens, and again there was no benefit to be found. It was evident, however, that the orientation of the yard to the top panel was significant. With the yard 'over-rotated', like a Tornado mast, flow was attached over the whole of the lee side downstream of the yard up to the stall. When 'under-rotated' the air would separate from the yard and degrade the lift-drag performance at low angles of attack.



Velocity Prediction Program

To interpret the wind tunnel results a velocity prediction program (VPP) was written for the dinghy. A VPP predicts the performance of a sailing boat given hydrodynamic and aerodynamic properties, and is typically used to assist the design process. In this case the steady state only is considered, and it is assumed that the boat is sailed upright in a perfectly uniform wind and on a flat sea. Justification is that full size testing is (preferably) carried out in a steady sea breeze on waters of restricted fetch and that the crew use their weight to "sit the boat".

Ideally, the hydrodynamic data would have been obtained from tank testing the dinghy hull. In the absence of such data a simple mathematical model was used relating the drag of the hull to the speed through the water and the side force from the sail.

The program finds the boat speed for which a balance between the aerodynamic drive force and hydrodynamic drag force exists, given true wind speed, true wind angle and a point on the sail Cl - Cd curve. If you think of sailing a fixed course gradually sheeting in from hove-to, the boat will accelerate from rest to a maximum speed and then when you

over-sheet the sail will stall and you slow down. Close agreement can be seen with the performance measurement of the dinghy with the sail set flat and cambered, figure 10.

Computational Fluid Dynamics

Because the flow pattern around the Junk sail is so largely influenced by separation effects, any CFD analysis must take this into account. Although an 'inviscid' boundary element method such as Francis Chiu's NWING provides an elegant solution for smooth aerofoil sections, either a discrete vortex or finite element method is required for the Junk rig.

The availability of ANSYS/ FLOTRAN at Exeter made it a natural choice. To overcome limitations of access at Exeter (being a part time student), a loan of the educational version was arranged. This has the same user interface as the full system for training purposes. As an exercise the influence of a cylinder in a region of re-circulation was investigated, being analogous to a mast in a separation 'bubble'. Because the cylinder had little effect on the size of the separation bubble, it would seem to be in agreement with earlier observations in this project as well as those of Gp Capt Smith and the Wolfson Unit (Newsletter 20).

Progress June — October 1997

Tethered Testing – 2

As mentioned above, additional equipment had been made to measure sail forces directly, analogous to an open air wind tunnel. This should have had the advantage of being a real sail tested in a real breeze, as opposed to artificial but controlled laboratory conditions, although since the boat is not moving the smoothing effect of the added component to create the apparent wind is absent as is its twist. There is the added problem of requiring smooth, tide free water together with a reasonable fetch for the wind to steady out.

A suitable location had been identified at the Mayflower Marina, Ocean Quay, Plymouth, where a floating breakwater provided the calm surface required, and tidal streams were minimal for 1 hr around high water neaps. Although it was expected that westerly winds would be appropriate, with a reasonable fetch down Millbrook Lake, they did not appear when boat, tide and crew were available. Instead, best conditions were found to be with a southerly sea breeze.

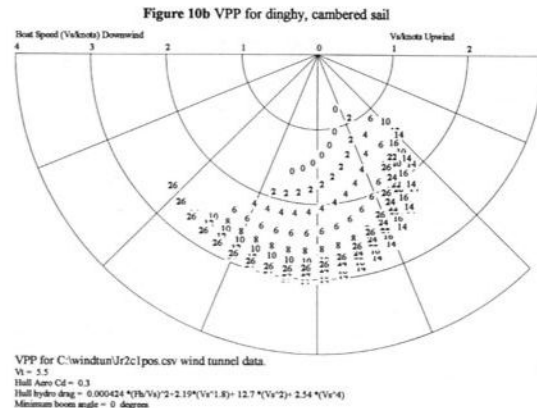
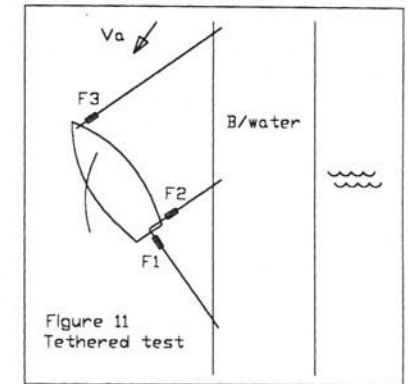


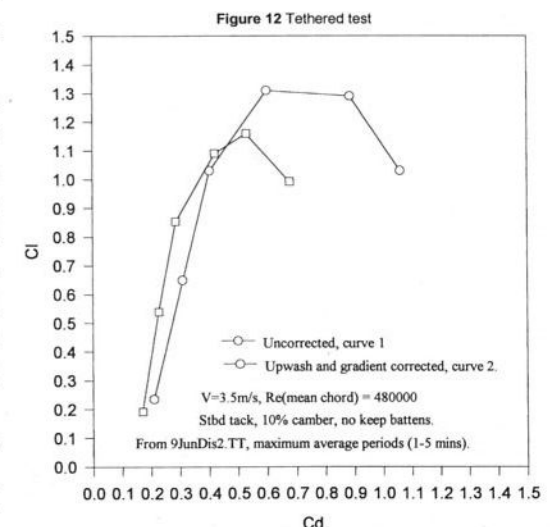
Figure 11 shows the test set-up. The dinghy was moored inside the breakwater by two lines perpendicular and one parallel to the axis of the boat. Signals from remote reading spring balances in these tethers were fed to a laptop PC, which also received wind speed and direction data from the standard bowsprit unit used for the sailing trials. The sail was sheeted to a number of positions noted by recording the angle of the boom to the centre-line, and data logged for up to 5 minutes for each setting.



A number of different ways of processing the raw data were investigated, the one used here is that of simply averaging the three forces over each sail angle period. The root mean square value of apparent wind speed was used in the calculation of lift and drag coefficients to allow comparison with the wind tunnel data, and corrections for atmospheric pressure and temperature applied. In figure 12, curve 1 is where C_l and C_d have been calculated using the average apparent wind angle b for each sail angle period whilst for curve 2 the average b for the sheet-right-out, sail-not drawing period was used for *all* the data. This is because the apparent wind angle as measured at the bowsprit was found to increase as the sail was sheeted in. If this was due to the wind vane being too close to the sail rather than a coincidental shift in true wind direction, then the sail-not-drawing case represents the best indication of b for the whole test. Curve 2 also has a modest correction for wind velocity gradient, it being reasonable to suppose that the wind was stronger higher up the sail than at bowsprit height (1.6m).

The large difference between curves 1 and 2 serves to highlight the *uncertainty* of these measurements, and give a reminder of the importance of recording wind gradient and identifying the influence of the sail on the apparent wind direction measurement. These problems apply equally to tethered and sailing tests.

Only two other tethered tests was made in less ideal conditions. Processing the data in the way



described above produced huge scatter from which little could be inferred. The problem of scatter and uncertainty is discussed later in this article.

Performance measurement

The basic 3-channel instrument (Va, Vs and b) was carried on the dinghy, *Capricorn* (Maurice Donovan's 28' monohull) and *Nymph* (Gp Capt Smith's 26' trimaran). The dinghy was fitted with 'keep' battens, figure 13, and polars sailed (i.e. sailed from pinching to running in stages so the results can be plotted on a polar diagram). For one set of polars the sheeting was adjusted for maximum boat speed and for another a fixed sheeting angle was used. Part of the idea of sailing with fixed sheeting is that it removes the sail trimmer from the list of variables. It was observed that the keep battens help to keep the fabric of the sail smooth against the main battens. The keep battens were then removed and the sailing program repeated on the same day. In both cases the hinges were set to flat and to give the sail a nominal 10% camber. Some of the results are shown in figure 14.



Figure 13 *Disa* (dinghy) keep battens.

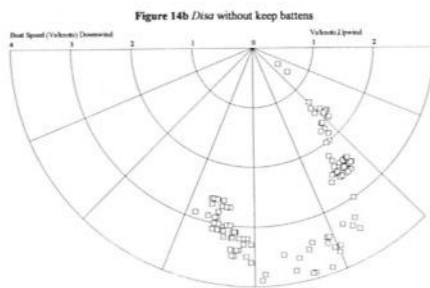


Figure 14b *Disa* without keep battens
Raw Polar for C:\Mons97\20jul97b dis from 2 mins to 6 mins
Filter VIMax= 8
Circle for Port tack, square for Starboard

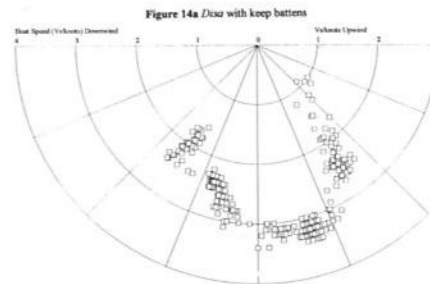


Figure 14a *Disa* with keep battens
Raw Polar for C:\Mons97\20jul97a dis from 55 mins to 60 mins
Filter VIMax= 8
Circle for Port tack, square for Starboard

Nymph was sailed in a similar manner, but the keep battens were not removed and the flexible battens offered no control over camber. By investigating the flow over the sail with a stethoscope it was found that there was immediate separation and transition to turbulence on the lee side from the leading edge on both tacks, and that the separated shear layer extended outside the mast when on Port tack. This was similar to the dinghy sail set flat.

For *Capricorn*, rather than sailing in circles to produce polar diagrams, extended periods of 'steady' sailing on a constant course were recorded. I hope that it will help in making decisions on data averaging intervals and conditions for future testing procedures.

Discussion 1 - How does a Junk sail work? Similarities and differences with Bermudan sails.

It has been said to me a number of times that "a Junk sail works in a totally different way to any other sail, such as Bermudan". To the extent that the mechanical arrangement of a JR is different to a Bermudan rig, and that it is therefore *worked* in a different way, this is true. But from the experiments and observations I have made, and after weighing up the evidence from others, it is my view at this time that for windward sailing in light to moderate winds a JR works, from an aerodynamic point of view, just like any other fore-and-aft rigged sail. (If you want to know how an 'ordinary' sail works I can strongly recommend "The Symmetry of Sailing - The Physics of Sailing for Yachtsmen", R Garrett, Adlard Coles Nautical, 1995.) I would almost go so far as to say that there are more similarities in aerodynamic detail than there are differences. Part of the problem is defining a Bermudan rig, so here I shall refer to 'classic' Bermudan (triangular main and jib, no battens and rigid non-rotating mast) and modern Bermudan (fully battened large roach main, triangular jib, bendy but non-rotating mast). Some of the similarities and differences are listed below:

Leading edge separation. As outlined above, this has been a feature of all the Junk rigged yachts I have sailed in where the sail is flat or with no camber near the luff. This was found by others as well as me to give an advantage to Port tack (mast to lee) over Starboard, since the mast is then effectively "hidden" in a separation bubble. A Bermudan mains'l has the same problem - the mast causes considerable disturbance and separation at the luff. For the Bermudan, a jib is added ahead of the mains'l to mitigate this problem. It works by *slowing down* the air as it flows past the mast reducing its detrimental effect. This transfers what would otherwise be a loss to a net gain at the optimally shaped leading edge of the jib, which has no mast to get in the way. For a Bermudan rig, 'the total is greater than the sum of the parts'.

Camber. A curved sail will develop more lift for a given drag and a smaller drag angle for the same lift than a flat sail. The curvature needs to be nearer the luff than the leach so that the local entry angle is small, avoiding separation. The sail should be nearly flat towards the leach to offer a gradual recovery to the air from a minimum low pressure on the lee side back to atmospheric pressure. Classic Bermudan sails often have short battens near the leach to prevent 'hooking' and keep the camber in the right place. Modern Bermudan sails which are 'cut flat' will take up a cambered shape aloft principally because the mast is curved. The optimum camber depends on the boat type, crew weight and distribution, heading and wind speed. Modern rigs have a large number of 'tweaks' to control the position and amount of camber. As a general guide, 10 to 15% at 35 to 40% chord is a good compromise

for a cruising sail. If you have the means to control camber then more will give you a higher maximum lift at the expense of a larger drag angle. In any case you need to keep the tell-tails streaming aft (attached flow) to keep the drag down.

Twist. One of the advantages of the JR is, of course, the ease with which twist can be controlled. Reducing twist helps windward performance in light to moderate conditions, and can be increased to reduce heeling moment as the stability limit of the boat is reached in stronger winds. There is little control over twist on a classic Bermudan main, but for a modern rig the twist control is partly automatic, with the battened roach bending off in gusts, and partly manual through vang tension. It is the self twisting feature of sailboard and skiff rigs that confers some stability on these craft.

Plan form. For most classic Bermudan yachts the sails are the three cornered shape they are so that they conform to class rules, even though it has been shown by Marchaj and others that the pointed top is not really contributing anything and might as well be cut off. Given a free hand, the outline or plan form of a sail could be optimised, for example for windward work, by consideration of the lift distribution over the sail required for best VMG for a given yacht in given conditions (e.g. "Towards an Optimum Yacht Sail", C J Wood and S H Tan, Journal of Fluid Mechanics vol. 85 part 3, 1978). In light winds something approaching an elliptical distribution, which would imply an elliptical plan if no twist were present, is best. As the wind increases and the stability of the yacht becomes a limiting factor this no longer holds, and the work suggests that the lift from the top of the sail should actually be negative to keep the yacht upright. In practice it is seaman-like to reef at this stage, and this is where the plan form of a JR really changes compared to a Bermudan sail.

When reefed, the JR takes on a very low aspect ratio, swept back 'delta' plan form, as shown in the picture of *Capricorn* in Newsletter 33. A triangular Bermudan sail, when reefed, retains approximately the same geometry, but just gets smaller. For the latter, the relatively useless pointed top becomes a greater proportion of the sail aloft, and so its overall performance suffers accordingly. For a JR like *Capricorn*'s, if reefed down sufficiently so that the yard is swept back about 60 degrees or more, and if at a high enough angle of attack, it is likely to be generating so called vortex lift. (This is speculation on my part because I have not investigated the reefed performance of these sails, but from my brief experience of *Capricorn* in a stiff breeze and from the accounts of others I feel that the strong wind characteristics of the JR is one of its greatest selling points.) If the upper surface vortex component of lift is significant under these conditions, I would expect the sail to develop a high resultant force and be tolerant to large changes in angle to the apparent wind which, I suggest, is what is needed under these conditions. The cost is the high drag that is associated with this lift mechanism, which makes it unsuitable for light wind windward sailing.

Discussion 2 - Keep battens and *Fenix*

So what are we to make of Gp Capt Smith's *Fenix* and the improvement in windward performance through fitting keep battens? It should be clear by now that I have been unable to find any evidence, from the experiments I have done, to support his finding. Remember that the undergraduate projects were only qualitative flow visualisations, and that I felt that it was necessary to make quantitative measurements both afloat and in the wind tunnel. So far as I know from the searches I have made the only other investigations into keep battens are the Cranfield MSc thesis, Victor Winterthun's letters in Newsletter 21 and possibly a report from the Nanjing Aeronautical Institute. The Cranfield result is shown in figure 5 and the Nanjing paper is in the process of being translated. Unfortunately Victor Winterthun did not report the wind speed he used for his very small models (136 sq. cm) so it is not possible to determine the likelihood of dynamic similarity with real sails, and his results are presented in the unorthodox manner of Lift²/Drag against angle of attack. This makes it impossible to work back to get Lift/Drag and hence drag angle, or lift and drag separately. In any case he says "I cannot shout the result until I have had the opportunity to try them out on a full scale boat", and I feel it would be unkind to comment further.

The measurement figures Gp Capt Smith presented for *Fenix* in his Newsletter 20 article in support of keep battens were hedged with the following notes:

Note 1. "Due to a snarl up, speeds were not recorded in the last [with keep battens] case, but Port was estimated to be faster than Starboard"

Note 2. "Uniquely accurate measurements made in a cold November dawn."

This means that it is not possible to calculate VMG or plot the performance on a polar graph, and that the weather conditions were in some way different to those for the without-keep-battens tests. I don't, however, believe these to be sufficient grounds to dismiss his observations. What else might have been happening and why was Starboard tack performance so poor in the first place?

The sail in use at the time was a modified Sunbird sail left over from an unhappy Folkboat project, and although I don't have any photographs of it I gather it was pretty awful. Prior to being fitted with keep battens the sheeting system had been improved, a kicking strap fitted, more flexible main battens and a flexible boom added. If the same materials were used as for the subsequent *Fenix* rig, the main battens were 1 1/4" (32mm) diameter by 2mm wall thickness pultruded GRP and the keep battens 32mm diameter plastic water pipe. Even though the plastic keep battens were probably many times more flexible than the GRP ones, they would have stiffened the latter, especially since they were lashed side by (other) side of the sail rather than one above the other. This offers the greatest resistance to bending from what has become a composite beam.

Depending on the apparent wind speed and sheeting arrangement, the use of these flexible battens can produce some interesting shapes, as figure 15 shows. Note the flat front half of the sail and hooked leach. Adding, or for figure 15 removing, the keep

battens is almost certainly going to change the shape of the sail. My suggestion is that by adding keep battens Gp Capt Smith stiffened *Fenix's* sail, reducing the hooking and its propensity to trailing edge separation. This also ties in with his observations of tuft behaviour. The flat leading section of the sail would still have caused a separation bubble to envelop the mast, so that the "sail area ahead of the mast [and] for about a foot aft of it contributes little to windward performance". In case battens do encourage attached flow over a hooked trailing edge on a poorly set sail I built another simple wind tunnel model and the result is in figure 16. Judge for yourself the effect of the battens.

Just to complete the story, Gp Capt Smith subsequently fitted *Fenix* with a rig to his own design, which from the photographs in Newsletters 23 and 25 has a fair and uniform camber. As such, this yacht has proved itself to be more than a match for Bermudan rigged Sadler 26s in competition and has safely carried its new owner (Gp Capt Smith's grandson) to Scotland, the Azores and beyond.

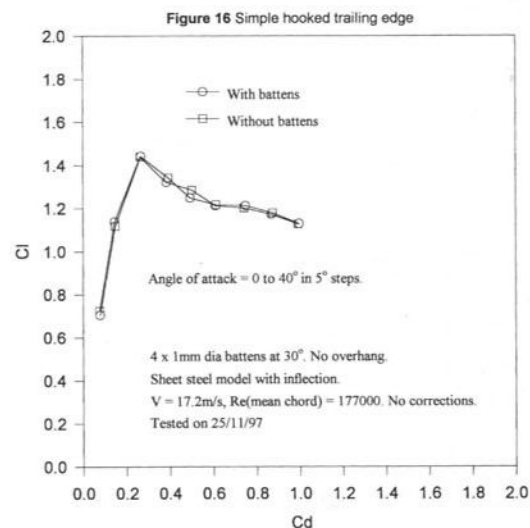
A mid-course correction

Francis Chiu, my supervisor since October 1995, left Exeter to work for British Rail Engineering in Derby at the end of the '96-'97 academic year. The university have now approved Dr Michael Belmont of the School of Engineering's Marine Dynamics Group to continue in this role. This prompted a shift back to full size yacht performance measurement as the central core of the project, which was how I got involved in the first place, and a literature review of previous attempts at such measurements.

Why should the JRA continue to be involved with this, and what is the value of full scale measurement?



Figure 15 Jillie November 1995



An ideal yacht measurement system could, one might suppose, produce a set of curves on a graph or figures in a table describing quantitatively the performance of a yacht in all winds and sea states. This in itself would be sufficient to assist the development of yachts of all kinds and not just for outright speed but sea-kindliness as well. It would also settle the disputes that occur from time to time surrounding exaggerated or inaccurate claims, and provide the customer of a new boat with a benchmark test report. This overall measurement would be useful for the verification of racing yacht velocity prediction both for designers and handicap systems such as the IMS.

With some additional input, such as hull tank test data and in particular leeway measurements, it would be possible to work out from the overall performance figures a set of aerodynamic characteristics for the yacht's sails. This is like running the VPP described earlier backwards to produce lift-drag curves for real sails in a real wind on a yacht that is actually sailing rather than tethered. This information, if sufficiently accurate and certain, would be of tremendous value in verifying wind tunnel test and computational modelling methods.

So why isn't this a routine procedure already? First we need to assess the current situation.

Background to Full Size Measurement

It is customary to quote the work of Davidson ("Some experimental studies of the sailing yacht", K S M Davidson, Trans. SNAME 1936) as being the first systematic measurement of a sailing yacht's performance. Davidson had already shown the value of tank testing model yacht hulls through comparison with full scale towing trials. He then set out to determine sail force coefficients through taking careful note of heel angle, apparent wind speed and boat speed on a full size yacht. These readings were made from hand held instruments whilst the 34ft sloop *Gimcrack* was sailed at what was deemed to be best speed to windward. From a knowledge of the hull's characteristics it was possible to calculate sail coefficients, which were then used to predict the performance of new yachts. The various plots of raw data show a fair amount of scatter, but by simply drawing lines of "best fit" the figures were successfully used to predict yacht performance for many years.

Similar measurement programs, such as those carried out by the Southampton Yacht Research Unit (the forerunner of the Wolfson Unit) in the 1950s and 1960s introduced more sophisticated instrumentation, but the problem of scatter was taken more seriously, and the uncertainty in the results increased. Driving force coefficients for the yacht *Baybea*, figure 17, show how bad this can be.

An alternative to the indirect method of sail coefficient determination was devised by MIT in the form of a sailing dynamometer. This consists of a space frame carrying the mast, shrouds, stays, sheeting points and winches suspended inside a hull by a network of load cells. Thus the forces and moments exerted by the rig on the hull can be measured.

Extensive use was made of this facility prior to the 1992 America's Cup, for which additional instrumentation to measure sail shape, mast twist and wind upwash was installed. Unfortunately the results of this work are not available in the open literature.

A similar sailing dynamometer has been built in Japan. Again, considerable scatter is present in the results, but it was considered that they revealed the detailed relationship between performance, apparent wind angle and sail shape better than through wind tunnel tests or CFD alone.

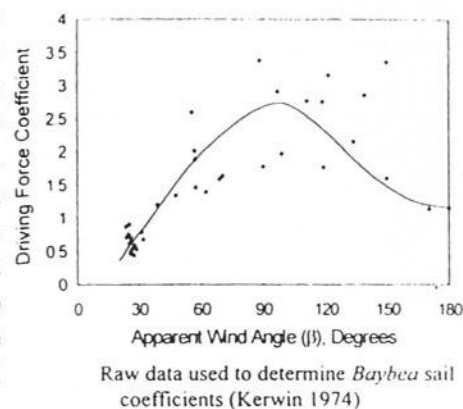
In an attempt to reduce the uncertainty in the measurement of performance, and sail coefficients in particular, a project at Mystic Seaport Museum, Connecticut, USA is in progress using the 47 ton schooner *Brilliant*. ("On test measurements in full scale sailing test programs", H P Grant and Olin J Stephens, 13th CSYS, January 1997). Although meticulous care has been taken over the calibration and alignment of sensors, it is surprising that measurements were initially taken by hand. By using correlation-weighted average boat speed in place of average boat speed, to allow for the response of the yacht to the fluctuating wind, the authors believe they have reduced the uncertainty in calculated sail coefficients to +/- 10%. This appears to be the first time anything more sophisticated than simple averaging has been used.

An analogy with wind turbines

In the absence of a really thorough yacht performance methodology it would appear necessary to create one. As a starting point I sent off for a copy of the International Energy Agency expert study group report entitled "Recommended practices for wind turbine testing and evaluation: vol.1 power performance testing" (S Frandsen and B M Pedersen, 1990, available from NEL Glasgow). This describes how wind turbines should be measured. These share the same resource, the wind, as yachts, but the financial backers and power utilities need a high degree of certainty in performance assessment to predict energy yield.

To provide this certainty, the testing method makes use of the "method of bins" or averages of averages. Specifically, the average of at least three 10 minute averages of power output is required for each 0.5m/s true wind speed "bin". A complete test would need a minimum of around 12 hours of data which could only be obtained in 12 hours if the wind blew steadily in increments of 0.5m/s every half hour. In practice several days to a couple of weeks is a typical test period.

Figure 17 Baybea sail coefficients



The wind turbine people have it relatively easy, since the turbine always points into the wind and is not subject to motions from the sea. Extending this method to a yacht and calculating averages of averages of boat speed for increments of true wind angle from say 25 degrees to 180 degrees in 5 degree steps, and for true wind speeds of between 2 knots to 30 knots in 1 knot increments would require about 18 days of "ideal" data. A few "Whitbread" legs might provide the information!

Even if the bracket of interest is restricted to windward sailing in 10 to 15 knots, around 30 hours of ideal data would be needed, maybe a week on board. By using something other than the method of bins, such as the selection of statistically 'steady' averages described above, I believe it should be possible to get this test duration down to a more practical value.

The next step

To progress with this project I am putting together a more powerful measurement and data logging system which I anticipate will address some of the uncertainties highlighted by the simple equipment used to date. In particular the issue of wind gradient, the influence of the sail on wind angle measurements and how best to measure leeway will be tackled. Also, the lesson from the *Fenix*/keep batten saga seems to me to be one of not really knowing what the sail shape is. I hope to resolve this uncertainty with a video/photographic 3-D dimensional measurement set-up originally developed for "reverse engineering".

I hope that information gathered with this equipment will enable a serious assessment to be made of different yacht testing methodologies. For example are sail coefficients best derived from sailing 'polars' with fixed sheeting or for maximum speed, and just how important is wind gradient data? Once a satisfactory method has been established, and accepted by others working in this area, it will be possible to produce reliable figures for various JRs and be able to say "this is what our sails can do, what about yours?"

Closing remarks

Because this work may have a much wider application than just for Junk sails, I am seeking comments from yacht designers and sail-makers to see if this has any relevance to what they do. If it has then I hope to form a wider interest group (and see if they will put some money into it!). So far I have had an encouraging response. If this works out, then I think the JRA stand to gain considerable credit from initiating this work.

Acknowledgements

Thanks are due to: Robin Page and the staff of the Mayflower Marina in Plymouth, Alec and William Blagdon, Maurice Donovan, Juliet Zha, Bunny Smith, George Chapman, Francis Chiu and Michael Belmont.

E J C Chapman 5 December 1997.

Dear Robin

As you are publishing my letter addressed to the Sub Committee members and Joddy Chapmans reply, I feel I have the right and indeed duty to comment to all J.R.A. members so that they can better judge whether or not their funds are being spent wisely

My principle objections to the path research has taken are:

Effort has been focused on the performance of the quarter scale model of Jillies sail plan as copied on Capricorn but with different battens and an inferior main sheet system in that it is sheeted differently on each tack. Capricorn is used as a test bed to a small extent, Capricorn is a look alike" only and I take no responsibility for it as I do for Fenix, Julie and Nymph.

Scale models can be misleading as research tools and at best can be relied upon only as far as the scale model is concerned and not for the real thing.

Measurement is everything & it is very difficult. In the past I have described the very tedious time consuming methods I had to adopt to obtain reliable comparative figures. I am wary of a lot of Joddy Chapman's figures because in the main they are short period measurements taken using their home made prototype unproven instruments on their hand steered 14 foot dinghy with its .10 sq. m. version of Jillie's 40 sq m. sail. Fudge factors are certain to abound.

I consider research should be focused on the particular and not the general. Wind tunnels are excellent tools for establishing reliable comparative data but they are not good at establishing absolutes nor are scaled models It is the designers responsibility to effect a successful compromise between all the values of the known factors inherent In any design to meet the owner's requirements It is the researchers job to try and establish values preferably in isolation and accuracy.

Two minor points need correction. I have never claimed Fenix to be "more than a match for Bermudan rigged Sadler 26's" My figures are given in Newsletter 26 If all things are equal, the Bermudan boat is superior when racing around the buoys.

Secondly, keep battens are not fitted as described by Joddy and were, of course, tested statistically in advance to make sure they did not alter the structural batten's properties.

If they are lashed with a continuous line, lightly tensioned and restrained at one end only, it allows them to slide fore and aft as camber alters and when tacking. Then there is no stiffening of the structural batten as they never form a composite beam as Joddy assumes.

Additionally, Fenix's structural battens were tapered from leech to luff to do two things, one to move the maximum camber ratio forward and two, to prevent leech hooking Her sail always had a sweet and smooth exit for the air. So too has Nymph. Joddy's assumptions are false, not that it really matters.

However, integrity does matter and current fictions such as "insects and the junk rig use different aerodynamics" do matter and need to be corrected. I have never written such, said as much, or thought so.

I suggest that all those involved in research follow "Ockhams Razor" which is a doctrine of simplicity. Keep it simple and above all true".

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