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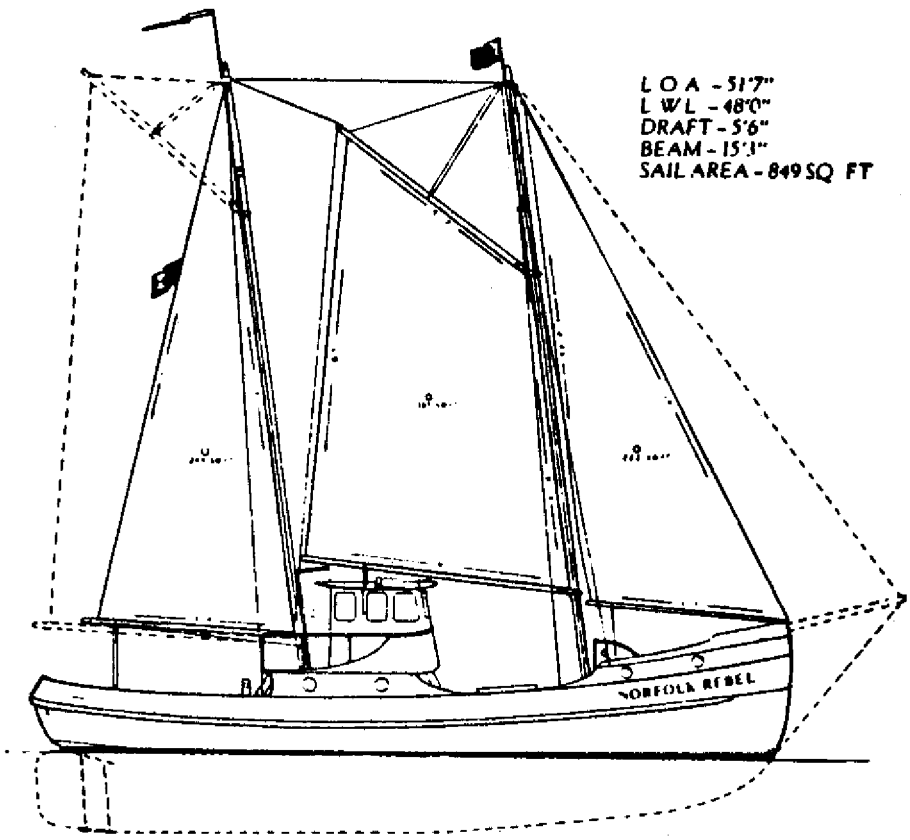
SAIL-ASSISTED COMMERCIAL MARINE VEHICLES
BIBLIOGRAPHY AND ABSTRACTS

by

John W. Shortall III, NA



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TECHNICAL PAPER NO. 28 MARCH 1983

SEA GRANT

SAIL-ASSISTED COMMERCIAL MARINE VEHICLES

BIBLIOGRAPHY AND ABSTRACTS

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John W. Shortall III, NA

Technical Paper No. 28
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University of South Florida
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ABSTRACT

The enclosed publication contains abstracts of 331 articles published on the subject of commercial sailing vessels and sail-assisted work boats of all kinds. This is part of a continuing project supported both by the University of South Florida and the Florida Sea Grant College, and is an update of the previous publication of abstracts, Florida Sea Grant College Technical Paper No.24, May, 1982. Abstracts are compiled regularly, and subsequent reports will be issued periodically. This report also contains a brief discussion of modern and historical commercial sail, the reasons for serious interest in same, and commercial sailing fishing vessels.

INTRODUCTION

In early, 1980, the Florida Sea Grant College approached the University of South Florida, College of Engineering and requested views on the holding of a conference on the subject of commercial sail with financial backing from the Florida Sea Grant College. After several discussions, it was agreed that it first would be better to survey the literature thoroughly, seek out gaps in information, make a recommendation as to whether such a conference should be held and outline the areas which it might address. The literature was more extensive than first believed. The of

For ease of use, the abstracts have been divided into the following twelve categories, each preceded by a brief discussion:

1. Major Commercial Sail and General Survey Reports
2. Historical Survey of Commercial Sailing Craft
3. Cargo and Passenger Commercial Sailing Ships
4. Modern Sailing Fishing Vessels
5. Sailing Work Boats
6. Economics of Commercial Sail
7. Technological Developments
8. Advanced Thrusters and Sail Rigs
9. Performance Prediction and Wind Routing
10. Research Vessels
11. Safety, Stability and Legal
11. Miscellaneous Applications

COMMERCIAL SAIL - A GENERAL DISCUSSION

Out of the last 5000 years, the world has been without a working sail fleet for only the past 50. This is not strictly true, because kattumarams - the progenitor of the modern catamaran - are the most widely used types of traditional craft on the east coast of India. There are approximately 50,000 sailing kattumaram fishing boats versus 15,000 fishing craft of other types. (6)

As evidenced by the large number of abstracts, there is considerable interest in the world in the prospect of commercial sail. Information available here indicates that the following countries are actively pursuing investigations into the practicality and economics of commercial sail: Australia, England, France, Germany, Greece, Norway, Netherlands, Sweden, Japan, Soviet Union and the United States. The motivation, of course, is the rapid escalation of petroleum-based fuel prices in recent years. Figure 1, taken from Reference (5), illustrates the dramatic rise in ship fuel costs and is summarized in the following table:

BUNKER C FUEL OIL COST

1973	$ 2.70 per barrel
1975	11.25
1977	13.60
1980	21.50
1990	200.00 est.

Engineers and others involved in the design and operation of commercial marine vehicles have undertaken studies and construction of vessels designed to utilize the wind and more have been proposed. The major reports listed in the references at the end of this section contain a wealth of information and opinions on the subject of the use of the wind to propel commercial marine vehicles.

ALTERNATIVE MARINE FUELS

Only four alternatives to petroleum have been identified as being of possible economic and engineering practicality: coal or its derivatives, nuclear fuel, wind and other means of utilizing solar energy. Coal has shown clear economic advantages, even over wind, for very large vessels - in excess of 25 to 30,000 tons. Due to governmental and private hysteria, nuclear propulsion will probably not be implemented for commercial propulsive use. There are no clearcut economic applications of direct use of solar energy in the forseeable future for marine transportation. This leaves for consideration a product of solar energy: the wind. The wind is free but fickle. Often there is either too much or too little and frequently it blows from the wrong direction. Nevertheless, its application for marine transportation has been demonstrated both by historical use as well as modern developments in materials and thrusters. As compared with coal, use of the wind is non-polluting, and there are no waste disposal problems. The mining of coal also wreaks havoc with the environment. This cost is often neglected by the economists who report favorably on the widespread re-introduction of coal into the world's economy.

SPEED COMPARISON HISTORICAL & MODERN SAILING VESSELS

NAME	DWL	DWT	SAIL AREA	SPEED	24 HR.RUN
PREUSSEN	407'	8000	56000	17 kn.	370 N.M.
CUTTY SARK		213	1500+	24850	15.1 363
THERMOPYLAE		210	1400+	25510	14.9 358
MONOHULL YACHTS					
ONDINE III		72	36.6	2650	12.2 293
KIALOA III		64	37.4	2880	11.3 270
EVIANE (12m.)		45.5	26.8	2200	9.8 235
MULTIHULL YACHTS					
MANUREVA	66.5	8.5	1480	13.6	326
SEASMOKE	48.5	9.5	1548	13.8	331
SEABIRD	35	3.2	880	14.4	345
PATTYCAT II		36.2	3.7	890	13.2 316
3 LEGS OF MANN			34	2.0	590 14.2 340
MODERN ENGINE DRIVEN FREIGHTER					
	900	100,000	---	15	360

MODERN SAILING SHIPS

Some of the pros and cons of such are given in the following tables:

ADVANTAGES

1. Minimize cost dependence on oil.
2. More freight capacity since less fuel storage space.
3. More stable - sails inhibit rolling.
4. Can maintain service speed a higher percentage of time than conventional ships.
5. Have the potential to fulfill 50-75% of the ocean transport needs.
6. Environment

DISADVANTAGES

1. Scheduling for port arrivals.
2. Apparent size limitation: 8000 - 15000 DWT.
3. Upwind tacking - denied quadrant or more.
4. Ballast while empty gives extra weight to propel and takes space.
5. Bridge heights at major ports limit mast heights.
6. Resistance to "new" concepts by management, governments, operators, insurance firms and unions.
7. Overly restrictive licensing restrictions particularly with regard to stability.

MINI LACE - AN EXAMPLE OF SAIL RETROFIT

The Wind Ship Corporation in 1981 retrofitted the Greek freighter MINI LACE with one 279 sq.m. (3000 sq.ft.) cat-rigged sail on a free-standing, unstayed, rotating mast some 30.5 m. (100 ft.) tall. The ship has already travelled some 10,000 sea miles and has proven to have 20% or more fuel economy as compared to identical vessels with engines only. The sail may be trimmed and furled from the bridge or manually. MINI LACE showed an unexpected side benefit: the ability to maintain full service speed in wind and wave conditions which force conventional ships to reduce speed. No increase in crew size was necessary, and training in operation of the manual sail controls was not a problem. A rigid wing sail is now being designed for installation on a second ship, and if it proves successful will be automated so it can also be controlled remotely. It is expected to improve fuel economy at least another 15 per cent. The figure illustrates the freestanding, furling rig.

CURRENT DESIGN APPROACHES AND THRUSTERS

There are three current design approaches for commercial sail: 1. retrofit of existing vessels with auxiliary sail power. 2. adaptation of historical sailing ship technology using modern materials. 3. totally new approaches to wind propulsion.

Retrofit of existing vessels must be considered on a case by case basis with a thorough evaluation of the economics involved. All of today's boats and ships cannot be scrapped in favor of wind technology. In some cases, retrofit can give clear advantages where sail provides extra horsepower to allow engines to be run at lower RPM and hence lower gallons per hour of fuel useage. The advantage is clearly proportional to the length of the vessel's route and the presence of sufficient winds from favorable directions. Some argue that the millenia of man's experience with sailing craft of all kinds should be utilized by returning to the designs of successful sailing ships of 70 or more years ago with perhaps the substitution of dacron for canvas and nylon for hemp. Other groups prefer to consider all the ways in which energy in the wind might be converted to useful propulsion. Some thruster systems for possible wind propulsion are sketched in Figure 2.

The Reference (5) study is probably the most thorough that has been done on the whole subject of commercial sail and represents the finest example of conceptual design ever seen by the authors of this report. One conclusion of many of this study is that of eight thruster systems studied, hard wing sails represent the most practical and efficient at this time. Rotors and turbines were only ruled out because of lack of data. See Figure 3 for a drawing of the solid wing mast as advocated by the Windship Corporation.

GAPS IN KNOWLEDGE

It is unfortunate that details have not been published on the French experiments with advanced wind thrusters. It seems abundantly clear that research should be undertaken in the U.S.A. on such potential high lift thrusters as Flettner and Coanda rotors and wing sails. Even some modest static experiments could provide a solid basis for a full-scale test on a small commercial craft.

Originally, it was intended to include a category on design engineering aspects of commercial sailing vessels. It was decided to divide that field into wind thrusters and technological developments, due to the potential significant advantages of rotors and wing sails over conventional soft sails and hence on the economics of commercial sail. Rotors would likely be more advantageous for the retrofit of such vehicles as commercial fishing boats. These subjects, and others are to be discussed at the Reference 11 conference.

Major gaps also includes the lack of reports on such significant areas as: banking, insurance, labor, unions and government, all of which will have significant impact on commercial sail. As one example, insurance rates for sailing fishing vessels in the Pacific Northwest are somewhat less than those for motorized craft, about the same in Virginia and more in one case in New England. Another example is the rather strict U.S. Coast Guard stability criteria for commercial sailing passenger vessels. Unlike many other countries, the United States does not enforce stability criteria for fishing vessels. These topics were addressed at the Reference 10 conference.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation to the many who have contributed difficult-to-locate articles and information such as: Alan Adler of Stanford University, Kathy Hill and Captains Lane and Jesse Briggs of SAILA and the "Norfolk Rebel", Lloyd Bergeson of Windship Corporation, Hugh Lawrence of Ocean Carriers Corp., Dr. James H. Mays consultant to Windship Corporation and now at Ocean Routes Corp., Jon Lucy of Virginia Institute of Marine Science, Virginia Sea Grant Program - College of William and Mary, Cliff Goudey of MIT Sea Grant, K.Lange of the Bundesforschungsanstalt fuer Fischerei - Hamburg, Germany, P.W. Ayling of the Royal Institution of Naval Architects, Society of Naval Architects and Marine Engineers Panel H13 for Sailing Vessel and Sailing Yacht Research and many others. Even a brief perusal of the abstracts will reveal the many articles published by the "National Fisherman", which long has been publicizing developments in commercial sail.

REFERENCES

1. "Feasibility of Sailing Ships for the American Merchant Marine"; Woodward, Beck, Scher and Cary. University of Michigan Report No. 168; Dept. of Naval Architecture and Marine Engineering; College of Engineering; Ann Arbor, MI 48109. February, 1975.

2. "The Future of Commercial Sail - A Selection of Papers Presented at the Meeting of RINA Small Craft Group"; Royal Institution of Naval Architects; 10 Upper Belgrave St.; London SW1X 8BQ, England; Occasional Publication No.2; 27th November, 1975.

3. "Commercial Sail - Proceedings of a Symposium Held at the Royal Institution of Naval Architects -14th June, 1979"; Department of Industry; London; 1980.

4. "Symposium on Wind Propulsion of Commercial Ships"; the Royal Institution of Naval Architects; London; November, 1980.

5. "Wind Propulsion for Ships of the American Merchant Marine"; Wind Ship Development Corporation; PO Box N; Norwell, MA 02061. Bergeson, Clemmer, York, Bates, Mays, Glucksman; March, 1981.

6. "Improvement of Kattumarams - Development of Small Scale Fisheries in the Bay of Bengal"; P.Gurtner; Chief, FIIT; Food and Agriculture Organization: FAO; Rome, Italy; February, March, 1979.

Figure 1
Oil Price Rise 1970-1981, Inclusive

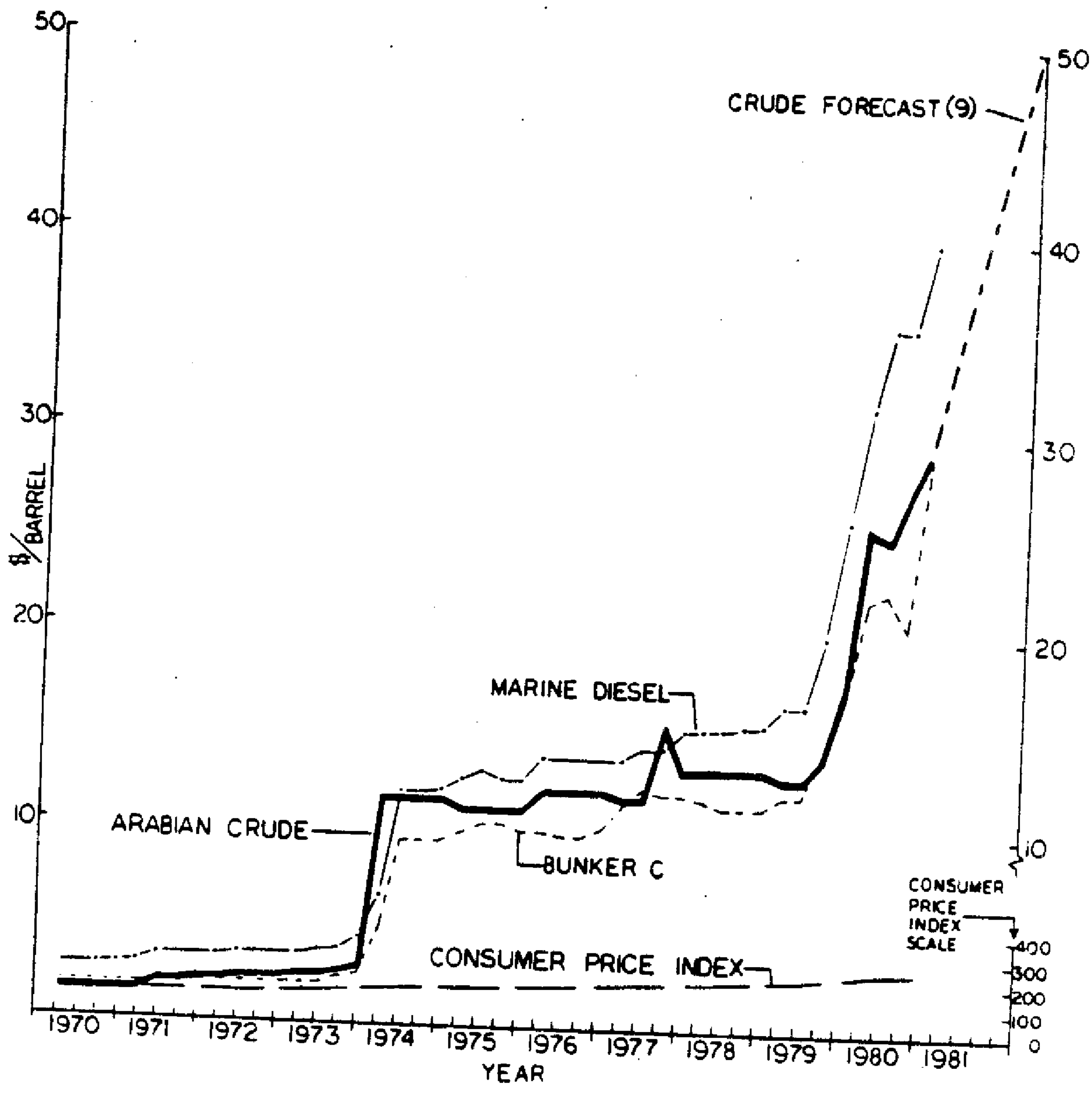


Figure 2

Rig Alternatives

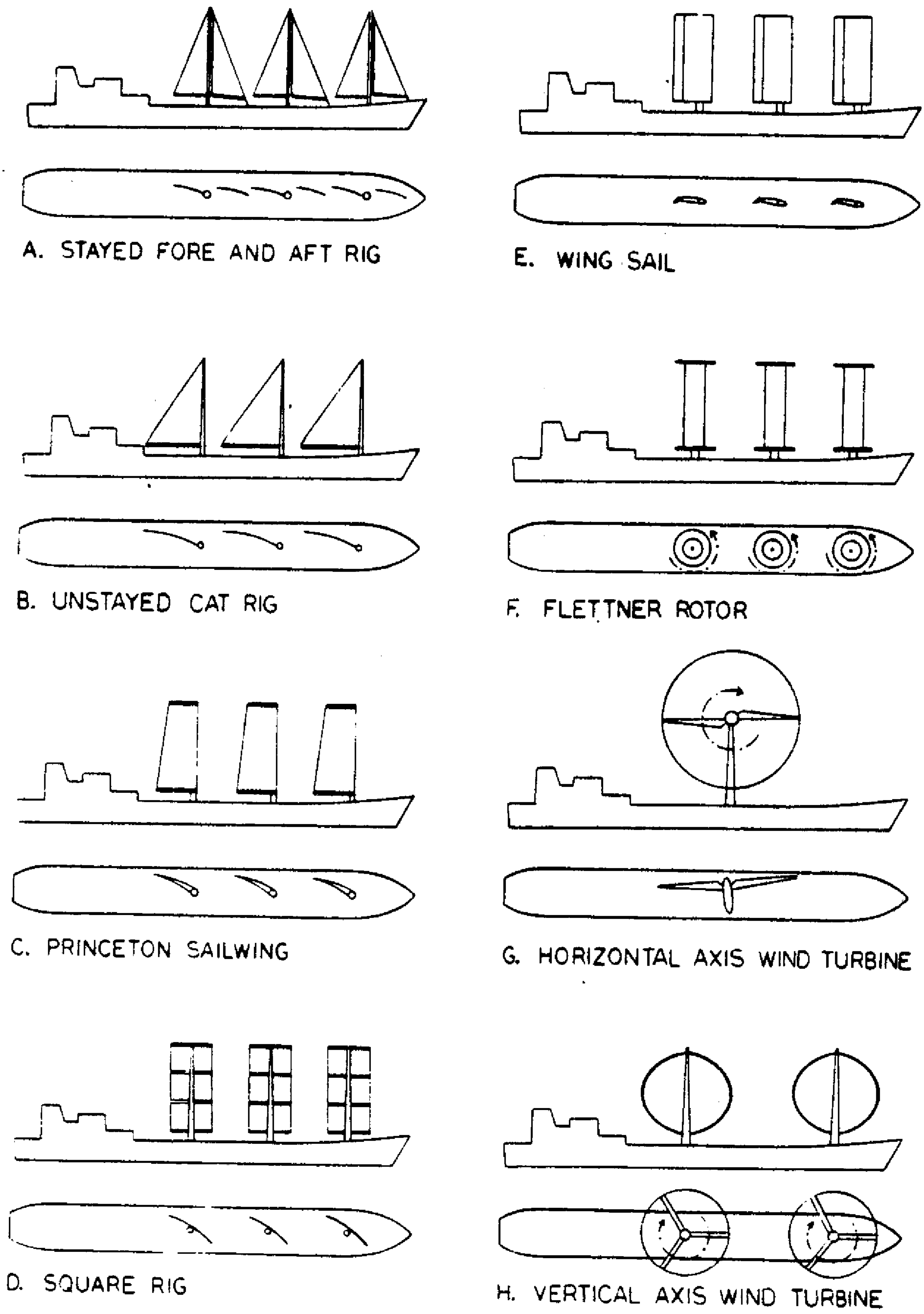


Figure 3
Wing Sail
Schematic Arrangement Sketch

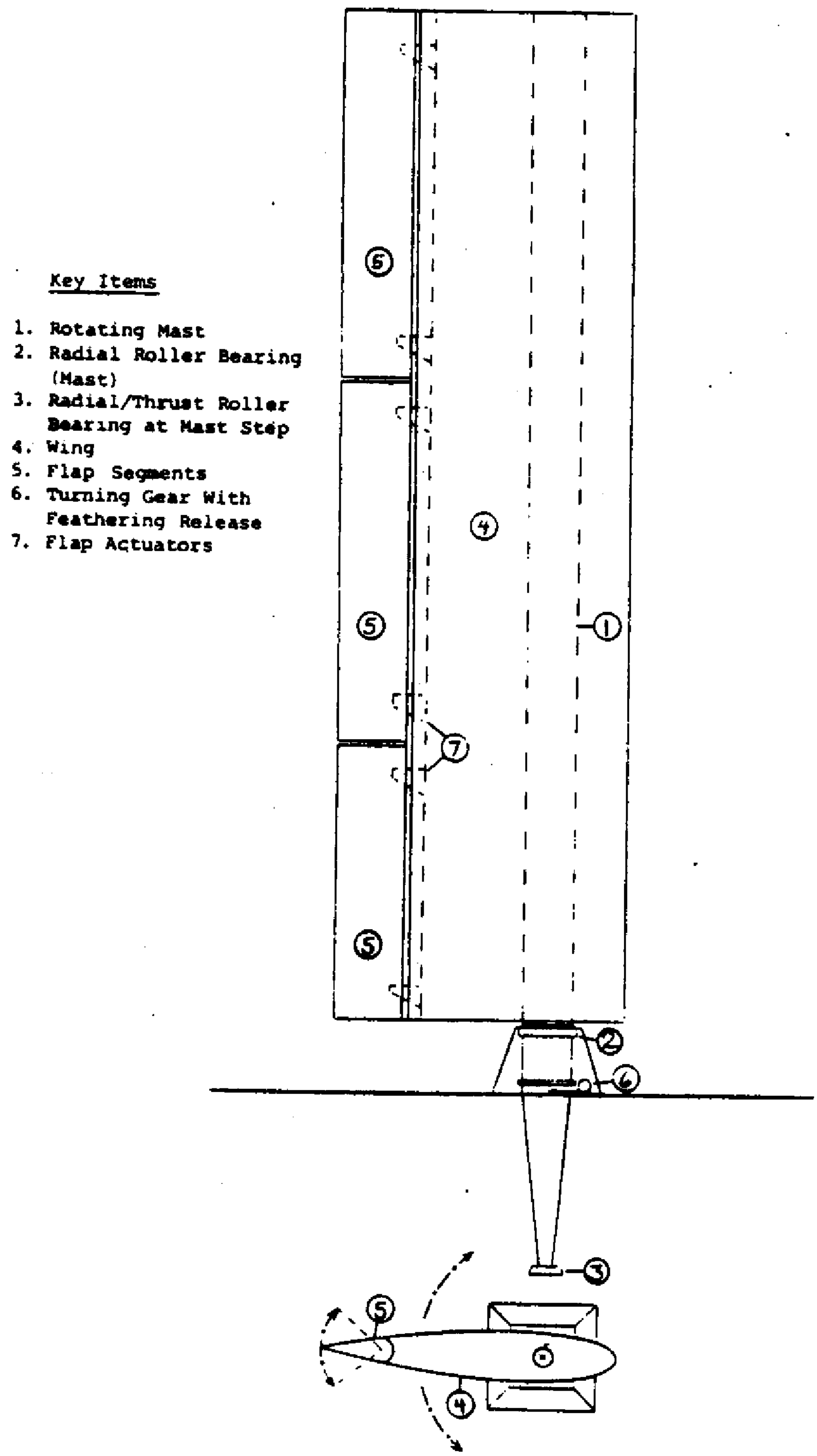
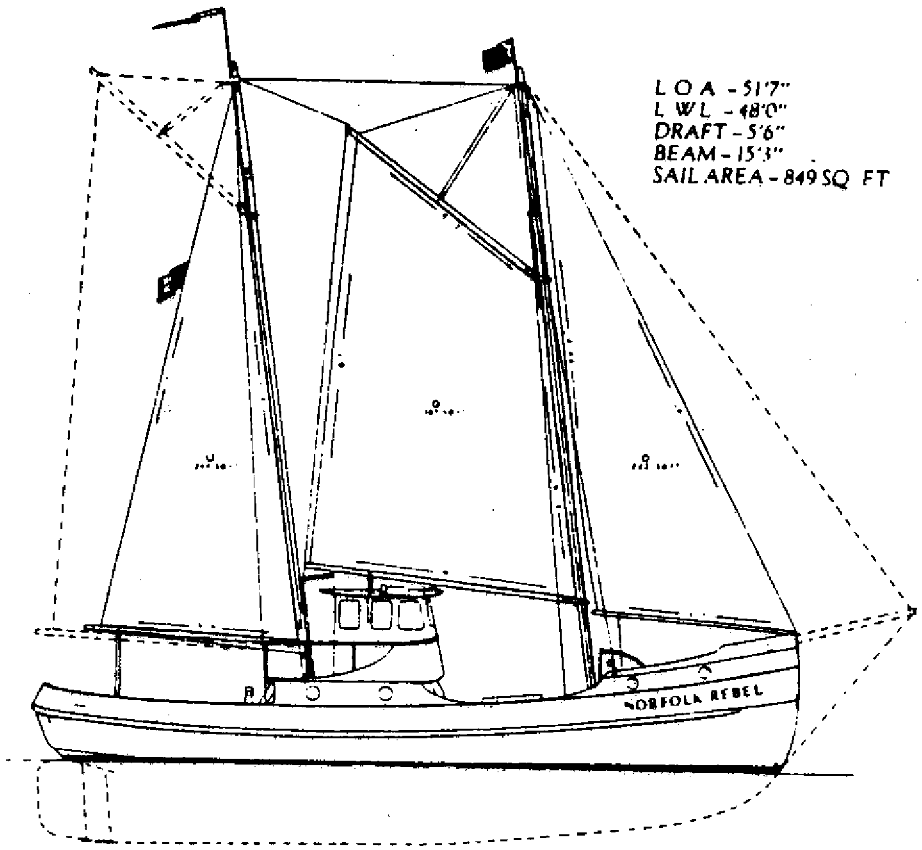


Figure 4



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MAJOR COMMERCIAL SAIL AND GENERAL SURVEY REPORTS

1. SYMPOSIUM ON WIND PROPULSION OF COMMERCIAL SHIPS. (SWPCS)(The Royal Institution of Naval Architects, London, November 1980, pp 250).

This is a compilation of 18 major papers which are abstracted separately. Topics include: economics, wind and weather routing, advanced thrusters, speed prediction, operations and sailcloth.

2. COMMERCIAL SAIL - PROCEEDINGS OF A SYMPOSIUM HELD AT THE ROYAL INSTITUTION OF NAVAL ARCHITECTS ON 14 JUNE 1979. (Department of Industry, London, 1980, pp 185).

Another compendium of six major papers plus extensive general discussion and written contributions. The papers are abstracted elsewhere in this report and cover historical surveys, design engineering, training, energy conservation, climatic factors, advanced thrusters and the Windrose square-rigged ship.

3. A. Millward ed., THE FUTURE OF COMMERCIAL SAIL - A SELECTION OF THE PAPERS RESENTED AT THE MEETING OF RINA SMALL CRAFT GROUP LONDON,27TH NOVEMBER 1975. (The Royal Institution of Naval Architects, 1976, pp 88).

Six major papers are published in this work on topics including a detailed description of DYNASHIP, a modern fore and aft rigged sailing cargo ship, a commercial sailing ship for the South West Pacific, sail for auxiliary propulsion of a VLCC and economic analyses.

4. L.Bergeson, G.L.Clemmer, J.E.York, A.P.Bates,Jr., J.H.Mays and M.A.Glucksman, WIND PROPULSION FOR SHIPS OF THE AMERICAN MERCHANT MARINE (WPSAMM)(Wind Ship Development Corporation and U.S.Department of Commerce, Maritime Administration, Office of Maritime Technology, March, 1981, pp 245).

This report presents the technical and economic rationale for utilizing wind propulsion systems for commercial shipping - specifically vessels of the American Merchant Marine. Alternative rig configurations ranging from fore-and-aft and square sails to wing sails and wind turbines, are evaluated for their aerodynamic efficiency, technical feasibility and cost.

An integrated, analytical computer model is described and used for the parametric analysis of conventionally powered and motor sailing vessels. U.S.-Foreign oceanborne trade routes are evaluated for their sail-assist potential. The conceptual design of a 20,000 CDWT sail-assist multipurpose dry cargo vessel is presented and discussed.

General conclusions of the report are:

1. Sail assist is technically feasible and economically advantageous.

2. Motor sailing rather than pure sailing vessels provide the greatest economic advantage in the current economic environment.
3. Motor sailing can be used either to reduce fuel requirements or to increase average speed without increasing fuel consumption.
4. The capital costs of sail-assisted vessels should be comparable to conventional vessels.
5. The wing sail appears to offer the best combination of aerodynamic efficiency, simplicity of operation and cost.
6. Weather routing enhances the economic performance of sail-assisted vessels.

An extensive bibliography is included of about 150 or so references divided into the following categories: engineering and economics, performance prediction, passage analysis and general and review.

5. J.B.Woodward, R.F.Beck, R.Scher, C.M.Cary, FEASIBILITY OF SAILING SHIPS FOR THE AMERICAN MERCHANT MARINE, (The University of Michigan, College of Engineering, Department of Naval Architecture and Marine Engineering, Report No.168. February, 1975. pp 98).

This study was performed for the U.S. Department of Commerce, Maritime Administration and presents an economic comparison of the performances of several sizes of sailing ships vs. those of comparable powered ships, all on several long trade routes from North American ports. Ships are of 15,000, 30,000 and 45,000 tons cargo deadweight. Conclusions: Deep sea commercial sailing ships are technically feasible including updated configurations with perhaps doubts about a few details, chiefly in the sail-handling arrangements. A significant technical point is the apparent upper size limit on commercial sailing ships, a limit far below that of powered ships. This is a consequence of the need for reasonable sail aspect ratio which requires height and the need for deep draft to develop needed side force for on-wind sailing. The limiting size is about 50,000 tons cargo deadweight, though bigger ships are possible if poorer performance is acceptable. The sailing ship must have more ballast capacity for good performance without cargo. Channel depths are limiting for sailing ships. For U.S. East Coast ports, the draft limitation is 45 feet which corresponds to a sailing ship of 45,000 DWT and a powered ship of 70,000 to 80,000 DWT. Centerboards were not considered in this study. Discussed is the need to be able to power at a minimum of six knots in calm water for maneuvering near ports and the difficulty of so doing in high winds. At this time the detailed economic studies seem to favor the powered ship. The conclusion is that the commercial sailing ship is not an economically feasible alternative for the American Merchant Marine in the near future. This is tempered by the fact that the estimates do show the sailing ship position to be close to equal footing with powered ships.

6. C.T.Nance, "Wind Power for Ships - A General Survey", Abstract (1) above. p 1-16.

The rise in recent years of interest in the possibility of wind energy once more playing a part in propelling commercial ships is surveyed, and the present status is briefly outlined. The six principal wind-propulsion systems-square rig, fore and aft rig, aerofoils, magnus effect devices, wind turbines, and airborne sails (kites) - are briefly summarized, and limitations frequently said to be imposed on such systems in terms of size, speed and practcal problems are considered.

Opportunities for the reintroduction of windships are reviewed, suggesting that the possible range of use extends far beyond the traditional limits of sail.It is deduced that the central problem at the outset of the 1980's is how to match to each requirement the most suitable rig, ship size, wind/fuel engine power ratio, and service speed; and that the pressing need is for the acquisition and organization of the necessary data to enable this to be done.

Experience in the Government-funded wind turbine ship study is then drawn upon to suggest a rational methodology boh for 'quick-look' and more detailed studies, aimed at presenting results in a form appropriate to the needs both of the marine economist and the ship designer.

It is concluded that the need for investment in this field of data collection and evaluation is now urgent.

7. G.Mearns, "The Large Sailing Ship-Dinosaur or Development". Abstract No.1, p.37-50.

The recent oil crises and the increasing price of fuels has triggered interest in the development of large sailing ships and wind propulsion systems. The paper reviews the development of the large sailing ship from 1824 to 1911 and concludes that even by the mid-point of this period, the large sailing ship could not be justified on commercial grounds.

The problems of analysing the performance of sailing ships are examined and factors affecting this perfomance presented as well as an attempt to establish the horsepower provided by conventional sails. A simplistic approach is suggested to permit comparisons to be made and a practical example is provided.

Some reasons for the demise of the large sailing ship are suggested and disadvantages summarised. It is noted that many of these disadvantages may have application to systems of wind propulsion or assistance. Finally, it is suggested that if fuel economy is the primary objective, there are a number of alternative strategies which can be adopted by shipowners and shippers which will be more attractive than the use of wind power as even today fuel costs are more favorable to the motor ship vis a vis the sailing ships than they were to the steamer of 1840.

8. A.D.Couper, J.King, P.B.Marlow, "An Evaluation of Commercial Sail". Abstract No. 2, p 6-41.

Commercial sail flourishes in many parts of the world. In Indonesia, 10,000 sailing arhus, very few of them motorized, are a vital part of the transport system. Similary, in other parts of Asia, the Pacific, Caribbean and Middle East sailing vessels are engaged in the carriage of goods and passengers. It was the poor safety record of sail during its last days that hastened its decline. Flettner's rotor ship BUCHAU which entered service in 1925 was one attempt to revive wind-powered ships. What has changed since the 1920's are the possibilities of better sailing ship design by advances in aerodynamics and the increasing fuel costs. However, Lloyds Register of Shipping concludes that sail is a very 'fringe candidate' for the next decade since sailing ships 'would be too slow to meet the general needs of international trade, and manning requirements are high at a time when it is increasingly difficult to attract men to sea careers.'

Rapidly expanding fuel costs have made it necessary to examine the case for sail in more detail. Commodities which have a potential for being carried in sailing ships include: copra, jute, sisal, coconut oil, palm kernels, grain, soft wood products, wool, cotton, fertilizers and possibly vegetable oils.

Problems of sailing vessels include the difficulty of maneuvering in restricted waters, and tugs are advanced as one solution. Pointing and the lee shore problem are also discussed. Detailed economic analyses are presented for eight different cases comparing motor and sailing ships with varying fuel costs in terms of the Required Freight Rate: RFR for two different sized vessels: 15,000 and 50,000 DWT. This analysis suggests that a larger sailing vessel has a greater advantage over and equivalent motor driven vessel than does a a smaller one but this advantage is reduced as the distance travelled increases except in the case where the motor vessel operates at the same average speed as the sailing ship.

9. General Discussion. Abstract No. 2, p. 149-185.

Wind power shipping has one great advantage over almost all other types of 'alternative energy' in that it has been historically demonstrated that the world's seaborne trade can be carried in wind powered ships. The Soviet Union is developing wind ships for use in the Black Sea. Also advocated was the need to minimize consumption of non-renewable source of energy, not necessarily their cost on a ton-mile basis. "We just will not have the energy at some time in the future." (Cmdr. Ranken representing the Watt Committee on Energy.) Mr. Ellison commented that an auxiliary engine can be much lighter and smaller for the same power output as an engine required for continuous running, because higher revolutions per minute are acceptable. This means that quite high power can be available for docking and for use in congested waters without having a large engine room. Propeller drag is a major consideration and variable pitch is highly desirable and suited for ships of 3,000 to 5,000 tons.

10. Peter J. Rappa, "Sail Assisted Technology and Related Topic: A Bibliography," Hawaii Sea Grant Program, no date. Probably 1981.

33 citations are given.

11. Capt. Ed Shields, "Veteran Skipper Sees Little Chance Working Sail Will Regain Favor," (Letter) National Fisherman, November, 1981, 7,224..

Sail was the only method for operating a vessel on the ocean for many years and did a good job during that period. Life on the vessels was not as severe as some of today's writers would indicate. The writer comments on the sailing lumber ships of the Pacific which were small by today's motorized ship standards. The schooners with auxiliary engines required such for operating in tight conditions around ice packs and in shallow confined harbors. There was also considerable pressure from the crew to operate the engines in periods of calm and light airs. Engines will be necessary. Fuel storage will limit cargo capacity. Crew wants steam heated individual staterooms. Today's high profile power ships require large engines to control them during high winds.

12. Lance Lee, "Is There Working Sail in Our Future- Experts Eye Freight Potential," National Fisherman, June, 1980, 78,79,91.

The author advocates the following guidelines for sailing freighters: 1. both public and private funds should be used. 2. modified rather than old fashioned rigs may be right. 3. steel hulls or at least composite appear necessary. 4. critical design factors include: hull and rig criteria, economics, viable routes, time of year, nature of paying cargo and the important variable of seamanship. The article mentions some details of the Windship study (Abstract No.4). Other projects mentioned briefly are: the scow sloop LILLY which runs general freight to and from Martha's Vineyard, Massachussetts, Jacques Thiry's UNICORN destined for the Caribbean trade the VERNON LANGILLE small lumber carrier, and Frank MacLear's design for a 330 ft. motorsailer with staysail schooner rig.

13. F.S.Schaefer, "New Pioneers of an Old Idea - The Commercial Windship," Sea Frontiers, Jan.-Feb.,1981, 2-12.

This survey of the entire field includes brief information on the sail-equipped oil rig ROWAN JUNEAU which travelled from Texas to Nova Scotia, the 60 foot steel schooner CORNUCOPIA which has been operated out of Honolulu, Hawaii for the past six years, the STEEL REBEL and NORFOLK REBEL of Norfolk, Virginia which operate as sail-assisted tugs, fishing vessels, salvage craft and small freighters, the SHIN AITOKU MARU of

Japan, the CSY 44 sailing fishing boat, the JOHN F.LEAVITT, Skookum Marine's line of 53 to 70 foot sailing fishboats, the PATRICIA.A. 180 ft. schooner being furnished for the Caribbean trade and various concepts sukch as: WESTERN FLYER, Frank MacLear designs of a 97 ft. fishing vessel and 140 foot cargo schooner, SAILINER by Windrose Ships in England, Flettner rotor investigations in England, DYNASHIP and the Windship Corporation Study.

14. Mike Toner, "Sail Power- Interest in Sailing Ships Rekindled by Cost of Fuel," Miami Herald, Aug.19,1981, p E-1 and 3.

This is another general survey which discusses fuel prices, the Windship report, the Japanese work, the PATRICIA A. et al. The point is made that there are 25,000 merchant ships plying the seas using an estimated 5 to 8 percent of the world's oil consumption. On smaller ships, under 400 feet in length, there could be some savings on fuel. The average shrimp boat uses some 60,000 gallons of fuel per year. There are 4500 shrimpers operating in the Gulf of Mexico, and fuel savings from sail retrofit could be considerable. Research at the University of South Florida is also mentioned.

15. Peter Rappa, "To Sail or Not to Sail?," Makai, Univ. of Hawaii Sea Grant College Program, Dec.,1981, p 5.

This short article lists some 17 references to commercial sail.

16. R.Robinson, J.Ross, "Will the Wind Work," Sail Magazine, Jan.,1981, p 92-99.

This is yet another general survey of the field. There are well over 10,000 registered sailing vessels in Asia, India and the Pacific, and they carry nearly 2 million tons of cargo annually. However, total volume of goods carried by sea is aproaching 4 billion tons, nearly half carried in vessels of 18,000 deadweight tons or greaer. Discussed are the Japanese projects, Windship Corporation, University of Michigan study, DYNASHIP, Michael Willoughby's SAILINER, Windship's Magnificent proposed construction of the PREUSSEN II and MacLear's and Dick Carter's designs. The 190 foot luff on the oil rig sail required a tension of 150 tons! Also described briefly are the PATRICIA A., Hugh Lawrence's 170 foot Baltic trader, D.C.(Sandy) Anderson's Sail Freight Interational, Ben Wynne's concept of a 100 knot hdyrofoil catamaran and Phil Bolger's design for the New Alchemy Institute's 210 foot ark, a 50 foot working model of which is now sailing out of Wood's Hole, Mass.

17. K.Leach, "Sailing Reaches into the Future," The Ensign magazine, April, 1982, 14-15.

This short article discusses some of the more commonly known commercial sail projects and emphasizes rig developments with comments on the unstayed mast and work by Garry Hoyt and the Gougeon Brothers. The latter have developed very high performance wing masts as an offshoot of work for NASA on laminated wood turbine/windmill blades for electrical power generation.

18. W. Marx, "Seafarers Rethink Traditional Ways of Harnessing the Wind for Commerce," Smithsonian Magazine, Dec., 1981, 51-59.

The following vessels are discussed: WONIYA, CORNUCOPIA, SHIN AITOKU MARU, NORFOLK REBEL, STEEL REBEL, MINI-LACE and the jack-up oil rig equipped with twin sails by Ratsey and Lapthorn. Mentioned also is Greg Brazier's PHOENIX which is to be a "volksboat" - a UPS of Long Island Sound.

19. Patricia A.Lawrence, "Bibliography: Wind Propulsion for Commercial Vessels," Ocean Carriers Corp., PO Box 1859, Sausalito, CA 94966, 1982.

This is an excellent 14 page bibliography of selected works on commercial sail: technical papers, periodicals, conferences or symposia, collections, bibliographies and abstracts.

20. Thomas Lamb, PE, "Fishing Vessel Fuel Utilization Study," Part I - Bibliography of Literature and Current Research on Fuel Utilization," Norship, Inc., 18303 84th Place West, Edmonds, Washington 98020, U.S.A. Report to SNAME Panel MS-11 on Fishing Systems. 185 pp.

Only a few pages concern commercial sail, and significant abstracts have been condensed in this publication under the appropriate categories.

21. Joanne A.Fishman, "A Fresh Wind for Sail Power," New York Times Magazine, December 6, 1981.

This covers most significant sail-assist studies, legislation and vessels at this date in the U.S.

22. Christopher Pope, "Saving on Sail," Renewable Energy News, June, 1982, pp 21-32.

This is an account of the Norfolk, May, 1982 conference/workshop on sail-assist.

23. "Sail-Assist Conference Scores a Success," The Work Boat, October, 1982.

Another account of this conference.

24. David Robb, "The New Age of Sail? As Oil Prices Rise, Wind Propulsion in the U.S. Gathers Steam," Sea Technology, August, 1982.

Same as above.

25."Alternative Fuels for Maritime Use," Maritiem Transportation Board, Commission on Sociotechnical Systems, National Research Council, National Academy of Sciences, Washington, DC 1980, 191 pp.

Only 23 pages are devoted to wind-driven ships in this comprehensive report which covers recreational and commercial craft. Discussed briefly are: Dynaship, sailwing, Flettner rotor and windmill driven ships.

26. John Frye, "Alternate Fuels Hold Little Promise as Power for Hungry Fishing Vessels," National Fisherman Year Book, 1980, pp. 90-94.

This is a comprehensive review of the Abstract 25 report and is summarized elsewhere.

27. "Hearing Before the Committee on Energy and Natural Resources United States Senate Niney-sixth Congress Second Session: S. 2992 A Bill to Authorize a Study of Sail-Assisted Technology as a Means of Reducing Energy Costs for Inter-island Transportation in the Trust Territory of the Pacific Islands, and for Other Purposes," August 26, 1980, U.S.Govt.Printing Office Publication No. 96-146, pp.300-552.

The hearings had as their purpose the determination as to the possibility of reducing energy costs for inter-island transportation in the Trust Territory by use of sail-assisted maritime vehicles. Senator Spark M.Matsunaga presided, and/or among those making oral and written statements were: C.R.Palmer of Rowan Co.(jack-up rig), Colin Ratsey, Capt.Jesse Briggs, Frank MacLear, Hugh G.Lawrence, Patricia A.Lawrence, William A.Warner, Lloyd Bergeson, Everett P.Lunsford, Jr., Dr.Paul C.Yuen, Bernie Arthur, Roy J. Yee and Dr. C.Dwight Prater.

28. Yvonne Freund, "Aeolus Helps Argonauts Save Fuel," Mechanical Engineering, August, 1982.

29. Jon Lucy, "Proceedings of the National Conference/Workshop: Applications of Sail-Assisted Power Technology - May 19-21, 1982," pub. ca. February, 1983.

Report on the Norfolk, May, 1982 conference. Virginia Institute of Marine Science, Virginia Sea Grant Program, College of William and Mary, Gloucester Point, Virginia 23062.

HISTORICAL SURVEY OF COMMERCIAL SAILING CRAFT

The following abstracts should be taken as merely representative of a vast body of literature in maritime history. Although some landmark authors and their works are cited, there are notable omissions such as those by Hornell, Greenhill, Worcester, Baker and many others. These are some of the books in the author's collection and were abstracted because of a close familiarity with their contents. Particularly noteworthy is Needham's volume described in Abstract No.20 which lists the accomplishments in ancient China, not all of which have even yet been adopted in the West. It might be that bow rudders, for example, would have a place in retrofit of power vessels with sails where more lateral plane as well as rudder area was required. For a particularly accurate expression of the apparent conflict between designers espousing old and new ways, see Abstract No. 10 under Technological Developments by Mr. Priebe. There is much that can be learned from past accomplishments, and it would be foolish to neglect the lessons of the past.

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HISTORICAL SURVEY OF COMMERCIAL SAILING CRAFT

1. George F. Bass ed. , A HISTORY OF SEAFARING BASED ON UNDERWATER ARCHEOLOGY. (Thames and Hudson Ltd., 1972).

Based on information derived from underwater excavations, 12 authors have written chapters on such subjects as: "The Maritime Republics: Medieval and Renaissance Ships in Italy", "Traders and Privateers Across the Atlantic: 1492-1733", "The Earliest Seafarers in the Mediterranean and the Near East", and "Waterways Open the New World", among others. Illustrations are excellent, and this work is particularly good at inferring methods of ship construction and emphasizes the need for trade being the prime stimulus for the development of sailing ships. Other stimuli for building and improving ships were for military and exploration applications. Unfortunately, the book's title does not indicate that it is limited to the Western world. Major ship developments from India, China and the Pacific Basin are largely ignored.

2. Fredrik Henrik af Chapman, ARCHITECTURA NAVALIS MERCATORIA - A FACSIMILE OF THE CLASSIC EIGHTEENTH CENTURY TREATISE ON SHIPBUILDING. (Adlard Coles, Ltd., 1968)

This work was first published in Stockholm in 1768. It is certainly one of the first known systematic, published books on naval architecture and ship design. Chapman's later "Treatise on Shipbuilding" which is also included in this republished volume was considered of such signal importance that it was translated into French in 1779 and into English in 1813. Translations into Russian and German followed. There are detailed, fold-out drawings of hull lines and rigging of numerous vessels. Of more interest is the treatise on shipbuilding which describes his resistance measurements of hulls, ship proportions, mast and yard specifications, scaling, test tank arrangement and more. He correctly approximates the metacentric height: GM and approximates by formula the stability moment. His prescription for merchant ships is: "1. To be able to carry a great lading in proportion to its size. 2. To sail well by the wind in order to beat easily off a coast where it may be embayed, and also to come about well in a hollow sea. 3. To work with a crew small in number in proportion to its cargo. 4. To be able to sail with a small quantity of ballast. He correctly enunciates the naval architectural principles to achieve these ends.

3.Howard I. Chappelle, AMERICAN SMALL SAILING CRAFT - THEIR DESIGN, DEVELOPMENT AND CONSTRUCTION. (W.W.Norton & Co.,Inc., 1951).

This is one of a series of classic works written by the late curator of the Smithsonian maritime collection. It gives hull lines, sail plans and descriptions of some 69 inshore sailing craft covering colonial and early American boats such as punts, bateaux and cutters, scows, shallops, skiffs, sloops, catboats, luggers, sloops, pinkies, Greek sponging boat, San Francisco Dago boat, Chesapeake Bay log canoes, Gulf scow shooners, skipjacks, etc.

4. Howard I. Chappelle, AMERICAN SAILING CRAFT. (International Marine Pub. Co., 1975)

This work is often confused with the reference cited above. It is a compilation of articles from "Yachting" magazine in the early Thirties. These were first collected and published in book form in 1936. There were over a hundred types of American sailing craft employed in the fisheries and in commerce between 1800 and 1900. A few scattered pictures, half-models and plans are all that remain of many of these types. This book is an attempt to make a permanent record of every type possible. As with all of Chappelle's books, detailed hull lines drawings and sail plans are given. Fifteen classes of boats are covered including: New Haven sharpie, Skipjack, Friendship sloop, Cape Cod catboat, Gloucester schooner, pinkies, Nova Scotia Tern Schooners, Bahama sharpshooters, Bermuda sloops and dinghies and American Pilot Boats.

5. Howard I. Chapelle, THE NATIONAL WATERCRAFT COLLECTION. (U.S.Govt. Printing Office, 1960).

This is a comprehensive catalog of the watercraft collection in the United States National Museum of the Smithsonian Institution. Many hull lines drawings and photographs of half-hull and fully-rigged models are included. The author describes a device to take off lines from a half-model, comments on the difficulty of obtaining true figures for displacement and discusses the construction of lift, block and hawk's nest models.

6. Howard I. Chapelle, THE BALTIMORE CLIPPER. (Bonanza Books, 1976).

First published in 1930, this book is a detailed appraisal of the class of sailing ship known as the Baltimore Clipper. Numerous hull lines and sail plan drawings are included with photographs of paintings of these vessels.

7. Howard I. Chapelle, THE AMERICAN SAILING NAVY - THE SHIPS AND THEIR DEVELOPMENT. (W.W.Norton & Co.,Inc., 1949).

Although concerned with sailing warships, this comprehensive work describes many American sailing vessels in considerable detail from the Colonial period until 1855.

8. Howard I. Chappelle, THE HISTORY OF AMERICAN SAILING SHIPS. (W.W.Norton & Co., Inc. 1935 and Bonanza Books).

With over 200 illustrations, this is yet another exhaustive treatment of the history of American sailing ships. Included are details on an 80 foot shoal draft, double centerboard schooner used to suppress the slave trade: UNION. Also covered are various frigates, privateers, slavers, fishermen, schooners, packets and a barquentine as well as sailing yachts.

9. Howard I. Chapelle, THE SEARCH FOR SPEED UNDER SAIL 1700-1855. (W.W.Norton & Co.Inc., 1967).

This work contains a good bit of naval architectural information on designing for high speed sailing as ascertained from detiled study of fast American sailing ships. The author has attempted to discover the influence of hull shape on speed by analysis of some of the faster vessels. His discussion of the influence on speed of the straightness of the quarter-beam buttock and its angle with the design waterline is excellent. Using lessons learned in the wind tunnel from aerodynamics, we understand this now to concern flow separation. There is a good discussion of early papers, articles and books on the naval architecture of high speed sailing vessels. First chapter of this book concerns the state of naval architecture and shipbuilding in the 18th century. The next six chapters divides the years from 1700 to 1855 into six logical time segments and discusses many vessels with the usual excellent drawings and pictures. For the naval architect, this is Chapelle's most interesting work.

10. Howard I. Chapelle, THE AMERICAN FISHING SCHOONERS 1825-1935. (W.W.Norton & Co.,Inc., 1973).

This is Chapelle's last great book. Again his superb draftsmanship and scholarly research are very evident. There are 137 plans of schooners with detailed descriptions including such usually neglected items as fife rails, saddles, figure-8 links, grab hooks, fisherman staysail etc. etc. This is a history of the commercial fishing schooner and its development in design, function and construction.

11. A.D.Couper & J.King, "Commercial Sail - Present Operations and Future Prospects," Symposium on Wind Propulsion of Commercial Ships: SWPCS, The Royal Institution of Naval Architects, 1980, 29-36.

This paper presents some of the background against which future sailing ship operations might take place. The present status of the world's merchant fleet is summarized and contrasted with sailing vessels in developing countries and in historical times. Described are some of the problems faced by shipping companies and some potential solutions. It is maintained that many proponents of commercial sail ignore the actual problems faced by the shipping industry. The authors maintain that there may be a role for sailing vessels, but that it is more likely to be in the operation of non-trading vessels and in developing inter-island services rather than in the mainstream of international seaborne transportation.

12. George Goldsmith-Carter, SAILING SHIPS AND SAILING CRAFT.

(Grosset & Dunlap, 1970).

This is a fine little book with color drawings and brief descriptions of sailing vessels from ancient times through medieval and modern periods.

13. Edwin Doran, Jr. WANGKA - AUSTRONESIAN CANOE ORIGINS. (Texas A&M University Press, 1981)

This is one of a number of papers and books by this author on primitive watercraft. Perhaps the oldest seafaring race is that located in the Pacific which people trace their origins from a homeland somewhere in Southeast Asia. Before caravels and junks, Austronesian sailing canoes crossed oceans with people and freight. There have been puzzling questions about how the Pacific Islands were settled. Professor Doran has measured the performance characteristics of many surviving sailing craft to determine exactly how well they do and did sail, and thus migratory routes can be traced. This work contains numerous drawings of native craft with sail plans and outrigger details plus polar curves of boat speed vs. angle to the wind and even stability diagrams. "Wangka" may be the earliest Austronesian word for boat. The book closes with distributional migration information and a discussion on ages and origins.

14. E.W.H.Gifford, "Improvement of Sailing Techniques in Tropical Countries," SWPCS, 241-247.

This paper traces the path of the development of traditional forms into more advanced sailing types, capable of giving improved performance and simplicity of handling. It demonstrates that there is scope for improvement in wind powered vessels without departing radically from traditional concepts, but taking note of modern knowledge of sailing theory and materials.

15. Basil Greenhill, ARCHEOLOGY OF THE BOAT. (Wesleyan University Press, 1976).

The author is Director of the National Maritime Museum in Greenwich, England, and he is well-qualified to trace the development of the boat from its four roots: raft, skin, bark and dugout boats. Much emphasis is given to Viking ships.

16. Bjoern Landstroem, SAILING SHIPS. (Doubleday & Co.,Inc., 1969 and 1978).

This is another picture book with fine black and white and colored drawings plus brief descriptions from papyrus boats to full-riggers.

17. David R. MacGregor, FAST SAILING SHIPS 1775-1875. (Haessner Pub., Inc., 1973).

The author is a maritime historian and used primary sources in this comprehensive work from the National Maritime Museum in Greenwich, England. There are many hull lines drawings and coloured plates. An excellent index makes this work particularly easy to use. Discussed in some detail among hundreds of other vessels are the tea clippers: CUTTY SARK and THERMOPYLAE, probably the world's fastest sailing ships. The CUTTY SARK is preserved at Greenwich ashore and may be visited. This monumental work is the first of its kind on fast British sailing ships. Some of the hull lines drawings are not internally consistent, and the author has the same problem as many in determining actual hull displacements. These carping comments in no way should detract from the importance of this book and its usefulness. Full-size blueprints of any of the reduced drawings may be obtained from the author for a small fee.

18. Edgar J. March, SAILING TRAWLERS - THE STORY OF DEEP-SEA FISHING WITH LONGLINE AND TRAWL. (David & Charles, Inc., 1953,1970).

Most of this work consists of detailed descriptions, with few illustrations, of the history of trawling, trawling grounds and yields, smack design, trawling gear, life on board, disasters and various fishing stations. The latter quarter of the book does have a large number of black and white drawings including hull lines and specifictions of a number of sailing trawlers.

19. George Mearns, "The Large Sailing Ship - Dinosaur or Development, SWPCS, 37-50.

This paper reviews the development of the large sailing ship from 1824 to 1911 and concludes that even by the midpoint of that period, the large sailing ship could not be justified on commercial grounds. Problems of performance and factors affecting performance are discussed in a simplified manner. Some reasons for the demise of large sailing ships are suggested and their disadvantages are summarized. Finally, it is suggested that if fuel economy is the primary objective, there are a number of alternative strategies which can be adopted by shipowners and shippers which will be more attractive than the use of wind power as even today fuel costs are more favorable to the motor ship vis a vis the sailing ship than they were to the steamer of 1840.

20. Joseph Needham, SCIENCE & CIVILISATION IN CHINA - VOL. IV:3 - PHYSICS AND PHYSICAL TECHNOLOGY - CIVIL ENGINEERING AND NAUTICS. (Cambridge at the University Press, 1971).

This is the seventh volume of Needham's projected life's work done in collaboration with Wang Ling and Lu Gwei-Djen with research conducted in China and in England. The latter half of this volume concerns nautics. Needham correctly ascribes credit for the following discoveries to the Chinese: magnetic polarity, fore-and-aft lug sails, multi-masted vessels, fully-battened sails, bulkhead built hulls, yulohs, bipod masts, axial rudders, anti-hogging trusses, collapsible masts, leeboards, centreboards, stem sliding centreboards, bow rudders, watertight bulkheads, free-flooding forward compartments for cushioning slamming shock loads, maximum hull section aft of midships, scale models and scaling to full-size, unstayed masts, quick reefing sails, fenestrated rudders, keels and sails, parrels, spritsail, triangular fore and aft sails, paddle boat, slung sliding rudder, balanced rudder, stern-post rudder, dry docks, copper hull bottom sheathing, iron armor for warships, bilge pumps etc. etc. Needham compares European developments in this field with Chinese and describes voyages of Chinese to East Africa and possibly South America which may have lead to propagation of these discoveries even before Marco Polo's time. Needham also appears frustrated by the problem of discovering true displacements of hulls: "Perhaps the most urgent need of naval archeology today is a systematic, sober and definitive study of estimated tonnages in all historical periods and cultures."

21. Sam Svensson, SAILS THROUGH THE CENTURIES. (Macmillan Co., 1962,1965).

This little book is another which surveys sailing ships from Roman times to the 1880's with brief descriptions and fine colored drawings of outboard profiles. As with many others abstracted above, it concentrates on European and American developments and ignores important contributions made in Eastern countries.

22. E.Doran, Jr., "On the Laguna Madre, Working Scows are Nothing New," National Fisherman, March, 1982, 75-77.

The author reports on the continued use in northeast Mexico of the previously reported extinct scow sloops. Hull lines taken from an abandoned craft are shown. The boats are still being built in Matamoros. In 1976, 120 of these sailing fishing craft were counted in operation.

23. S.D.Orsini, "The Great Steel Square-Riggers Thrived on Gales, "; National Fisherman Yearbook 1981, 126-129.

The apex of commercial sail was reached in the years surrounding 1900. The large sailing fleets were primarily European. In 1900, the French had a fleet of 1,235 square-rigged sailing ships. The largest sailing vessel ever built was the FRANCE II, launched in 1911. She was 419 feet long, had a gross tonnage of 5,633 and spread 68,350 square feet of sail. Sailing ships attained their highest degree of technical advancement during this final era. Most were built of steel. The PREUSSEN is described as a prime example of the later-day sailing ship. She was 407.8 feet long, had a gross tonnage of 5,081 and could haul 8,000 tons of cargo. Sail area was 59,000 sq.ft.between 48 sails. When she was built, the science of aerodynamics was nonexistent. Tank tests, years later, showed that her sails developed more than 6,000 hp at top speeds. At times, she could maintain speeds of 17 to 17.5

knots. Over the 14 voyages of her career, she averaged 8 knots. She sailed in the days before anti-fouling paints, and the author speculates on how well she might have performed with such. She went on the rocks in 1910 after a collision and was lost.

Also discussed in this article is the Unversity of Michigan report, Wind Ship Development Corp., the Ocean Carriers Group WESTERN FLYER,modern periods.

24. D.B.Irani, "India Has Never Stopped Using Sailing Vessels," ibid. p.129. (quoted from The Naval Architect, September, 1980.)

India has very sound maritime traditions under sail dating back several centuries. Modern, mechanized sailing ships have been developed of 150 tons: KOTIA type and 300 tons: BRIG type. They are fully decked, internally subdivided and fitted with auxiliary engines to give a cruising speed of six knots.

25. F.F.Kaiser, "Impressive Fore-and-Afters Showed Their Good-and Very Bad-Points," ibid, 1980, pp. 120-124.

Described is the 1902-launched steel schooner KINEO of dimensions 295.5 x 45.3 x 22.9 feet (90 x 13.8 x 7 m) and 2,128 gross tons. She had five masts and was rigged with fore and aft sails. She had a particularly rugged time in the Pacific with much rigging damage. Manning difficulties are discussed. Many difficulties of operating the larger sailing vessels are detailed. The author questions many of the new proposals for going to sizes beyond those found practicable during the sailing era. The idea of sail-assist also "leaves him cold."

CARGO AND PASSENGER COMMERCIAL SAILING SHIPS

All of the large commercial sailing ship projects known to exist, both abuilding and planned, are described in the following 60 abstracts. Many of the smaller vessels are covered as well. Perhaps the best known of these are: Bergeson's study and his retrofit of MINI-LACE, the DYNASHIP series, PATRICIA A., the WINDROSE square rigger, the excellent Japanese work on DAIOH and SHIN AITOKU MARU, PREUSSEN II and some lesser-known work in the U.S.S.R. Many of the smaller, modern cargo schooners are described as well. Here again emerges the controversy between those advocating the use of hulls and sail rigs from the turn of the century and those convinced that by use of modern materials and aerodynamics, new, more efficient ships can be designed.

CARGO AND PASSENGER COMMERCIAL SAILING SHIPS

1. H.F.Morin Scott, "A Full Scale Experiment in Commercial Auxiliary Sail." Symposium on Wind Propulsion of Commercial Ships, The Royal Institution of Naval Architects, 1980. 189-198.

It is proposed that a full scale experiment be carried out as soon as possible by fitting an existing commercial vessel with a number of simple, easily-worked sails and then gather with care, over a 12 month period, the appropriate data of wind direction and strength, sea state, ship speed and fuel consumption, man hours worked and cost of repairs and renewals to the sailing gear. This information together with original capital cost should enable a financial appraisal of the benefit of auxiliary sail to be determined. It is the author's belief that the fuel savings achieved in one year while maintaining the ship's service speed will approximate half the cost of fitting the sailing gear in a normal installation.

2. W.J.Hood, "Using Wind Reliable Routes for Bulk Cargo Transport," ibid. 17-28.

Some bulk cargoes from Australia have been shown to be be suitable for transport in sailing ships along wind reliable routes. Matching the cargoes and the routes remains a significant problem. This paper investigates the possibility of using a traditional wind reliable route in the Southern oceans to transport wheat along part of the distance between Australia and Europe. Following trans-shipment, the cargo reaches its ultimate destination by motor ship.

A much larger sailing vessel than any proposed to date and a type of rig using soft sails would be used. The rig is suitable for sailing with the wind well abaft the beam. No auxiliary engine would be fitted.

In spite of substantial savings in fuel consumption compared to a pure motor ship providing the same amount of transport, the paper concludes that the idea is not financially attractive at present day fuel prices.

3. R.M.Willoughby, "The Windrose Ship - Why Square Rig?" Commercial Sail Symposium, Dept.of Industry, London, 1980. 129-148.

A considerable part of this paper examines various thrusters and rig types including the fore and aft rig, windmills and air turbines, rotor ship and the square rig. The author concludes that a large sail cargo ship must be square rigged, either of orthodox design or of the fully automated DYNASHIP type. Discussers of this paper differed profoundly with some of the conclusions, especially the restriction of winds abaft the beam for sailing.

4. H.G.Lawrence, "A Modern Fore and Aft Rigged Sailing Cargo Ship," The Future of Commercial Sail, RINA Small Craft Group Meeting, London, 1975. 15-28.

The author discusses the design of a four masted, fore and aft schooner equipped with a 600 hp diesel engine. Length on deck is 96 meters (315 ft.) with a maximum of 4856 DWT. The author comments that there has been no sailing cargo ship since 1957 when the German four-masted barque PASSAT withdrew from the seas. He also believes that there is no way to find out how such a ship will operate without actually going to sea with her which is what he intends to do.

5. P.R.Warner and W.J.Hood, "A Commercial Sailing Ship for the South West Pacific Ocean," ibid. 29-46.

Presented are design details on a 240 foot long, four-masted schooner of 2200 DWT in 110,000 cubic feet of hold space. A double bottom for 600 tons of water ballast tanks is provided. The authors believe that sailing vessels can operate profitably on appropriate routes, and the ones chosen in this study seem pertinent.

6. J.B.Wynne, "Sails for the Auxiliary Propulsion of a VLCC Trading on the Northern Europe - Persian Gulf Route," ibid. 47-56.

The class of vessels studied was of 220,000 DWT tankers 310 meters in length (1017 ft.) with 20880 kW of power (28,000 hp.) The author assesses the prospects of sailing vessels in this service as unlikely unless the price of fuel oil rises several fold in real terms or the cost of wind propulsion can be made considerably less than assumed in this study.

7. J.F.R.King, "A Technical Description and Performance Analysis of the Dynaship," ibid. 1-14.

This paper reviews the present stage of development of the Dynaship project. It is an advanced sailing vessel developed over the past 20 years. The prototype proposed for construction is a 17000 DWT bulk carrier capable of 20 knots in a Force 9 wind. Rig consists of six large-sectioned, elliptical, hollow cantilever masts without stays. They are aerodynamically profiled and rotate to meet the apparent wind. Sail control is by hydraulics, remotely from the wheel house. Achieved are remarkably competitive voyage times and costs per ton of cargo delivered.

8. "Wind Blown Vessels," Motor Boating & Sailing magazine, January, 1976. 21 & 26.

John Couch of Dynaship explains the modern concepts of sailing freighters with all sail handling by pushbutton controls on the bridge. Wind tunnel test have proved the design concepts. Prof. Shallenberger and Bill Warner mounted three masts on a Shields One Design to further test the rig design on a scale basis in San Francisco Bay. Dynaship Corporation is located at 81 Encina Ave.,Palo Alto, California 94301.

9. M.Stuttaford, "A Return to Sail?", South African Yachting magazine, Sept., 1975. 32-35.

This is another presentation of the DYNASCHIFF concept (Dynaship in English) with details of the sail furling gear into the masts, speed predictions and economics. The author quotes Antoine de Saint Exupery: "Every technical development proceeds from something primitive via something complicated back to something simple, and a technical development is not perfect until a stage is reached where it is impossible to leave out anything else."

10. R.M.Engelbrecht, "DYNASHIP - Economical Cargo Carrier with Push-Button Sails," Popular Science magazine, August, 1976. 58-59.

This is a popular presentation of this concept. It is claimed that DYNASHIP will burn only 10% as much fuel as a conventional ship of the same size.

11. J.McCawley, "Return of the Tall Ships," Rudder magazine, November, 1971. 29-31, 70-72.

Discussed are the sail thrusters, computer performance predictions, wind tunnel tests at Hamburg

12. S.D.Orsini, "Wind-Powered Cargo Ships May Be On Horizon," National Fisherman, ca. 1976. 76-81.

This is a detailed appraisal of commercial sail which includes considerable details on DYNASHIP. Others discussed include: WESTERN FLYER, and the Woodward report from the University of Michigan.

13. "Dynaship - Modern Wind-Powered Cargo Ships to 45,000 DWT," brochure from the Dynaship Corporation, 1975. 12 pp.

In November, 1974, the DynaShip Corporation in the U.S. obtained the exclusive manufacturing and marketing rights to the DynaShip patents and technology in North and South America and the Pacific Basin countries. The brochure gives economic parameters, some details of rig design and overall layouts of a 527 ft. ship.

14. L. Bergeson, "Sail Power for the World's Cargo Ships," Technology Review magazine (MIT), March./April, 1979. 23-36.

A detailed review of the potential for sail power is presented. The author predicts the possible doubling or tripling of the price of marine bunker oil within the next decade. At present prces of $15 per barrel, potential savings through use of sails could reach $5.5 to $22 billion per year. Wind energy could replace a significant part of oil consumed in sea transport, but a conversion program will require governmental support. Tables are given of factors affecting windage and consequent tacking angles for maximum speed to windward. The 1902 square-rigged PREUSSEN had a tacking angle of 70 degrees. DYNASHIP is predicted to have 55 to 60 degrees as did the 1902 THOMAS W.LAWSON. A MacLear designed boomless 1979 fore-and-aft rig under sail alone achieved 40 to 50 degrees and while motor sailing 20 to 40 degrees. The author advocates consideration of a catamaran configuration because: 1. 50% of the cargo can be effective ballast. 2. When beached, the catamaran gains stability with both bows grounded, while a trimaran can lurch violently. 3. The catamaran is safer and more practical in larger sizes designed to carry heavy cargo and water ballast. A prototype might be about 220 feet long providing a cargo capacity equivalent to a 180 foot long single-hull prototype. Maximum potential catamaran speed of this type is calculated to be 25 knots in winds of 25 to 30 knots.

15. L.Dennis, "Greek Shippers Catch Wind of Sail Power," Soundings, August, 1981. 14.

Wind Ship Corporation has been approached by Ceres Hellenic Shipping Enterprises, Inc. of Piraeus, Greece, a shipper with more than 50 vessels that wants to take the plunge - experimentally - into sail power. Single mast rigs will be mounted on two 3,000 ton (dead weight) motor vessels. One rig was expected to finish sea trials with the sail rigs by the end of August. The two, a general cargo vessel and tanker, were being retrofitted with msts and two different types of sail rig at Buzzard's Bay, Mass. The ships will carry a 3,000 square foot sail on a single mast mounted near the bow to make room for working cargoes through hatches midships. Two rigs are being designed: a mast roller furling and reefing cat rig and a wing sail rig. Both are to be fully automated and pushbutton controlled from the bridge.

16. "The New Age of Sail Has Diesel Aboard," Technology Review (MIT), Aug./Sept., 1981. 80-81.

This is a summary report of the Wind Ship Corporation's comprehensive conceptual study. See abstract under the General Survey classification.

17. "MarAd Awards Contract for Sailing Ship Study," Maritime Reporter/Engineering News, January 1, 1980.

Announces the award of a $138,840 contract to the Wind Ship Corporation, headed by Lloyd Bergeson for a 12 month study to expand on the 1975 Michigan study. Other members of the contract team are: Frank MacLear, Prof. Henry S. Marcus, Dr. James H. Mays, A.P.Bates, Dr. Petrus, A.M.Spierings and P.C.Anderson.

18. J. Laitin, "Sail Power Still the Way to Go, Says Developer," Soundings magazine, February, 1980. 11.

Announces the Maritime Administration award to the Wind Ship Development Corp. and that private industry has contributed another $ 160,000 for the studies. Frank MacLear, a principal subcontractor and stockholder is quoted as stating that freighters can burn as much as $10,000 worth of fuel each day, accounting for 20 to 30% of their total operating costs. He estimated that the cost of fuel will be up to $5 per gallon by the end of the decade. He further said that a catamaran drawing less water may be the answer for shallow draft harbors.

19. "Harnessing the Wind," Yachting magazine, November, 1981, 25-26.

On August 24, 1981, Wind Ship Development Corp. unfurled the "world's largest single sail intended for continuous duty." The prototype consists of a Hodgson steel-spar and a 3,000 square foot dacron sail by Hood. Furling and unfurling is remote controlled from the bridge using hydraulic winches. The trial ship is the 200 ft. MINI-LACE, one of a fleet of 48 identical cargo vessels owned and operated by Ceres Hellenic Shipping Enterprises of Piraeus, Greece. Fuel savings are expected to be about 20%.

20. "MINI-LACE," Technology Review (MIT), Nov./Dec., 1981.

Announcement of completion of installation of the sail rig on the 3000 DWT MINI-LACE with an unstayed, rotating mast. "It's the first sukbstantial, modern auxiliary sailing rig in the world to be put on a commercial vessel for regular service."

21. G.Murray, "Japan Returns to the Days of Sail," Christian Science Monitor, undated.

With an urgent need for energy conservation, as well as for cutting down on the oil-dominated transport costs of its raw material imports, Japan has decided there is a definite place once again for the merchant sailing ship. The first commercial vessel, a 1600 ton coastal tanker, is now being built and is scheduled to take to the seas this fall. The shipbuilder, Nippon Kokan, at first thought of merely rigging an existing tanker with sails, but he eventually decided it was more sensible to specially design a vessel. An experimental ship of the same class is aleady at sea. Plans have also been drafted for a 14,000 ton gravel barge using sail for auxiliary power. The barge will have to be towed, but sail-assist will cut down on the engine power required. Being studied for potential auxiliary sail are automobile carriers plying the Japan to U.S. route and large, ocean-going fishing boats.

22. "Are Sail-Assisted Tankers Feasible?", Ocean Industry, February, 1980. 103-111.

The Japan Marine Machinery Development Association has given Nippon Kokan: NKK, $ 60,000 to perform feasibility studes, including refitting the 3200 ton tanker AITAKU MARU with a pair of sails as the first computer-age sail-equipped tanker in service. Completed are sea tests of the 77 ton DAIOH equipped with three types of sails. Auxiliary sails have resulted in fuel savings of more than 10%. Research began in May, 1979 with wind tunnel tests. The three types of thrusters tested were: rigid, hinged sails, soft sails, and a triangular soft sail behind a hard wing mast.

23. "Tanker to Use Sails," Tight Lines (Florida Sea Grant Program-Key West), March, 1980. 1.

Sea tests of the 77 ton DAIOH are announced with computer controlled sails.

24. "Sailing Into the Future...", St. Petersburg Times, August 2, 1980. 2A.

The Imamura Shipbuilding Co. launched on August 1, 1980 the first sail-powered oil tanker, the SHIN AITOKU MARU with two 39 by 26 foot metal sails. 50% fuel savings are hoped.

25. M.Ishihara, T.Watanabe, K.Shimizu, K.Yoshimi, H.Namura, Nippon Kokan K.K., "Prospect of Sail-Equipped Motorship as Assessed from Experimental Ship 'DAIOH'," The Society of Naval Architects and Marine Engineers, Shipboard Energy Conservation Symposium, September, 1980. 181-205.

Tests were conducted in wind tunnels, on shore and at sea on sail rigs and controls. The economic aspects of a 10,000 to 35,000 DWT bulk carrier equipped with sails were also studied. This is a report on the successful termination of the first stage in the development process. Sea trials concluded: power gain by the practical sail on the ship can be estimated accurately enough from wind tunnel tests and computation; the wind force acting on the hull should not be neglected to estimate the sailing ship speed more accurately; automatic sail trimming equipment should be installed to set the sail at optimum angle of attack. The rigid sail was more desirable. Conclusions: 1. An efficient laminar flow rigid sail was selected based on wind tunnel experiments. 2. Full-scale tests on the DAIOH proved estimations and studies were approximately correct. 3. Performance and efficiency at full scale can be predicted. 4. 10,000 to 35,000 DWT bulk carriers can readily accommodate auxiliary sail in an early stage.

26. same authors, "Nippon Kokan's Experimental Ship Proves Sail-Equipped Motorship Feasible," Maritime Reporter/Engineering News, March 15, 1981.24-28.

Summary of the preceding report.

27. "Second Wind-Assisted Diesel Propelled Ship Building in Japan," ibid, Nov.1, 1981.

A second coastal tanker designed for wind-assisted diesel propulsion will be delivered soon by Imamura Shipbuilding to Aitoku Co.,owner of the first such commercial sailing vessel. The second ship: AITOKU MARU will be built initially as a normal power-driven vessel with sails installed later, so that realistic economic comparisons can be made. Hull design is similar to the earlier SHIN AITOKU MARU. There will be two masts with 160 square meters of rigid sails when spread. Length is to be 217 feet with 1600 DWT.

28. M.Murata, M.Tsuji, T. Watanabe, "Aerodynamic Characteristics of a 1600 DWT Sail Assisted Tanker," Technical Research Centre NKK. Summary: The Naval Architects, The Royal Institution of Naval Architects, November, 1981. E276.

This presents results of wind tunnel tests of sails and hulls and sea tests of the 1600 DWT SHIN AITOKU MARU. The investigation included the study of presure distribution on the sail surface and the effects of heel angle and surface roughness. Wind tunnel tests using complete ship models showed a significant interaction between the hull and sails in the leeward direction.

29. B.Dooley, "Wooden Ship, Iron Men Era Reborn", Boston Herald American, Aug.2, 1979.

On August 8th, 1979, the 97 foot, 98 ton JOHN F.LEAVITT will be launched. Built in the 19th century style of white and red oak, yellow pine and hackmatack or tamarack, will have a capacity of 150 tons of cargo and six passengers. The 37 year old owner, Ned Ackerman will operate his vessel in true tramp fashion from port to port. The Leavitt has no engine but carries a 15 foot push boat for docking. she carries 6441 square feet of canvas.

30. J.Freedman, "Success of a New Sailing Ship Hinges on the Ill Winds of Oil", Soundings magazine, Sept.,1979.

Announces the launching of the JOHN F. LEAVITT on August 8th at Thomaston, Maine. Ackerman has invested three years and several hundred thousand dollars in the vessel. He is a former English teacher and medieval scholar. Not carrying auxiliary power exempts her from federal regulations. There will a crew of three plus the skipper.

31. M.Crowley, "New Schooner Tests the Water for Carrying Cargo,"; National Fisherman, Oct.,1979. 80-81.

Characteristics of the JOHN F.LEAVITT are given as well as a summary of other projects such as the DYNASHIP design. Whether the scheme will succeed is anyone's guess. A tested ingredient is the LEAVITT whose breed has been proved from her keel to the tops of her trucks; another, her driver, has not.

32. J.Laitin, "The Leavitt Failure -- Was It a True Test?", Soundings Magazine, Feb., 1980. 10.

The JOHN F.LEAVITT was abandoned at sea on December 27, 1979. Inexperience is blamed for the failure. Placement of lumber and chemicals may have contributed. After launching, the ship ran aground, a compass that had not been compensated was not bolted down, and the bowsprit snapped. There was no shakedown cruise. After ten days at sea, high winds caused the vessel to pitch, and a 40 foot cargo boom broke loose. Water began to enter the cargo hold, and oil poured out of a vent over the donkey engine- the only source of power for the electrical system and bilge pumps. The ship reportedly cost $500,000, and it was partially insured.

33. T.Sullivan, "Me.Coastal Schooner Leavitt Lost On First Working Voyage," National Fisherman, March, 1980. 14.

This is another account of the loss of the JOHN F.LEAVITT. First operation in the winter in the northwest Atlantic may have contributed to the loss plus an accidental jibe. The yawl boat broke loose from the stern davits and filled with water, dragging down the stern.

34. "Leavitt's Loss Won't Deter Sail Experiments," National Fisherman, March, 1980. 15 & 98.

Lloyd Bergeson's business-like approach to the problems of commercial sail is contrasted with that of Ned Ackerman, owner of the ill-fated Leavitt. "He took an old design, shunned modern technology and tried to make a go of it, turning down a less risky short but steady run from Maine to Boston for the more romantically risky New England-to-the-Caribbean run on which the Leavitt foundered on her maiden voyage." Greg Brazier, owner of the Atlantic Coasting Schooner Co. of Long Island, NY is building a 70 foot gaff rigged schooner for the coastal trade. Ackerman chose to avoid Coast Guard certification and regulations about engines, watertight bulkheads etc. Ackerman chose to maximize his hold space instead of installing watertight bulkheads that would almost certainly have kept her afloat long enough to install more pumps. Fran Morey, a designer for Hood Yacht Systems has recently contracted for the design of a 96 foot swordfish longliner and a 76 foot combination vessel both to be equipped with sails and auxiliary engines.

35. T.Weber, "Requiem for a Dream," Motor Boating & Sailing magazine, April, 1980. 52-53, 120-122, 135-138.

Yet another summation of the loss of the Leavitt.

36. J.Carson, "Sailing Bulk Carrier Design," New England Section, The Society of Naval Architects and Marine Engineers, November, 1976. 34 pp.

This paper considers the preliminary design of a series of large square-rigged steel sailing vessels. Primary emphasis is on choice of hull parameters rather than sail system design. Maximum deadweight for such a vessel is 32,300 DWT based on a limiting draft of 34 feet. The design of six vessels is presented to act as a data set for later calculation of actual sailing speed and trading economics. Methods for sizing auxiliary equipment, the sail system, hull and outfit weights, and manning are discussed. Stability calculations are shown, and the effect of cargo density on vessel stability is shown to be a limiting factor in choosing feasible trades for such a vessel.

37. B.Azarin, "In the Wake of the Flying Cloud - Ocean Shipping Sets a New Course with High-Tech Clipper Ships," Science 81 magazine, March, 1981. 81-85.

This is yet another survey of the state of the art article. Covered are the Japanese experiments, the PATRICIA A., DYNASHIP, and the Windship Development Corporation. Mentioned is work in Germany.

38. Y.Lukasik, "Wind-Powered Vessel Designs of the Soviet Union," Sea Technology, Feb.,1982. 34-35.

Sail equipped research vessels are mentioned as the ZARYA and the MAZUREK. Several preliminary designs of modern sailing ships have been completed at the Nikolayev Shipbuilding Institute on the Ukraine's Black Sea Coast. One is a cruise vessel of the river-sea type. Optimum craft for this service is a motor-equipped trimaran. Cabins are located in all three hulls. Foremast is 12 meters (39 feet) and mainmast 20 meters (66 feet) high. Draft is about one meter (39 inches). A sailing ore carrier of 60,000 tons has been designed with 14,000 square meters of sail area (150,695 sq.ft.). Sic. A short sea vessel has also been designed of about 200 tons deadweight with a draft of not more than two meters (6.6 feet). In addition, tests are to be conducted of a rotor wind propelled ship designed after the pattern of the German engineer Flettner who built the BARBARA in 1926. Other designs are also being considered.

39. "Small Simple Sails Save Money," The Naval Architect, The Royal Institution of Naval Architects, Nov.,1981. E243.

160 square meters (1722 sq.ft.) of sail has been installed on the 1300 DWT Danish coaster INGER M. During a ten day voyage, fuel savings of 1500 liters per day (396 U.S.gallons) were recorded.

40. S.Renner-Smith, "Computerized High-Tech Sailing Ships," Popular Science, December, 1980. 78-80.

Although yet another survey article, it contains the best description and drawings yet of the Japanese furling steel airfoils and their controls. The needs of Micronesia, also known as the U.S. Pacific Trust Territories are described with the ways in which sailing freighters can help.

41. "Expect Wind Powered Ship to Start Caribbean Cargo

Operation This Summer," Maritime Reporter/Engineering News, March 1, 1982. 29.

Described is the 460 DWT PATRICIA A. which is expected to enter the Caribbean trade this summer. She has been rebuilt for $ 1 million in England according to her owner Hugh Lawrence, president of Ocean Carriers, Inc. She was built in Germany in 1932 and refurbished in 1952. She will have four or five sails of five to six thousand square feet total.

42. "Ship Designers Get Wind of Forgotten Fuels," South China Morning Post, May 9, 1981, Business Section. 2

This is a summary of a report given by P.B.Joshi and D.A.Taylor, senior lecturers of the department of mechanical and marine engineering of Hong Kong Polytechnic University.

Nuclear power holds little future scope for ship propulsion. Diesel engines will continue, and coal-fired vessels may complement diesel. There may be limited use for sails. Fuel oil has increased from U.S. $13 in 1973 to U.S. $218 per ton at the beginning of 1981. Wind power is used even today in the South China Sea, around the South Pacific islands and in the Arabian Sea. The Sailiner is described as a bulk carrier of 15,000 DWT with 6200 square meters of sail (66,700 sq.ft.). Described briefly are the Japanese experiments and DYNASHIP. The Flettner rotor is discussed and the two ships built in Germany in 1924 and 1926 utilizing the Magnus effect.

43. "Waertsilae Cruise With Sail," The Naval Architect, Sept.,1981, The Royal Institution of Naval Architects. E219.

A 110 passenger cruise ship is proposed by a Helsinki ship yard powered by both sail and engines. The 88 meter (289 ft.) ship is to be three masted carrying boomless sails of 1300 square meters area (14,000 sq.ft.).

44. J.Stansell, "A Tall Ship for the Next Century," New Scientist, 11 December, 1980.

This is essentially a summary and commentary on the RINA November, 1980 Symposium on Wind Propulsion for Commercial Ships. The fine sketches illustrate the various possible rig types. Flettner rotors are discussed as is the possibility of hydrofoils as advocated by Colin Herbert.

45. "PREUSSEN II Represents Modern Breed of Windships," Sailing Magazine ca. January, 1981. 11.

Windships Magnificent of Venice, California has announced a two stage development program to construct a 480 foot, 17 million dollar commercial cargo vessel using 88,000 square feet of sail. She is scheduled to be launched March 15, 1982. She will have five 200 foot masts carrying four head sails, 12 staysails and 30 square sails. Sails will be trimmed by computer.

46. J.Mays, "Cargo-Carrying Windships Article Draws Fire for Technical Naivete", National Fisherman, December, 1979. 7.

This refers to Michael Crowley's article on sailing freight but differs with him strongly, especially on the grounds of sailing experience and mathematical analysis and modelling.

47. J.Waller, "Tour Ship's Sails Spur Slight Flap," Soundings Magazine, April, 1980. 9.

Described is the conversion of a Potomac River tour ship for the Hawaii cruise trade by retrofitting her with 6500 square feet of furling sails on four masts and a 42 foot bowsprit. The RELLA MAE, formerly GEORGE WASHINGTON, is 283 feet long and will carry 1500 passengers. The masts are 200 feet from deck.

48. "Commercial Sail", Amateur Yacht Research Society pubication No.17, Feb.,1958. 42 pp.

This booklet contains articles on: The Fan Rig, A Sailing Coaster, A Sailing Ship Rig, The Top's'l Gaff Bermudian, Another Aft Dipping Lugsail, Sailing Ship Design, and the Kite Rig among others.

49."NKK Building Sail-Assisted Cargo Carrier for Affiliate," Maritime Reporter, 1 November, 1982.

A 2100 DWT steel carrier due for completion in March, 1983 will carry products in Japanese coastal waters and will consume 40-50% less fuel than conventional ships. It will use two sails and other energy-saving systems. The fore sail has an area of 1485 sq.ft. (138 sq.m) and the aft sail 1035 sq.ft. (96 sq.m). The vessel will be 236 feet (72 m) long and will be computer controlled.

50. Russell M. Woodin and Parker E. Marean III, "Sailing Passenger Vessel Experience," Woodin & Marean, Inc. naval architects-marine engineers, PO Box 26, West Boothbay Harbor, Maine 04575, U.S.A.

This firm lists nine vessels for which they consulted and calculated stability and four on which they did computer hydrostatic calculations and provided stability data at large angles. They are the designers of the schooner HOMER W.DIXON.

51. David Robb, "Japanese Wind Ship Proves Successful," Sea Technology, April, 1982.

A report on the SHIN AITOKU MARU after the first year's performance. She used sails plus engine 60% of the time, and a fuel savings of 10% was attributed to sails. Sailing in typhoon conditions showed that the sails increased roll damping characteristics.

52.Bill Robinson, "A New Age of Sail," Yachting, May, 1982, p.62.

Brief discussion of the square rig on SEA CLOUD, Flettner rotor and other ideas.

53. L.Bergeson & G.Clemmer, "Wind Propulsion for Commercial Ships," Wind Ship Development Corp., Fifth Biennial Wind Energy Conference & Workshop, Washington, DC, October 5-7, 1981.12 pp.

A summary of the comprehensive Wind Ship report giving rationale and highlights of their excellent study which is summarized elsewhere.

54. Lloyd Bergeson, "Sail-Assist for Commercial Vessel," Yachting, January, 1982.

A brief letter differentiating between yacht and commercial sail rigs. Several initial ideas proved not to be borne out by research: pure sailing ships could be economical - they were found not to be so, specially-designed hulls required -not so, stayed masts required- unstayed more practical in most cases.

55....he m/v MINI LACE Sail Power Unit," Windship Corp., no date, 1 page.

A one sheet description of MINI LACE and the retrofitted sail rig developed for her.

56. "Sail Equipped Motorship," brochure from Nippon Kokan: NKK picturing and describing the SHIN AITOKU MARU. 1982. NIPPON KOKAN K.K., 1-2, 1-chome, Marunouchi, Chiyoda-ku, Tokyo 100, Japan.

57. "Japan's NKK Commissions New Sail-Equipped Ship," Sea Technology, September, 1982, p.67.

Sister ship of the above vessel: AITOKU MARU was commissioned recently. The new 1600 DWT ship will transport oil and chemicals.

58. J.-L. Armand, P. Marol and G. Saint-Blancat, "Aerodynamics of Sail-Assisted Propulsion of Commercial Ships: A Preliminary Study," Proceedings of the 12th AIAA Symposium on the Aero/Hydronautics of Sailing, by AIAA and SNAME, V.28, Oct. 30 & 31, 1982, San Francisco, pp 230-237.

This is a comprehensive technical report on a research program conducted in France to study sail-assisted propulsion for cargo ships. The wind device is a pair of slotted flap wing sails on a 3100 DWT chemical product carrier. Stability is contrasted with French and IMCO dynamic criteria, wind tunnel tests are reported on and a theoretical estimate is made of power gained. The preliminary study indicates that the proposed

system is feasible, and the French shipyards have decided to undertake a new research program to develop the system to building and fitting on a cargo ship for full scale testing.

59. T.Watanabe, Y.Endo, K.Nakanishi, K.Takeda, "Sail-Equipped Motor Ship 'SHIN AITOKU MARU' and Studies on Larger Ship," ibid, pp 238-249.

This is a technical report giving results of sea trials and actual voyages, sail performance through wind tunnel tests and design of larger sail-equipped motor ships. A 35,000 DWT bulk carrier equipped with sails is described.

60. Niels E.Sorensen-Viale, "A 35,000 Ton Motor and Sailing Bulk Carrier," ibid Seattle, 1981, pp 43-71.

This is a comprehensive study concerning history, hull design, weather forecasting and economic analyses.

61. Wallace H. Close, "Power Termed Vital to Cargo Sail Operation," Letter, National Fisherman, March, 1980.

Comments on the JOHN F. LEAVITT foundering and a strong argument for having at least auxiliary power on ocean going vessels.

62. "Sail Power for the Merchant Marine: Photographic Study of MINI LACE, and MINI LACE Sail Power Unit," Hood Yacht Systems, Marblehead, Massachusetts.

63.Jim Fullilove, "Ill-Fated Cargo Schooner Leavitt Stars in an Entertaining Movie," National Fisherman, July, 1981, p.99.

Rather wry comments about making the documentary film on the JOHN F.LEAVITT.

64. "Va.-Built Schooner is Bound for Caribbean Cargo Trade," National Fisherman, January, 1980. 82.

In October, a 50 foot steel schooner was delivered which is intended to haul fruit and produce among Caribbean islands and possibly back to the East Coast. The gaff-rigged schooner MEMORY was designed by Tom Colvin and carries 1600 square feet of sail. She has a 30 hp diesel engine for auxiliary power and draws six feet of water.

65. "Wind and Sun-Powered Cargo Vessel Being Built for the South Pacific," Maritime Reporter/Engineering News, May, 1980.

Nearing completion in New Zealand is the 112 foot, 146 ton steel schooner MANUTES with 5500 square feet of sail and 5,000 cubic feet of cargo space. Most of the electronic navigation and auxiliary gear will receive power from wind driven generators or solar-powered batteries.

66. B.Grant, "250 Tonnes...and a Deckwatch of Two," Boat

Technology International magazine, no date. ca. 1981. 5-7.

This is a three masted schooner of steel with a length of 36 meters (118 feet), draft of 3.8 meters (12.5 ft.) with 560 sq.meter of sail (6027 sq.ft.) area. She will be used in the Caribbean.

67. "Development Plan Presented for U.S. Pacific Islands," Sea Technology magazine, Oct.,1980. 19.

An ambitious five year plan for economic development of the U.S.Pacific Basin Islands was presented to the Carter Administration on August 7th. 150 programs were proposed costing over a billion dollars, and funding at this level is unlikely. Projects were suggested in fisheries development, port construction, coastal zone management, telecommunications and other areas. Total gross annual product of the region is estimated at $600 million - only half the cost of the recommended projects.

68. T.E.Colvin, "Inter-Island Trade is Best for Small Schooners," National Fisherman, August, 1980. 62.

Colvin has designed, built and sailed commercial sailing vessels for 35 years. He believes such to be feasible but to attempt to sail freight in the U.S. borders on the ridiculous because of existing laws and regulations. Colvin's 15 ton cargo schooner MEMORY is used for inter-island trade of package freight. He has designed several two and three-masted fishing schooners. The Caribbean seems a much better area in which to trade. The most economical size for a cargo schooner is between 15 and 20 tons since this can be manned by a small family crew. This limits size to about 60 feet on deck.

69. "Schooner Being Built for Lake Champlain Service," Maritime Reporter and Engineering News, Feb. 15, 1982.

Construction has begun in Portsmouth, NH on a 76 foot steel hull schooner to carry passengers on Lake Champlain beginning in the spring of 1983. She will have a capacity of 24.

70. J.L.Shaw, "A Return to Sail in the Pacific?", Sea Frontiers magazine, Jan./Feb., 1981. 13-17.

The once self-sufficient Pacific islands have gradually become totally dependent on the outside world. Interisland trading vessels usually of 200 to 500 ton capacity, play a vital role. Ironically, the Pacific island trading fleet was one of the most recent to give up the use of sail. Only two decades ago, sails were still used as the chief form of vessel propulsion. Few of these craft are seen today.

71. L.Dennis, "Florida Contractor Built his Own Cargo Schooner," Soundings, April, 1980. 13.

On Feb.21, 1980, Harold Haglund launched his 42,000 lb., 64 foot, steel-hulled topsail cargo schooner. It is designed to carry 3,000 sq.ft. of canvas and has two 120 hp auxiliary diesel engines.

72. W.L.Warner, M.M.Kossa, "Updating an Ancient Art- Research and Development Toward Modern Wind Powered Cargo Ships," Society of Naval Architects and Marine Engineers STAR Symposium, San Francisco, May 25-27, 1977. 20 pp.

Some general remarks on modern sailing cargo vessels are followed by a detailed description of the proposed DynaMast series- 16 different proposed rig arrangements. Included also are characteristics of ten proposed DynaShip bulk carriers ranging from 2950 to 68,900 tons deadweight. Experiments with the Princeton Sailwing are described and compared with the Proelss rig. The evolution of the present design for the DynaShip rig is described with photographs of model rig arrangements and polar curves. Included are 28 references.

73. H.G.Lawrence, "The Western Flyer Project - A Modern Sailing Cargo Ship," The Society of Naval Architects and Marine Engineers, Northern California Section, Sept.9, 1976, San Francisco, Calfornia. 39 pp.

This paper describes the various criteria selection and design processes as they relate to a project which is intended to construct the first ship to carry cargo under sail again. The emphasis is on the expediency, efficiency and economy of the various decisions to be made when considered in terms of putting a new 4500 DWT sailing ship to sea, rather than in terms of the highest attainable hydrodynamic or aerodynamic performance of some future sailing vessel.

The WESTERN FLYER is modelled after older types which successfully rounded Cape Horn, almost routinely. She is to be rigged as a four-masted Bermudian rig schooner with bipod masts. She is 96 m.(315 ft.) on deck, and sail area can be varied between 23,440 and 32,498 sq.ft. She has a 750 hp diesel electric engine. The author concludes that sailing cargo ships have greater competitive advantage in the smaller ship sizes than in the larger, and that it is not realistic to start cargo operations under sail in carriers of the size 15,000 DWT and up. A reasonable size may be 8,000 DWT. A summary is given of the Argentine grain trade from the Rio de la Plata. 43 references are included.

MODERN SAILING FISHING VESSELS

Commercial sailing fishing vessels have existed almost as long as man has been on Earth. Although not many are now found in Europe and the U.S., they are used in large numbers elsewhere in the World. In the past few years, such have made a modest comeback in the so-called developed countries. Skookum Marine in Port Townsend, Washington has constructed and sold 40 to 50 such craft for fishermen in nearby, Alaskan and Hawaiian waters. Others have been built in California by R.W.Davies. Captains Lane and Jesse Briggs operate two such vessels which also serve as tugs, salvage craft and freighters as shown in Figure 4. The French and Germans are actively pursuing sail assist for fishing vessels as well. There are isolated experiments in many parts of the U.S. and other countries where either sails have been added to power vessels or yachts have been converted to commercial fishing craft.

Major limiting factors on the use of sails by fishing vessels are: bridge heights and distance to fishing grounds. The farther the fisherman has to travel before he reaches the fishing grounds, the more advantageous sail assist becomes. For fishing grounds 200 or more miles out, fuel savings on a year-round basis of up to 40% have been forecast. Others are not so optimistic. See Abstracts 44 and 46, for example. There appears to be no uniform insurance policy with respect to sail-assisted fishing boats. In New England, one firm threatened to increase premiums if sails were added using the justification that crew injury and fatigue were enhanced. In the Pacific Northwest, premiums are less for sail-equipped fishing vessels and in Virginia no change was exerienced in retrofitting an existing craft with sails. Capt. Davies in Hawaii cites a reduced premium because of no need for towage insurance. Sailing vessels usually can make it back on their own.

MODERN SAILING FISHING VESSELS

1. M.A.Jacquemin, "A Multi-Purpose Tuna Fishing Boat with Combined Propulsion," Symposium on Wind Propulsion of Commercial Ships, The Royal Institution of Naval Architects, London, 1980. 233-240.

A multi-purpose tuna fishing schooner has been designed for use on the Atlantic coastline of France to be powered by motor and sail. French statistics show that it costs about one liter of fuel to land one kilogram of fish (0.12 U.S.gallons per pound). The vessel designed is 19.3 meters (63 ft.) long with a light displacement of 60 tons and a loaded displacement of 95 tons. Hull is double-chine steel. Main diesel engine is 160 hp with a secondary engine of 40 hp working an altenator and hydraulic pump. The boat will be fitted out with two 15 meter (49 ft.) masts. On the foremast, a boomed staysail will be rigged to a roller stay of 52 sq.m.(559 sq.ft.) A large genoa can also be set of 104 sq.m. (1120 sq.ft.) On the mainmast is a staysail with boom measuring 48 sq.m.(517 sq.ft.) and a main sail of 50 sq.m.(538 sq.ft.) each on a roller stay. Sail rollers are driven by small hydraulic engines controlled from the bridge. Sheets are controlled via winches from the helm.

Tests on a scale model have been carried out in the laboratories of nautical hydrodynamics at Nantes. With an average wind of Force 4 to 5, the vessel should reach a speed of eight to nine knots. Calculations indicate an annual fuel saving of 200,000 liters (52,834 U.S. gallons).

J.F.Fyson had a number of comments on this paper. Firstly, the major difference between fishing vessels and most other commercial craft is that they work all year round and take on their cargo at sea. Looking at some of the designs proposed for sailing fishing vessels, he doubts that this is always appreciated. Sails and rigs must not interfere with fishing and cargo operations. Consideration of working deck space availability is all-important. Other considerations- time spent getting to the fishing grounds, power requirements during the fishing operation, expected catch and method of bringing it aboard, auxiliary sources of power necessary for the fishing operation, conservation of catch and power necessary for refrigeratin and normal requirements for life on board. Mr.Fyson is in favor of high cut mainsails, spritsail rigs and junk rigs but not spinnakers and rigid airfoils. Rotors might be possible. Mr. MacLear asked for a breakdown on the costs. The reply gave such and claimed a benefit for 10% lower insurance and perhaps 50% lower engine repair costs.

2. E.W.H.Gifford, "Improvement of Sailing Techniques in Tropical Countries," ibid. 241-247.

See Abstract No.6 under Advanced Thrusters for a description of this paper which concerns beachable catamaran and sailing canoe fishing boats.

3. B.Townes, "Behm-Designed Sharpie Deserves a Trial Run for Inshore Fishing, " National Fisherman, August, 1981. p.97

This is a 32 foot aluminum sharpie, gaff rigged, freestanding ketch powered by a 10 hp engine and suitable for hand trolling, trap fishing and longlining in sounds, rivers and estuaries.

4. J.Frye, "Modified Bugeye Designed for Shrimping," National Fisherman, March, 1981. p.73.

This is another proposed fishing vessel, a 50 foot modified bugeye with a staysail rig. The architect, Bill Hall, calculates she could tow two 35 foot shrimp trawls at four to six knots in 12 to 15 knots of wind. A 130 to 140 hp engine would be fitted linked to a sel-feathering propeller. During trawling operations, with engine idling for hydraulic deck gear, fuel consumption is estimated at 1.5 gallons per hour.

5. J.Capps, "Fiberglass Combination Vessel Designed for Sail Power Too," National Fisherman, Feb.,1981. 72-73.

Skookum Marine molded the BELINDA V's fiberglass hull which can become a two masted sailing vessel. Wheelhouse is of one-quarter inch aluminum to keep center of gravity low. She is 53 x 16 x 8 feet and is powered by a 6-71 Detroit Diesel.

6. G.Wells, "Marine Tech's Sailing Fishboat Gets Hull Speed on Little Power," National Fisherman, August, 1980. p.70.

Marine Tech has sold six 34 foot sail trollers of the True North Design in four years, but all were delivered minus optional sails. The new boat which is of the Hylebos schooner designs will be delivered in October. She is 47 x 13.5 x 6.4 feet and is reminiscent of the turn-of-the-century halibut schooners. She will be equipped with an 80 hp Dietroit Diesel 4-53. Cost will be $ 238,000. Fishermen will have to expect a smaller payload. A standard 47 foot fishing boat routinely carries up to 300 hp, but it takes only 47 hp to move this vessel at hull speed.

7. L.Cole and A.Sager, "46 ft. Sealing Schooner Can be Set Up for Pleasure or Commercial Fishing," National Fisherman, Jan.,1976. 14-C & 30-C.

Designed from memory by Francis Fredette, this beautiful gaff-rigged schooner is 46 x 12.75 x 6 feet and measures 36.75 feet on the waterline.

8. K.Brueckmann, "Skookum Sailing Fishboats Growing in Popularity," National Fisherman, Feb.,1978. 16-C.

Bernie Arthur, president of Skookum Marine in Port Townsend, Washington states that 50% of his production this year will be sailing fishboats. The Skookum hulls are designed by Edwin Monk with a capacity of up to 20 tons of frozen fish and a 3,000 mile range under power alone. Sails increase range and fishing options and decrease costs. At present, the Skookum 47 and 53 are being used for sailing fishboats. Five of the boats are already fishing, and eight are under construction. A 70 footer is being designed. Sail advantage is used to travel to the fish- not when fishing. It does not seem practical to troll with sails set. Skookum Marine is located at 2900 Washington St., Port Townsend, Washington 98368.

9. M.Miller, "Californian Copied Slocum's SPRAY to Build Efficient Trolling Vessel," National Fisherman, Oct., 1980. 82-83.

A 16 ton sailing fishing vessel was built in Morro Bay, California by Bob White. She measures 36.75 x 14 x 4.5 feet. Bowsprit is 16 feet, main mast 43 feet with a 21 foot top mast and 27 foot mizzen. She is powered by a Perkins 108 delivering 55 hp. At present the fish hold carries four tons of fish, and there is no refrigeration other than ice. It is planned to double the cargo capacity and install electric refrigeration.

10. T.Lesh, "West Coast Commercial Men Find Sailing Fishboats are Now Viable," National Fisherman, Sept., 1980. 80-82.

Capt. R.W.Davies fishes the 60 foot sailing schooner CORNUCOPIA out of Hawaii for albacore tuna. The idea was to develop a long-range vessel that could get to the increasingly remote fish resource and get back to market. She is patterned after an 1890's schooner called a Gloucester sloop boat, often called an East Coast oyster schooner or Grand Banks schooner. She is built of steel and is now valued at $450,000. She is gaff rigged and uses mast hoops of 10 oz. tightly woven Dacron and no sizing. Two people can run and sail the craft. Davies claims: "the reason there are not more sailing workboats on the West Coast is that most fishermen will buy fuel, regardless of how much it costs, as long as it's available. In other parts of the world, either the fuel is not available or the fishermen can't afford to buy it. "These sailing workboats are really solar-powered protein producers."

Davies' son Morgan now operates the Davies Boat Building Co.l in Sacramento and is building his own version of the steel commercial sailing schooner. The basic boat measures 53 x 16.5 x 7 feet and cargo capacity is 20 tons. The Mobil vinyl system is painted over zinc chromate primer. In seven years, the CORNUCOPIA has only needed minor touch-up. There is no fin keel. She is rigged as a gaff-headed schooner with appoximately 1500 sq.ft. of lowers and 500 sq.ft. of uppers. Morgan Davies, Davies Boatbuilding, 2620 American Ave., Sacramento, California 95833.

11. B.Townes, "2 Sailing Workboats from the West," National Fisherman, Dec., 1975. 1-C and 16-C.

Described is a George Buehler designed 42 foot sailing workboat and a Jay Benford designed 36 foot sailing dory, both suitable for commercial fishing.

12. B.Townes, "Tiare Debuts as State of the Art Sailing Fish Boat," National Fisherman, March, 1981. 74,75 & 104.

Naval architect J.P.Hartog of San Francisco designed the steel 65 x 15.25 x 7.5 foot sailing fishing vessel for a client. She is ketch rigged with up to 2400 sq.ft. of sail and a hold able to keep 60,000 to 65,000 pounds of fish blast frozen at -25 degrees F. She is due to be launched any day and is the first of what is hoped will be a series from the Blue Bahia Boatworks.

13. T.Lesh, "Wind Energy - Free to the Fisherman," National Fisherman Yearbook, 1980. 113-117.

Since 1973, the cost of fuel has risen 727%! Much of the Gulf fishing fleet has been idled by the cost of fuel, and the U.S.fishing industry is suffering more than its neighbors. Last fall, marine fuel in Mexico was 17 cents a gallon and in Canada 36 cents while in the U.S. it was 93 cents.

More sailing fish boats are seen every year in answer to this problem, but their number is few in comparison to the number of powered vessels. There is hardly a fishery that could not benefit from sail. Sail is generally used to extend range. In general, the farther a boat has to travel, the more valuable sail will be. To date, none of the U.S. fisheries has used sails for trawling, but India and England have. Sailmaker Paul Mitchell (2805 Canon St., San Diego, CA 92106) has been making sails for commercial fish boats as well as yachts. He is an advocate of simple rigs and opposed to furling gear. He estimates costs of outfitting with sails at 2 to 5% of the boat's cost (for sails alone). A sailing fishboat costing $200,000 was just outfitted for $4,000. This compares with $20,000 for high-technology rigging. New Dacron weaves, such as Carolon are softer, easier to handle and last longer.

A traditional sailing fishing craft is the TIA MIA, a 27 x 9.25 x 5.75 foot Friendship sloop type. She is operated out of Oregon. Bill James of Morro Bay, California has recently turned out four designs for sailing fishing vessels. Larry Fulgham is a builder in Moss Landing, California has a gaff-rigged steel fishing schooner 65 feet in length: FOURTH OF JULY. Also mentioned are: Skookum Marine, Marine Technical Services and Morgan Davies.

On the East Coast, interest is increasing as shown by the Northeast 77, designed by R.Woodin and P.Marean and built by Northeast Boat Co., Stonington, Maine 04861. In Australia, John Clode has built the 54 x 15 x 5 foot ketch CALIPH with 44 hp diesel and variable pitch propeller. Perhaps the smallest is the Drascombe Fisher built in England for the Caribbean fisheries. Its 21.5 x 7.25 x 2 foot DRIFTER model has been modified for such. The most complicated built in this country is the Bottom Line 44: CSY 44 which can carry 12,000 lbs. of ice and fish.

14. K.C.Samples, "The Cornucopia - One Fisherman's Answer to the Fuel Price Squeeze," The Marine Advisory Program Makai Newsletter, Univ. of Hawaii Sea Grant College, June, 1981. p.1 & 5.

A detailed account of the CORNUCOPIA described above. On an average, he probably uses 7000 gallons of fuel per season less than a comparable size diesel powered albacore boat. On a recent 1500 mile trip from Honolulu to Midway, he used only sail power. Insurance cost is less because no extra premium is paid for towage insurance to protect against mechanical breakdown. Annual average sail replacement cost is about $1000.

15. B.P.Brown, Jr., "An Evaluation of a Potential Use of Sail Power in the Commercial Shrimp Fishery of Texas," M.S. thesis, Texas A&M University, August, 1976.

See Abstract No. 10 under Economics.

16. "Almost Lost - The Art of Fishing Under Sail," Coast Watch, University of North Carolina Sea Grant, Feb.,1981. p. 6.

Mike Alford hs begun a study of North Carolina's historic boats for the Hampton Mariners Museum in Beaufort. "We almost, but not quite, lost the art of fishng under sail. We need to go back to the extremely efficient boats of a couple of generations ago, and pick up where we left off." There were three mainstays of the old North Carolina sailing fleet: sharpie, spritsail skiff and the Albemarle shad boat.

17. T.Sullivan, "Sail-Aided Power Could Save Some Fishboats Plenty," National Fisherman, Dec., 1979. 69.

Presented is a prototype design for a 73 foot sailing fishing trawler. Designer Fran Morey, of Hood Yacht Systems says the hull design alone would make the vessel between 10 and 25% more efficient. She is equipped with Hood's Stowaway mast and Seafurl gear. Icing of the mast is one concern, so a possible solution is advocated of venting engine exhaust up the mast.

18. N.Lucander, "Building a Good Sailing Fishboat is More Than Just Adding Sails," National Fisherman, Oct.,1980. 76-77.

A commercial fishing boat is a small business all by itself. Conventional sail rigs are criticized because of interference with fishing gear. In 1976, the author designed a 29 foot fishing boat for the Dominican Republic carry a single roller-furling genoa fitted on a head stay. 21 of those boats were built and are used, and others are being retrofitted to use similar sail systems. A new 36 foot fishing boat for Honduras will also have a roller furling genoa. He has now designed his Albacore Clippers. One illustrated measures 68 x 5.75 ft. and carries 3195 sq.ft. of roller furling sails on three equal-height masts. Sails are hydraulically controlled for furling and easy reefing.

19. T.Lesh, "Sail Power Gains Popularity in Pacific Fisheries," National Fisherman, Oct., 1980. 78-80.

BORN FREE is a 65 foot sailing schooner to be used for albacore fishing at Coos Bay, Oregon. She is of steel from a J.P.Hartog design. Gaff rig was chosen for 730 sq.ft. loose-footed mainsail of 13 oz. Dacron, 645 sq.ft. foresail of 12 oz. Dacron and 315 sq.ft. staysail of 8 oz. Dacron. Skookum Marine has delivered sevral 53 foot sailing fiberglass sailing fishing boats as well as a number of 47 footers with 20,000 lb. holds.

20. "Durbeck 50 ft. Fisherman," National Fisherman, no date, advertisement.

Described is a ketch-rigged fishing vessel measuring 50.75 x 13.8 x 5.25 foot 15000 lb displacement sailing fishing vessel. Durbeck's, 4504 28th St., Bradenton, FL 33507.

21. "Third World Needs Stimulate Ideas for Boats and Gear," National Fisherman, Britsh Supplement, Oct.,1980. 53-54.

British engineer and vessel designer Edwin Gifford introduced a 36 ft. beach sailing catamaran fish boat to Ghana. He then designed a smaller and simpler catamaran called the SANDSKIPPER to Sri Lanka. A 1978 cyclone destroyed 5,000 fishing boats in Sri Lanka. Gifford's idea to replace this fleet was a 19 foot dory made of marine plywood by a stitch and glue technique. (tortured plywood). They could be put together from kits by the fishermen themselves. One boat and two kits were sent to Sri Lanka, where demonstrations made a good impression. They can be sailed or powered by a Petter 6 hp air-cooled engine. They can carry three men, catching gear and a ton of fish.

22. P.O'Driscoll, "No Easy Way Back to Sail," ibid. p.58.

In Britain there are still a few sailing fishing boats around, but they are mostly museum pieces. One exception is in Cornwall where there still is a small oyster fishery worked by sailing craft. At Grimsby, there are a number of wooden inshore boats operating of average length around 60 feet. They set a trysail, mostly for steadying purposes. If the wind is right, even this small sail will add a knot or two to the boat's speed.

23. "He Hopes Shrimper with Sails will Sell, " St. Petersburg Time, Apr.12, 1981. 16B.

Master boatbuilder Oscar Ewing of Apalachicola, Florida has built a model of a wind driven shrimp trawler at the request of Bangladesh. Price of diesel fuel there ranges up to

$6 per gallon. It is hoped that two boats will be ordered. The vessel is 56 feet long and could carry a regular load of 20,000 pounds. It will have an auxiliary engine. "It takes $1,000 of diesel fuel to go to Key West. With this, you can get there for nothing."

24. "Hood Makes a Sail for a 250 Ft. Freighter," National Fisherman, Nov., 1981. 14.

In addition to discussing the freighter sail, Hood said that three sailing fishing vessels in the 60 to 96 foot range have been designed and await serious buyers. The economic feasibility of the new vessels can easily be proven. Robie Doyle commented: "commercial fishermen tend to think of their vessels as extremely sturdy, while seeing yachts as frail, a perception that, until recently, may have been accurate. The push in yachting lately has been toward larger and larger vessels for offshore racing and cruising. The trend came about primarily because of new developments in sailcloth and equipment that made it easier for racing crews to handle a greater volume of sail. Previously, everything was limited to the ability of humans. The automation of handling equipment allowed designers to go beyond this limitation in response to everyone's wanting to go faster than the last one. This development in turn led to stronger and heavier construction on truly large racing yachts. This led to the development of self furling sails, masts in which sails could be stowed and better powering systems that allowed push-button control from the pilothouse. And, these developments all have commercial applications."

25. "No Dramatic Breakthroughs for Wind Propulsion," Ship & Boat International, Dec.,1981. 5-6.

Described is the research project at the College of Engineering of the University of South Florida, funded by Florida Sea Grant College. The French work is described. The catamaran concept was chosen as offering optimum compromise between stability, draft and hull resistance. Hull design is by Rodney March. Described also are the EOLE and other French concepts treated in a separate abstract. In Australia, Lock Crowther a leading designer of catamaran and trimaran racing yachts, has recently turned his attention to fishing vessels and workboats. He has chosen the catamaran for both a 46 foot biological research vessel and a similarly sized pearl fishing craft. Two 40 hp Lister engines are used driving fully feathering controllable pitch propellers. Hydraulic power is supplied by a pump off one of the engines. The rig is set aft on a single mast. There are long, shallow skegs on the hulls giving a draft of less than four feet.

26. H.Seki, A.Hamada, T.Iwami, R.J.LeBrasseur, "Hobikiami Sail Trawling in Japan, " Fisheries, V.6.No.6, Nov.-Dec., 1981, 2-15.

Sail trawling of Hobikiami fishing consists of a boat drifting sideways downwind while towing a net. This picturesque fishing method was invented about 100 years ago as a means to reduce the then labor-intensive methods. Hobikiami trawling is analogous to flying a kite wherein kite, tail of kite and man correspond to sail, boat and net respectively. The wind must be approximately parallel to the long axis of the lake where it is used and of moderate strength and frequency. Diesel trawlers have replaced many of the sailing drifters. The fishing method, trawl nets, catch and boats are well described in figures and text.

27. "Yacht Conversion to Sailing Fishing Vessel in Florida," Visit Report, Oct.,1981.

In Port Richey, Florida, Don Sorenson is outfitting a 40 foot Sampson Marine designed ferrocement yacht for commercial fishing. She has a 95 cu.ft. hold for 2000 - 2500 lbs. of fish. All sail controls are led to the helm. She is due to be fished in the summer of 1982.

28. R.Browning, "The Wind is Free," Fishing Gazette, March, 1982, 42-52.

A 130 foot Bering Sea crabber takes on 50,000 gallons of fuel. In the light of world conditions the sail-assisted fishing vessel will play a part no matter how small, no matter how great, in the fisheries of all three coasts. Since 1974, Skookum Marine of Port Townsend, Washington has built at least 47 sail-assisted fishing vessels up to 70 feet LOA. Skookum is a Chinook word meaning good, well or excellent. (or well built) Other firms have built sailing fishing vessels, and there may be as many as 200 such in use in the Pacific, under construction or on the drawing board. One disadvantage is that beam must be narrowed for economy and the fish hold is smaller as a consequence. Load capacity is traded for economy. Icing can foul up furling gear in northern waters. The largest sailing fishing vessel today is the 74 foot ketch designed by Bill James of Morro Bay, California. Western tuna fishermen travel routinely to West Africa while other albacore fishermen have increasingly been moving farther into the Southwest Pacific.

29. S.E.Barnes, "Shapely 50-footer Offers Flexibility for Today's Fisheries, "; National Fisherman, Apr., 1982. 82-83.

This presents the results of a preliminary study for a 50 x 16.7 x 7.75 foot sailing fishing vessel with three chines. Fish hold has a capacity of about 1320 cu.ft. or approximately 50,000 lbs. of iced fish. Power is to be a 280 SHP diesel. Sail rig is a simple gaff ketch.

30. "Wind-No Fuel Like An Old Fuel," Makai Newsletter, University of Hawaii Sea Grant College, Nov., 1980. 6.

Dr. Edward Shallenberger is in Port Townsend, Washington putting finishing touches on a 51 foot sailing ship designed for fishing and research. Roy Yee has plans for a 38 foot motor sailer that will use only 25% of the fuel used by a power boat of this size.

31. C.A.Goudey, "Fishing Vessel Sail Assist Feasibility and Demonstration Project," MIT Sea Grant, August, 1980 and Apr., 1981. 10 pp.

This is a project summary with objectives: a. To study the feasibility of using sail assist to reduce the energy requirements of fishing boats. b. to determine what types of boats and modes of fishing lend themselves best to sail assist. c. to determine if a cost effective retrofit can be made on a significant number of the existing small fishing boats in New England. d. to delineate what steps should be taken by a boat owner interested in a sail retrofit. Estimated completion date is March, 1982. A demonstration project is part of this project. The 79 foot VINCIE N. was chosen for retrofit. Drawings show a conservative sloop free-footed sloop rig set well forward.

32. G.Miles, "Men of Sea Studying Sails for Commerce," Norfolk Ledger-Star, Apr. 12, 1982. C-1 & 2.

Announcement of the Norfolk 19-21 May conference on commercial sail. Jon Lucy is quoted as referring to these as hybrid boats - combining the best of sail with the best of power. About 100 vessels on the West Coast and a dozen on the East Coast use the sail-assist concept said this representative of Virginia Institute of Marine Science. Colvin's 72 foot cargo vessel SHARON VIRGINIA will be tied to a Norfolk dock as well as NORFOLK REBEL. Colvin is sailing from Miami to Hampton Roads in his Chinese junk to attend the conference. Also present will be Merritt Walter who designed the 57 foot, 20 ton cargo carrying PHOENIX due to be launched shortly. Studies at the College of Engineering of the University of South Florida are referenced.

33. P.Griscti, "Sailpower Propulsion of the Future?" Commercial Boating, Oct., 1981, 17-19.

This is a detailed interview with researchers at the College of Engineering of the University of South Florida on commercial sailing fishing vessels. The three year research program, begun in 1981, has the following phases: a. collect data, write engineering analysis computer programs. b. study the technical, operational and economic feasibility of retrofitting existing craft with sails on a fishery by fishery basis. c. development of instrumentation to measure fuel economy and performance. d. preliminary design of new vessels optimized for sail-assist. e. full-scale experiments using the instrumentation developed.

34. J.W.Shortall III, "Commercial Sailing Fishing Vessels, Computer-Aided Design," SNAME Fishing Industry Energy Conservation Conference, Oct., 1981.

The University of South Florida, College of Engineering has a continuing research program concerned with the computer-aided design of commercial sailing fishing vessels. This research is also funded by Florida Sea Grant College, and the program is projected to end in December, 1983. The program is described in the above abstract. Results are reported on a detailed examination of the snapper-grouper fishing industry and vessels used therein where minimum fuel savings of 30 or 40% are projected. Preliminary studies on stone crab lobster boats are also reported where the situation does not seem so optimistic. Sail rigs proposed are of the unstayed mast type for minimum interference with the fishing operation and are user-kindly and simple with a minimum of failure-prone gear.

35. C.J.Kibert, "Computer Analysis of the Economics of Sail Assisted Commercial Fishing Vessels, " Society of Naval Architects and Marine Engineers: SNAME- Southeast Section, Feb.,1981. 15 pp + 16 pp. appendices.

An interactive computer technique is described which allows a rapid assessment of the potential for retrofitting existing commercial fishing boats with sails. This tool permits a rapid parameter analysis of a variety of retrofit cases and a graphical display of the results. A listing of the computer program is enclosed in Tektronix BASIC.

36. R.A.Jøhnson, "Research on Commercial Sailing Fishing Vessels at the University of South Florida," ibid. 5 pp.

An early description of the Florida Sea Grant College funded research program at the College of Engineering of the University of South Florida. This is updated in abstract no. 34 above.

37. A.X.Gares, "Performance Prediction of Sailcraft," ibid 18 pp

A computer graphics program has been developed on the Tektronix 4051 high resolution graphics computer to predict sailcraft performance for all points of sailing via generated polar plots. Speed and force equations are presented, and the associated algorithms are derived for both heeling and non-heeling vessels. A test case using the catamaran configuration is included to illustrate the capability and effectiveness of the program. Note: the algorithms used come from the work of Piper Mason. This program has been extended and improved and a version has been prepared for the Apple microcomputer.

38. C.Swenson, "Computer-Aided Design of Freestanding Spars," SNAME Southeast, Sept.,1981. 31 pp.

This paper is a summary of recent work undertaken to apply the microcomuter to the design of freestanding spars for sail-driven fishboats and large recreational watercraft. The author briefly reviews the history of such spars in the American fisheries and discusses the inter-dependence of spar and hull design criteria. The engineering approach to the design of the freestanding spar as a poly-axis loaded cantilever is presented and the translation of the design methodology into a highly interactive, iterative computer program is summarized by a flow chart. The author concludes with a description of the program's limitation and presents the reader with several design alternatives for integrating new and old technologies.

39. D.R.Breault, "Computer-Aided Method for Determining Stability Curves of Multi-Chine Hulls," SNAME Southeast Section, March, 1982. 7 pp + appendices.

A method is described for determining curves of static stability of one or more chines using a computer program written in BASIC on the Tektronix 4051 high resolution graphics computer. Except for the graphics portion of the program, this is readily portable to other dialects of BASIC. Major limitation of this method is that calculations are performed only until deck edge is immersed. This program is used to determine stability parameters for commercial sailing fishing vessels in a program funded by Florida Sea Grant College and the College of Engineerng of the University of South Florida. A ten degree heel criterion is used therein for sail area sizing, so the deck edge criterion poses no problem in these investigations. A program listing in Tektronix BASIC is included.

40. C.J.Kibert, "The Economics of Sail Power for Snapper-Grouper Boats of the Florida West Coast Fishing Fleet," Florida Sea Grant College, Sept.,1981, 11 pp.

Described in detail is the use of an improved version of the economic analysis computer program as described in abstract no. 35 above. Analyzed is the snapper-grouper fishery, and the 15 year life cycle costing method is described. With 30% of the power being supplied by sail, predicted fuel savings for a typical 44 foot snapper-grouper boat amounts to 1440 gallons per year or a projected savings over 15 years of $ 54,903 per boat. For the 40% case, the figures are 1920 gallons per year and $72,204 saved over 15 years.

41. J.W.Shortall III, "Sailing Fishing Vessels Engineering Economic Analysis - An Interactive BASIC Computer Program," Florida Sea Grant College, Technical Paper No.25, December, 1982, 26 pp.

The implementation of the life cycle costing method with a BASIC program by Charles J.Kibert is described with extensions to the Apple microcomputer. This is the third in a series of papers describing the engineering economic analysis of commercial fishing vessels retrofitted with sails to effect fuel economies. This report describes the computer program used and presents a listing together with screen outputs and variable cross reference. The computer program is written for an Apple microcomputer but uses an especially uniform variety of BASIC which should allow its conversion to most other computers with a minimum of translation.

42. J.W.Shortall III, "Sail-Assisted Power for Florida Stone Crab-Lobster Fishing Vessels," Florida Sea Grant College, Feb.,1982. 31 pp.

Three vessels typical of the larger stone crab-lobster craft are analyzed for possible retrofit with sails for wind-assisted power as an aid in reducing fuel costs. A brief description is included of this important fishery in Florida with pertinent references. The computer-aided analytical methods are described. The application of sail-assisted power for this fishery is estimated to save, on the average, 15% of the fuel useage. Major limiting factors include severe bridge height restrictions on permissible sail area and the one to 70 mile range to the fishing grounds. Visualization sketches of possible sail rigs on typical hulls are included.

43. N.E.Sorenson-Viale, "Fishing Under Sail," Fishing Industry Energy Conservation Conference - The Society of Naval Architects and Marine Engineers, Oct.,1981.

The concept of motor-and-sailing is adopted for the propulsion of a fishing vessel. The innovative design is primarily based on the author's exerience in the design and operation of motor-and-sailing fishing vessels in 1944 and on the introduction of state-of-the-art sailing technology developed for competition yachts since sail was abandoned as primary propulsion for commercial fishing vessels. The design combines bipod masts without shrouds, with fore-and-aft boomless sails on roller furling struts. Power consistes of two engines in a father and son configuration driving a single shaft with controllable pitch propeller. Hull was specifically designed for performance under sail. Dynamic routing will be used to obtain the best wind conditions for motor-and-sailing. The result is an energy efficient fishing vessel not intended for character building but for highly competitive economically feasible fishing in comparison with conventional motor-propelled fishing vessels of the same payload capacity.

Several in the audience took issue with one or more points in this paper. Particularly questioned were the comments and data on motorsailing.

44. A.G.Hopper, "Energy Efficiency in Fishing Vessels," ibid.

This paper is largely devoted to energy economies possible for large, engine-powered fishing vessels. Sail power was commented on late in the paper where two cases were examined. "These cases studied only relate to the application of sail as auxiliary power for a modern trawler and show there is no justification for such a move at this time. This should not, however, exclude sail as a long term option."

45. H.S.Noel, "French Fishing Industry is Actively Developing New Boats," National Fisherman, Feb.,1982.

A catamaran sailing fishing vessel, 37 ft. 7 in. long hs been built of aluminum by Dar-Mad with government aid. She has two 55 hp engines and sail area of 613 sq.ft. A 45 ft. fiberglass power catamaran fishing vessel: NOTRE DAME DE FOY has twin trawl winches, net reel and two 215 hp diesel engines. The owner states she will out-tow a 600 hp single hull craft. Designer claims that a catamaran has generally 25% more speed than a single hull vessel for the same power and size. The owner of a 39 foot steel power catamaran states that the catamaran is ideal because of the deck space available for crab and lobster traps. Steel was too heavy, so he ordered the 38 ft. DIOGENE of AG4MC aluminum alloy. His fuel bill is 40% less than a 53 foot single hull craft.

There are three new French sailing catamaran fishing vessels. These are trap line or gill net boats. Each has jib and Bermuda main sail with roller reefing. In Brittany, the 63 ft. EOLE had her first trial run to the Atlantic albacore grounds. She is the first of three steel boats, ketch rigged and total sail area of 2173 sq.ft. without balloon jib. Sails are controlled remotely from helm with hydraulic winches. Price was $450,000 per boat. See the abstract under advanced thrusters for information on Flettner rotor-powered 100 ft. fishing catamararan conceptual design.

46. K.C.Samples and J.H.Prescott, "The Use of Sail-Assisted Commercial Fishing Vessels in the Pacific: An Economic Appraisal." International Conference on Ocean Resource Development in the Pacific," Honolulu, Hawaii, 13-15 Oct., 1981. 29 pp.

Over the past decade, Pacific-based commercial fishermen experienced and unprecedented 1,000 percent escalation in prices paid for diesel fuel. This upward price spiral, which as of yet exhibits no indication of reversion, has proven particularly troublesome for fishermen who use significant quantities of fuel. Adoption of sail-power technology has recently been suggested as a way to relieve fuel dependence. This paper investigates the projected profitability of operating sail-assisted commercial fishing vessels in the Pacific Basin. Analysis focuses on the feasibility of procuring and operating two sizes of multipurpose sail-assisted vessels to fish in Hawaiian waters. For purposes of comparison, investments in comparable size diesel-powered vessels are also analyzed. For all four alternative vessels under study, projected costs and returns are calculated and profitability estimated. A sensitivity analysis of investment performance is conducted using alternative assumptions about fuel prices and vessel acquisition costs.

Analysis of the financial results indicates that investment in sail-assisted fishing boats is not economcally feasible given current fuel prices, costs of borrowed capital and vessel construction costs. A more attractive investment alternative appears to be purchasing used (and therefore less expensive) diesel-powered vessels. This holds true despite the fact that diesel vessels generally incur 40 percent higher annual fuel expenses compared to sail-assisted boats.

Based on these findings, it appears that investment today in a sail-assisted vessel similar to the prototypes under study is not financially justified. However, with continued upward fuel price hikes, increased availability of lower cost sail-assisted vessels, and the possibility of special government sail-assist investment tax credits, this conclusion could be altered. If so, wind-power may yet be an important energy source behind future fisheries development in the Pacific.

47. Karl C.Samples, "An Economic Appraisal of Sail-Assisted Commercial Fishing Vessels." ms. submitted for publication in "Marine Fisheries Review," 1983. 23 pp.

Similar economic analytical methods were used by this author with similar conclusions. However, he states that: "retrofitting an existing fishing vessel with sailing apparatus is an inexpensive way to take advantage of wind energy." The author mentions the efficient hull forms of yachts but criticizes yacht conversions to fishing craft on four grounds: 1. initial high acquisition costs. 2. limited hold capacity. 3. restricted deck space. 4. need for a crew experienced in handling a sophisticated sailing vessel. The third approach cited is to design and build a sail-assisted vessel from the keel up. Efficient hull shapes time fuel useage in either power or motor sailing modes, but disadvantages are: high acquisition costs, deckspace shortage and need for experienced sailing crew.

On vessels examined in the field fuel savings on a 47 foot sail-assisted craft are anticipated to be 37% as compared to a similar power-only boat. The figure for a 65 footer is calculated to be 36%. These are slightly higher than projected by Shortall in 1979 of 30 to 35% and considerably lower than by Sorensen-Viale in 1981 of 75%. The problem with all new sail-assist vessels is that the fuel cost savings are overwhelmed by: high purchase prices, higher maintenance, depreciation and insurance.

48. M. Crowley, "Fishermen View Conversion to Sail as Unlikely Prospect," National Fisherman, Sept., 1982.

A negative article summing up one reporter's impression of the Norfolk conference on Applications of Sail-Assisted Power Technology. The idea of putting sails ona boat equipped with a modern diesel engine, electronics and hydraulics is incongruous. However, he believes conservative, simple sailing rigs as advocated by the University of South Florida studies have the greatest chance of being accepted by the commercial

fishermen. The work of Jack Shortall was summarized. Also discussed was a paper by John Sainsbury on the CSY 44 sailing yacht rigged for bottom line fishing which showed considerable fuel and cost savings.

49. Nicholas Anthony, Designs of Sail-Assisted Fishing Boats, 1158 Willow Green Drive, Newport News, Virginia 23602. 1982.

1. 44 ft. (13.4 m) catamaran.
2. 90 ft. (27.4 m)trawler.
3. 62 ft. 7 in. (19.1 m) catamaran.

50. Lock Crowther, Designs of Sail-Assisted Catamaran Fishing Boats, Crowther Multihulls, Box 35, P.O. Turramurra (Sydney) N.S.W., Australia. 1982.

1. 46 ft. (14 m) aluminum trawler or game fishing catamaran.
2. 46 ft. (14 m) research catamaran vessel.
3. 73 ft. 6 in. (22.4 m) pearl fishing catamaran.

51. 32 ft. 10 in. (10 m) sail-assisted fishing boat by Norlin Yacht Design, Blasieholmsgt. 2, 11148 Stockholm. (NEW DEAL 33)

52. Hood Sailmakers, Marblehead, Mass. "Sail Power for Fishing Vessels." Manufacturer's brochure given at Fish Expo, Seattle, 1981.

The case for motorsailing within ten degrees of the true wind direction is made on the basis that: 1. it saves fuel. 2. it reduces pitch and roll. 3. it reduces engine wear. These points are made for retrofit of existing vessels and an outline of the design phase is given: A. Superficial evaluation of retrofit prototype vessels. B. Evaluation of selected vessel. C. Compatible rig alternatives with three options: 1. minimum sail array for at least downwind power assistance. 2. modest changes in rig, deck layout and hull to achieve a cross-wind capability. 3. optimum rig for full cross- and off-wind caabilities with substantial changes in rig, deck layout and hull. D. Economics. E. Summary Report.

53. "A Diesel and Sail Powered Combination Vessel with an Energy Efficient Hull," ibid.

This is a proposal for a Hood design of a new 96 foot (29.2 m) multipurpose fishing vessel prototype with 40% fuel savings.

54. John Frye, "Alternate Fuels Hold Little Promise As Power for Hungry Fishing Vessels," National Fisherman 1980 Year Book.

This is a summary of the 1980 report on "Alternative Fuels for Marine Use," by the Maritime Transportation Research Board to the National Academy of Sciences. Direct wind energy as a candidate for alternate fuel for all marine vesels was categorized as high level of technological achievment, high availability, low probability of economic production and low

potential market size for marine propulsion systems.

55. Hugh McKeller, "Low Cost and Ease of Construction Highlight this Trailerable 22-footer," National Fisherman, December, 1982.

Designed by J.P.Hartog is a 22 foot (6.7 m) commercial and sport fishing boat with a $2,000 maximum price tag for the do-it-yourself builder plus engine and controls. A small headsail is shown.

56. John W. Shortall III, "Design and Realities of Sail-Assisted Fishing Vessels," Sail-Assisted Fishing Vessel Workshop Summary, University of California Sea Grant Marine Advisory Program, Ocean Carriers Corp., University of Florida Sea Grant College Program, University of South Florida College of Engineering and the Pacific Coast Federation of Fishermen's Associations, Inc. Sausalito, California, November, 1982.

Approximately 50% of shrimpers' costs and 30% of Gulf longliners' costs are fuel related. Sea Grant funded research in Florida has been directed toward retrofitting and the snapper-grouper industry. Shrimper retrofit is difficult because of the complex deck equipment. Retrofit of a snapper-grouper vessel will cost approximately $10,000. Problem areas include: ballast tradeoffs, variable center of gravity affects allowable sail area, lateral plane and rudder areas, shoal waters, balanced sailing rigs, stayed vs. unstayed masts, type of rig: gaff, bermudian, ketch, schooner, ability to predict motor sailing performance. Consideration of catamarans is suggested for some applications.

57. Chistopher M. Dewees, "Overview of Economic Studies of Sail-Assisted Fishing Vessels," ibid.

Since 1967, fuel prices have risen 1,100 percent - 1000 percent since 1973. The high cost of technology and high interest rates make sail-assisted fishing vessels difficut to justify economically. Fuel bill might be a significant portion of the vessel's variable (operating) costs. While Gulf of Mexico shrimpers spend 57% of their variable costs on fuel, West Coast fishermen devote 5 to 25% of their costs typically to fuel. On the Pacific Coast, the most likely to benefit from sail-assist are fishermen with long trips to the grounds as the offshore albacore fleet and Seattle-based vessels travelling to Alaska. Fuel savings must be balanced with a loss in hold capacity up to 50% and a loss of deck space. If another crew member has to be added to handle sails, sail-assist probably won't be economically viable. Loss of speed (time) needs to be considered.

58. Peter Sutter, "Practical Sails for Fishing Vessels," ibid.

Not always can sails alone make a fish boat move from one area to another as well as an all power vessel. Hull shape is very important. Very few of the sailing fish boats seen are designed for ease of movement through the water. The Grand Banks schooner had a very fast, easily moved hull. These were 135 to 140 feet (41 to 42 m) long and held about 70 tons of fish. The smaller vessels were 70 feet (21 m) and held 40 tons. They had good sailing qualities empty or loaded because of hull shape and low aspect ratio rigs.

Running riggins should be simple. Halyards should be non-stretch braided dacron. Lazy jacks should be used to contain sails. Sails should be cut fuller than for average yacht for more power. The heavier the dacron fabric, the longer it will last. We are getting sails back in the loft that are 25 years old. After some resewing, they are ready for many more years use. Most are of 9 ounce or heavier dacron and sun damage has not occurred. Nine ounce should be used in 40 to 45 foot boat and 10.5 ounce in boats in the 50 to 60 foot range. Sails should be cut without batten pockets or roach - real problem areas on most sails. Corners must be stronger and heavier. If the main and mizzen are to be used as trysails, the top thirds should be of heavier dacron. Seams should be broader than usual and triple stitched.

59. Panel Discussion: Morgan and David Davies, J.P.Hartog, M.Kossa, J. Shortall and C.Dewees, ibid.

Among other points, it was emphasized that more information and education in a form usable to the fisherman about sail-assisted vessels is needed.

60. Cynthia Roby, "Program at Army Corps of Engineers Considers the Benefits of Sail-Assisted Fishing Vessels," Marin Scope Newspaper, Nov. 9-15, 1982.

Full page summary of the above workshop.

61. D.R.Reid, et al, "Projeto 'Pesca A Vela," (Fishing with Sails) Brazilian report in Portugues, 1982.

This hundred or so page report is a feasibility study to the governor of the state of Rio Grande of the North of the use of sail fishing vessels in Braziian fishing waters and a proposal to buy, build and operate same. The report contains the following sections: historical, objectives, means, justifications, systems and methods of fishing, electronic equipment, markets, refrigeration systems and economic viability.

An economic study in support of this project was done at the request of Captain Reid at the University of South Florida. At 35% mortgage rates, general inflation at 106% and fuel inflation at 138%, purchase of anything new did not seem to make sense. Low catch prices did not help the economic assessment.

61. James W. Brown, "New Working Watercraft," Virginia Sea Grant Program, 1982.

Much of this fine work treats sailing fishing craft in Africa and the Pacific. It is abstracted in the section on Work Boats.

62. Woodbin and Marean,Inc., Box 26, West Boothbay Harbor, ME 04575, "Design Proposal for a 77 Foot (23.5 m) Sailing Fishing Vessel."1982 release.

Described is a sail-assisted fishing vessel for the U.S. east coast fisheries to be powered by 100 to 350 hp engines with 2600 sq.ft.(242 sq.m) sail area and rigged as a ketch.

63. K.Lange and P.Schenzle, "Full Scale Trials with Wind Propulsion on a Small Fishing Vessel." International Council for the Exploration of the Sea, Fish Capture Committee, 1980, 16 pp.

Described is a series of measurements of motor sailing performance in winds up to 25 knots of two sail-retrofitted Baltic fishing vessels of 24.5 m (80 ft.) and 27 m (88.6 ft.) each of displacement 120 and 100 tons each and sail areas of 95 sq.m (1023 sq.ft.) and 180 sq.m (1938 sq.ft.) respectively. This is rarely seen operational information on the motor sailing mode.

63. "24 ft. Fish Boat Rigged for Single Hand Operation," National Fisherman, January, 1983.

Described is a 24 ft. (7.31 m) catboat for clamming, scalloping and longlining. Power is a Westerbeke 27 putting out 23 bhp at 2500 rpm.

64. Endicott M. Fay,NA, "The Economics of Sail for a 70 Foot Fishing Boat," The Fishermen's News 1982.

Described are the costs for capital investment and operation of a 70 foot (21.3 m) sailing fish boat. Included is a table of annual costs and savings. Over a ten year period, the net profit increased from $31,013 to $82,089.

65. Cathy Vaughm, "Seacrests Launch Unusual Vessel," New Smyrna Beach Journal, June 2, 1981.

The 35 foot (10.7 m) sailing fishboat CLINTWHEEL is launched. The boat will be used to fish in Alaskan waters.

66. Andrew J.Shanley, "New Fishing Boat Relies on Its Sails," Vineyard Gazette, Martha's Vineyard, Mass. Nov. 26, 1982.

Pictures and a brief description are given of this Dick Newick designed sailing trimaran fishing vessel which can carry up to one ton of fish. It is particularly suited to third-world countries.

67. Richard Bowles, "A Pinch of Salt- Economical Boat is

Well-Equipped Fishing Machine," Gainesville, Sun, Florida, June 18, 1982.

The EFFIE CAMPBELL is a 65 foot (19.8 m) gaff rigged sharpie drawing two feet (0.6 m) of water and operated out of Suwannee, Florida by Captain Ron Kinsey. The auxiliary is a two cylinder diesel which burns two quarts (1.89 lit) of fuel per hour. Capt.Kinsey has developed his own refrigeration system using a compressor salvaged from a refrigeration truck belted to the engine.

68. Richard Bowles, "Resurrected Sharpie Makes Good on Florida Bottomfish," National Fisherman, Nov., 1982.

The EFFIE CAMPBELL was built in 1974 and is modeled after a working sharpie of 1899.

69. Terry Lesh and Patricia Lesh, "New Dimensions in Sail Assisted Commercial Fishing Designs," book in preparation (1983)

70. James W. Brown, "New Working Watercraft," subtitled: A Return to Former Capabilities. 1982. Virginia Sea Grant Program, 95 pp.

See abstract under Workboats

71. Jean Andrews, "Wind Power for Working Boats, " USF Magazine, University of South Florida, June, 1982. p.8-9.

Described is the program for investigation of sail-assisted propulsion for fishing vessels at the University of South Florida College of Engineering. Savings to the snapper-grouper industry on a per boat basis are estimated to be at least 30% for an annual fuel savings of 1,400 gallons or $1600 as an absolute minimum.

SAILING WORK BOATS

The combination work boats of Captains Lane and Jesse Briggs are perhaps the best known in this class: NORFOLK REBEL and STEEL REBEL. The former is illustrated in figure 4. These Tugantines(r) can serve as tug boats, salvage vessels and for trawling and longlining in commercial fishing. The 2000 pound payload SMALL IS BEAUTIFUL trimaran sailing pickup truck is a fascinating concept. Other concepts appear in this category as well.

SAILING WORK BOATS

1. "They All Laughed When Cap'n Briggs Went Sailing," Coast Watch, University of North Carolina Sea Grant, Feb.,1981. 1-2.

This is a light article giving the background on Lane Briggs' sail-equipped tug STEEL REBEL which first used auxiliary sail in 1975. Naval architect Merritt Walter then designed a sail-assisted tug for Captain Briggs which could double as a commercial fishing boat: NORFOLK REBEL. She is 51 feet long and was launched May 22, 1980. She carries 1200 square feet of sail including a foresail that can be used with a retractable bowsprit. Main power is from a 320 horsepower diesel engine. In the first year of operating STEEL REBEL, enough was saved on fuel to more than pay for sails and rigging. Capt. Briggs expects to use sails on NORFOLK REBEL 50% of the time, saving about 40% fuel. The National Marine Fisheries Service awarded a grant of $72,000 to rig the boat with sail. The NMFS estimates that for trawlers about 57% of overhead is spent on fuel. The average shrimper burns one and one-half gallons of fuel for each pound of shrimp landed.

2. "Sail Power - Will It Work?"; ibid. 3-4.

Discusses sail power in general and refers to some of the well-known designs. Bill Hall has modified the design of a 50 foot Chesapeake Bay bugeye as a sail-assisted trawler. Bryan Blake has modified two Fulcher sharpies which have small engines and sails.

3. "Sailboats Built to Work (play!)," ibid. 5-6.

Discusses the sharpies - 20 ft. TORTUGA and 30 ft. SAKONNET which are commercial sailing fishing boats with small auxiliary engines.

4. Capt. J.Briggs, "Sailing Workboats - Practical Propositions Based on Experience with a Sailing Tug," Paper presented at New Orleans Work Boat Show, January, 1980. 10 pp.

Tugantine(r) is a word coined to describe a sail-assisted tug boat. The STEEL REBEL is 46 feet long and has a 225 SHP engine with a cruising speed, light, of eight knots. In 1975, the addition of a simple square sail and jib increased hull speed 1.6 knots. The most effective rig on this vessel is a gaff-rigged schooner with squaresails. This combination gives the most sail area with the lowest possible mast height. When towing, the sails do not add much to the speed unless the apparent wind is more than 50 degrees off the bow. This is due to excessive leeway. A spinnaker is occasionally used in light airs. On numerous occasions, towing speed has been increased by 20% and when running light by 30%. On a tow the craft was making five knots with engine alone. When sail was raised, boat speed increased to six knots in a 15 knot wind. When running light in an 18 to 22 knot wind, the boat made 5.5 knots under sail alone.

The NORFOLK REBEL was designed as a sailing tug boat with engine assist and is a gaff-rigged squaresail schooner with 1400 square feet of sail. Fuel savings of 30-40% are expected. Some of the advantages of using sail on workboats are: fuel savings, less engine repair and maintenance due to operating at lower RPM's, more job satisfaction, come-home capability in the event of engine failure.

5. B.Harden, "A Tug With Sails is Christened by Norfolk Captain," Washington Post, June 24, 1980.B1&B3.

Decribes the launching of Capt. Lane Briggs' tug with sails: NORFOLK REBEL. Some 17 articles have been written about the two sail-assisted tugs. The Virginia Institute of Marine Science estimates that up to six gallons of diesel fuel per hour can be saved. Among the advantages are a smoother ride in rough water.

6. R.D.Gersh, "Sailing Tugboat is a First," St. Petersburg Times, May 24, 1980. 4A.

Describes the Tugantine(r) concept. The Virginia Institute of Marine Science plans to study the vessel to detemine the most efficient power-sail combinations under different conditions.

7. J.Waller, "Tugantine Best of Two Worlds--Tug, Sails," Soundings magazine, July, 1980. 36.

Describes the Tugantine(r) and the launching of the NORFOLK REBEL. It is hoped to save as much as 1000 gallons of fuel per week while fishing under sail. The only time the engine is needed is to haul in the 10 to 15 mile longline. She has a strong enough power plant for salvage and towing. The tugantine(r) has 10 tons of lead in the keel for stability and an 820 cubic foot insulated hold for fish or other cargo.

8. Merritt Walter, "TRADE ROVER," Rover Marine, Inc., 1651 Bayville St., Norfolk, VA 23503. 5 pp.

After having designed the NORFOLK REBEL, a 52 foot sailing tug, naval architect Merritt Walter received a number of enquiries about various types of sailing working vessels. He has added the TRADE ROVER as a stock freighter to his plans. She is 57 feet long, displaces 66470 lbs., has a draft of 5 ft. 6 in. and carries 1285 square feet of sail on a gaff topsail schooner rig. The cargo hold is 20 feet by her beam.

9. J.Dorsey, "Winds Blowing in His Favor in Sail Study," Norfolk Ledger-Star, May 24, 1979.

Merritt Walter, NA is quoted as saying that naval architects hired to study the modern use of sail for today's cargo vessels should come down from the rigging. "They're studying it. We're already doing it. He advocates the smaller cargo vessels up to the 1000 ton, 200 foot class for small Mom and Pop organizations.

10. John W. Shortall III, "The Wind-Powered Work Boat...'Small is Beautiful' - SIB," Multihulls magazine, Jan./Feb., 1979. 70-76.

Designed by Jim Brown and Dick Newick and backed by Phil Weld with the Gougeon Bros. and Dave Dana as consultants, SIB is a 31 foot trimaran sailing freighter/water-borne pickup truck with a cargo capacity of 2000 pounds. She uses two unstayed masts with wishbone boom on the after mast and Ljungstrom rig on the fore mast. She is designed as a day sailer for 10 to 12 passengers or equal capacity in freight and has particular application to Third World countries. She uses the Constant Camber (tm) cold moulded method of construction.

11. John W. Shortall III, "Sailing Cargo Carrier - CHANGED, A Unique Design for Pleasure and Profit," Cruising World magazine, March, 1972. 59-61.

Described is the design of a 5 ton cargo capacity, cutter-rigged sailing freighter with accomodations for a cruising couple plus one berth for crew. Cargo is contained in two holds which may be used for people and/or for freight. The craft is a shoal draft, centerboard type whose design was modelled after the PRESTO type of Commodore Munro. She is 42 feet long and has moveable internal ballast to compensate for various cargo loadings and the light ship condition.

12. Jim Brown, "Knock on Wood - Part I: Plight of the Canoe People," Woodenboat magazine, May/June, 1981. 78-86.

The author comments on sailing canoes and their probable demise on Lake Victoria, the Phillipines, Central America, Kenya and the Pacific. Also discussed are dhows of the Indian Ocean.

13. Jim Brown, "Knock on Wood - Part II: The Laminated Dugout Caper," ibid, July/August, 1981. 50-57.

SMALL IS BEAUTIFUL IS described as is the Constant Camber (tm) method of cold moulding hulls particularly suited for third world countries. This is a low technology, manufactured craft with simple and reliable components.

14. Jim Brown, "Knock on Wood - Part III: Wind Wagons of the Future," ibid. Sept./Oct., 1981. 66-73.

The author emphasizes the ability of trimarans to move under sail efficiently and rapidly and discusses designs from 31 to 52 feet in length overall. He describes the application of variable pitch, full-feathering propellers and motor sailing plus a special down-wind sail termed the working cargo chute designed as a sail for working vessels.

15. "Can Sail Help Save an Island Resource?" National Fisherman Yearbook, 1981. 130-134.

Maine has 1200 wooded islands with 269,512 forested acres with 2.2 billion board feet of sawn lumber. The annual continuous growth amounts to 135,000 cords of wood. The forests are not being maintained and represent a fire hazard. A 28 foot wooden sailing barge has been designed to facilitate small-scale foresting and logging. Due to unreal conservation restrictions, firewood now has to be delivered by ship to the Maine islands. It is transported regularly by the LAURA B., a Tancook whaler built at the Bath Marine Museum's Apprenticeshop. Delivered price of firewood is $135 per cord.

16. James W. Brown, "New Working Watercraft," Subtitled: A Return to Former Capabilities. 1982 Virginia Sea Grant Porgram, 95 pp.

Based on reports of boat design and construction consultancies originally prepared for clients in the Third World beginning in October, 1981. This work covers Mr. Brown's travels and experiences in East Africa and the Pacific on behalf of the World Bank. He describes the laminated dugout which is a local adaptation of the constant camber (tm) technique using cross-laminated strakes of thin, native-grown wood and waterproof glue over curved forms for local series production of hull shapes. The technique was then adapted to the banca in the Philippines for production of sailing outriggers as fishboats and workboats. Maritime conditions in Tuvalu are next described with examples of local craft and improved sailing canoes are shown. There are numerous excellent illustrations including an 80 foot (24.4 m) catamaran inter-island passenger ferry, and the constant camber (tm) method is described graphically and in words. Twenty questions are included on: Native Fishery Vital Signs to analyze local trends and determine design parameters for new boats.

17. John Gardner, "Economic Factors Determine Value of Sail Power for Commercial Craft, " National Fisherman, Jan., 1983. p.63-64.

This is a review of the above book described in Abstract 16.

18. Rudy Choy, Manley St.Denis, Richard Rhodes, "On the Design and Sailing Performance of the Polynesian Voyaging Canoe Hokule'a," Pacific Ocean Power Conference, SNAME Spring STAR Meeting, Hawaii, April, 1982.

An analysis of the ancient Polynesian craft Hokule'a which made round trip voyages between Hawaii and Tahiti.

19. "Sail's Day in the Sun May be Returning," Christian Science Monitor, April 19, 1982 from Sail Assistance News, SAILA, May,

1982.

UN experts interviewed in various Asian nations said they were reintroducing the use of sails to reduce fuel costs. One foreign aid program would put sails on a fleet of about 1500 fishing craft now equipped with 30 hp engines. Top choice is the Chinese junk rig.

20. "Government-Funded Study of Sail-Assist Nears Completion," Sail Assistance News, May, 1982.

Prelminary fuel savings findings are given for NORFOLK REBEL and sample readings are given for engine only, sail assist and sail only for engine rpm, wind direction and speed, sail area, fuel consumption rate, boat speed, trip time etc.

21. "Norfolk Rover will be Carrying Pasengers in June," ibid.

Quote from designer Merritt Walter of Rover Marine who has obtained U.S.Coast Guard approval for his 63 foot (19.2 m) schooner design. She is designed to carry both freight and passengers.

22. "Launching of PHOENIX Heralds Rebirth of an Industry," ibid.

Quote from Greg Brazier, President of Atlantic Packet Lines. The 27 foot (17.4 m), 20 ton vessel will operate between Long Island and Connecticut hauling cargo.

23. "Freighting Under Sail Never Died, but for a While It was in Ill Health," ibid Sept., 1982.

Quote from Tom Colvin. Most famous of his 2500 or more designs now sailing is the GAZELLE, of which more than 60 are now engaged in fishing, freighting or chartering. The schooner MEMORY has 18 sisterships, of which six are commercial. His most successful commercial sailing vessels are between 40 and 60 feet (12.2 to 18.3 m).

24. "Sail-Assisted Cargo Vessel has Certification Trouble in New Zealand," ibid Dec.,1982.

A company based in Coromandel has already put a prototype hull on its Hauraki Gulf route and has a second vessel under construction, but they are finding their Ministry of Transport and Marine reluctant to grant full certification. Design is based on the MESSENGER - Chesapeake Bay skipjack, 37 feet (11.27 m) long and with a cargo capacity of three to five tons.

25. "Atlantic Packet Lines Inaugurated its Cross-Sound Cargo Service," ibid.

Capt.Greg Brazier annouced the start of his packet service on 25 October, 1982.

26. "Micronesia Needs a Sail-Assisted Ambulance," ibid.

Required is a steel vessel, sail-assisted, capable of 10 knots under power, refrigeration, etc.

27. "Sailing Vessel Carrying Aid to Caribbean," ibid.

The 105 ft. (32 m) sailing vessel FRI has embarked on a voyage to the West Indies after a major refit in Amsterdam.

28. "Manutea Achieves Near-Record Passage on Maiden Voyage," ibid.

This 112 foot (34.1 m.) sailing vessel can haul 40 tons of payload and is capable of making 300 miles per day. She is operated by the South Pacific Energy Systems company, is built of steel and carries a crew of six.

29. "Germany also has a Finger in the Wind," ibid.

The German Federal Ministry for Research is financing development of a sailing vessel to carry cargo in Indonesia. She will be about 200 feet (61 m) long, with hydraulically operated sails and able to carry about 2000 tons of cargo.

30. Jim Brown, "The New Sailing Multihull Workboats," National Conference/Workshop -Applications of Sail-Assisted Power Technology, May 19-21, 1982, Norfolk, Virginia, USA

31. Paul Mooney, "Cargo Schooners - Builder's Perspective," ibid.

32. Gordon Baxter, "Schooner MEMORY," ibid.

33. Joe and Sharon Spivey, "Cargo-Schooner SHARON VIRGINIA," ibid.

34. Capts.Lane & Jesse Briggs and Robert Lukens, "Tugantine (r) NORFOLK REBEL (Tug/Fishing Vessel)," ibid.

35. Merritt Walter, NA, "TRADE ROVER Design), ibid.

Packet schooner PHOENIX launched April, 1982 in Long Island.

36. Merritt Walter, NA, "SEATTLE ROVER Design (Cargo/Cruise Vessel)," ibid.

37. "Annual Report July 1981-June 1982: Hawaii Natural Energy Institute," University of Hawaii at Manoa, Honolulu, Hawaii.

This is an outline description of a project for: Sail-Assisted Technology for Pacific Marine Transportation. Head of the project is Dr. Theodore T.Lee, and his staff includes: Dr.Karl Samples, Wayne Thiessen, Leo A. Daly, Angela Topliss and Mauro Vidal. A market opportunity analysis will be completed for sail-assisted technology in the Pacific, routes will be studies, economic analyes be made, ship configurations evaluated and costs compared for retrofit versus new designs.

38. R.D.Gersh, "Captain Sees Joke Turn into Reality," Richmond News Leader, August 27, 1981.

An account from on board the NORFOLK REBEL of the tugantine combination fishing-tug boat with sails and engine. Photograph is shown with sister ship the STEEL REBEL.

39. Merritt Walter, NA, "Design Philosophy," no date.

An account of the design philosophy of Merritt Walter with descriptions and drawings of these examples of his designs: COAST ROVER, TRADE ROVER and SEATTLE ROVER varying in length from 52 to 57 feet (15.7 to 17.4 m).

40. "Sail Cargo Vessel Will Ply L.I. Sound," Sailing Magazine, July, 1982.

A brief account of the 69 foot (21.0 m) PHOENIX.

41. Francis James Duffy, "Cargo Schooner Constructed for Duty on L.I.Sound," National Fisherman, July, 1981, p.80.

A more detailed account of Greg Brazier's PHOENIX designed by Merritt Walter as one of the TRADE ROVER series. Capt.Brazier is the first to receive a U.S.Coast Guard certification for this type of vessel. Since she is under 100 gross tons and has less than 100 hp, it will not be necessary to file with the Interstate Commerce Commission to carry cargo.

42. William O.Foss, "Designer Finds Commercial Sail Feasible for Smaller Operations," ibid p. 81.

Merritt Walter designs and builds in traditional steel. He does not believe there is any future in sails for large ships but thinks they are eminently suitable for smaller work boat operations. Fishery applications seem favorable. The NORFOLK REBEL is of the COAST ROVER series designs.

43. Rick Friese, "Schooner's Owners Hope to Haul Cargo Under Sail," Sail Magazine, March, 1982, p. 264H.

This is a description of the Spivey's SHARON VIRGINIA, designed by Thomas Colvin and built by the Mooney Brothers of Deltaville, Virginia. She is 54 feet (16.5 m) LOA, 74.5 feet (22.7 m) with bowsprit and can carry 15 to 20 tons of freight.

ECONOMICS OF COMMERCIAL SAIL

For some years, marine economists have attempted to assess the practicality of commercial sailing vessels. The major inhibiting factor appears to be that the current high interest rates make it unlikely that any kind of new vessel can be purchased or built whether with or without sails. One author has mentioned that even if the economics of sailing ships appeared favorable vis-a-vis new motor vessels, this probably would not be so if the price of building a new sailing ship or fishing vessel were compared against that of a buying a used one. See various abstracts in the commercial fishing section as well for economic analyses pertinent to that field.

ECONOMICS OF COMMERCIAL SAIL

1. G. Mearns, "The Large Sailing Ship-Dinosaur or Development," Symposium on Wind Propulsion of Commercial Ships, The Royal Institution of Naval Architects, London, 1980. 37-50.

This paper reviews the development of the large sailing ship from 1824 to 1911 and concludes that even by the midpoint of that period, the large sailing ship could not be justified on commercial grounds. Problems of performance and factors affecting the performance are discussed. Finally, it is suggested that if fuel economy is the primary objective, there are a number of alternative strategies which can be adopted by shipowners and shippers which will be more effective than the use of wind power alone. See this article abstracted in more detail under the General Survey category.

2. E.P.Crowdy, "The Economics of Sail," ibid, 51-66.

The annual cost of propulsion as a function of ship's speed is examined, and fundamental economic relationships between propulsion cost, total cost and revenue earning potential of merchant ships is deduced. The economic attractiveness of sail is shown to be totally dependent on the cost of alternative means of propulsion. Coal-fired and nuclear comparisons are given. The paper examines the factors which should influence the installed power of the mechanical propulsion equipment, and its optimum output at sea in varying wind conditions. The paper concludes with some observations on the relative merits of various types of wind-powered propulsion equipment.

3. R.C.T.Rainey, "The Wind Turbine Ship," ibid. 97-116.

The author analyzes the potential of a vertical-axis wind turbine on a 4,000 ton passenger/cargo ship on the UK-Cape Town and Cape Town-Ascension routes. Based on official discount rates and fuel price projections, the payback period comes out as 12-22 years on the former route and 5-7 years on the latter. These figures give encouragement for future development of the scheme.

4. A.D.Couper, "An Evaluation of Commercial Sail," Commercial Sail Symposium, London, 1980. 6-77.

This is abstracted in detail under the General Survey category.

5. P.J.Jonas, "Energy Conservation Perspectives," ibid. 97-111.

Oil prices are expected to double by the year 2000. Alternative sources of energy are not being developed sufficiently quickly, cheaply and acceptably as yet to take the place of oil. Energy principles are discussed. A man working at a pump can work at the rate of about 30 watts; cranking he can achieve 60 watts, and a cyclist can do spurts of 300 watts. Watermills and windmills attained powers of 4000 to 6000 watts. Energy conservation and pricing are covered.

6. J.Wellicome, "A Broad Appraisal of the Economic and Technical Requisites for a Wind Driven Mechant Vessel," The Future of Commercial Sail, The Royal Institution of Naval Architects, 1975. 57-80.

The current high level of bunker fuel prces and the prospect of dwindling oil supplies in the comparatively near future may well lead to a reappraisal of the means of propulsion used by commercial ships. If oil fuel becomes uneconomic, the forseeable alternatives are nuclear power or a return to sail. One could claim that the future of nuclear power is in doubt from long term pollution and safety considerations. It is also true for technical reasons that nuclear power is suited for large or fast ships requiring 30000 SHP upwards. Thus, there may well be grounds for considering a return to sail, at least for the transportation of those commodities which do not command a high freight rate. Square and fore-and-aft rigged vessels could be reintroduced along the lines of those used at the turn of the century, but with design changes to use auxiliary power for sail handling. A number of alternative means of achieving wind propulsion have emerged which suggest the possibility of a radically different form of wind propulsion.

7. A.S.Miles, "The Economics of Commercial Sail," ibid. 81-88.

The commercial sailing vessel was ousted by the powered ship as a result of a combination of technology and cheap fossile fuel. This paper investigates the economics of operating two hypothetical sailing vessels in competition with powered ships to determine comparative economic performances. Future costs and comparisons are assessed. The largest vessel ever to use sail power was the GREAT EASTERN of 28,000 DWT, although they were rarely over 4,000 DWT. The inference is that even in the mid-nineteenth centry, the capability existed to build and sail pure sailing vessels considerably larger than the largest sailing vessels that were then in service.

8. L.Bergeson et al, "Wind Propulsion for Ships of the American Merchant Marine," Wind Ship Development Corp., March, 1981.

See the abstract under the General category for more information. Sections IV and V of this comprehensive report deal with varous of the parameters and optimizations by RFR: Required Freight Rate.

9. J.B.Woodward et al, "Feasibility of Sailing Ships for the American Merchant Marine," The University of Michigan, February, 1975.

See the abstract under the General category. Economical analyses are contained in Section VII, pages 52 to 77.

10. B.P.Brown,Jr., "An Evaluation of a Potential Use of Sail Power in the Commercial Shrimp Fishery of Texas," M.S. Thesis, Texas A&M University, August, 1976.

The fuel intensive Texas shrimping industry is experiencing economic difficulties partially due to the rising cost of fuel. This thesis invesigates the economic feasibility of using the wind as an alternative source of propulsion. Comparisons are calculated between a conventional 72 foot steel, 340 hp diesel-powered shrimper pulling two 36 foot nets and a hypothetical sailing shrimper with a smaller engine. The sailing vessel has a 40% lower annual fuel consumption but its catch is estimated at to be only 68 to 72% of the powered vessel. The sailing shrimper shows a profit with shrimp prices above $2.92 per pound. Higher fuel prices favor the sailing model, and higher catch prices favor the powered vessel.

11. W.L.Warner, "Updating an Ancient Art," Society of Naval Architects and Marine Engineers STAR Symposium, San Francisco, 25 May, 1977.

The economics of motor ships vs. sailing vessels are compared. Analyzed are the effects of inflation on required freight rate and annual transportation costs.

12. "A Transportation Need Study in the Trust Territories of the Pacific Islands with Emphasis on the Potential for Sail-Assisted Technology," U.S.Dept. of the Interior, 1981.

Described is the political climate of the Marshall, Truk, Palau, Pogape and other Pacific islands which make up the Trust Territories. Vessel operating costs are given. The Pacific islands are totally dependent on the adequacy and regularity of inter-island surface transportation. This is completely dependent on uncertain supplies of increasingly expensive imported fuel. Recent developments in sail-assisted technology offer the potential for alleviating the dependence on imported fuel for surface transportation, thereby improving the capability for regular supply schedules to the various islands.

13. C. Mudie, "Reducing the Running Costs at Sea," Journal of Navigation, May, 1977. 172-180.

The author presents a number of ways to reduce the running costs of existing ships by making use of power sources freely available. These considerations are addressed briefly: 1. ocean currents. 2. buoyancy. 3. gravity. 4. magetism. 4. solar power. 6. wave power. 7. wind power. The latter is discussed in some detail with thrusters reviewed: bermuda sail rig, Flettner rotor, multiple aerofoils, windmill and ducted fan.

14. "Capital Report: Matsunaga Enthusiastic Over Commercial Ship Sail Power," Sea Technology, October, 1980.

U.S.Senator, S.M. Matsunaga (D- Hawaii) is enthusiastic about encouraging sail-assisted technology. He chaired a hearing of the committee on energy and natural resources on August 26, 1980 on sail-assisted technology for the Pacific Trust Territories. A bill he has introduced, S.2929, would authorize a study of sail-assisted technology. One possiblity is an energy tax credit for use of wind power on the high seas which is equal to the tax credit for the use of wind power on land.

15. M.Stuttaford, "A Return to Sail," South African Yachting, September, 1975.

A detailed presentation is given of DYNASHIP with a personal perspective on its conceiver and designer: Wilhelm Proelss. Economic incentives are appraised. There are lower interest rates for less expensive vessels and depreciation would be extended over 20 years instead of 12. Insurance premiums should be lower due to lessened fire hazard.

16. Karl C.Samples, "An Economic Appraisal of Sail-Assisted Commercial Fishing Vessels," University of Hawaii, Honolulu, Hawaii 96822, 16 pp plus tables and figure. Proposed for Marine Fisheries Review, 1983.

See Abstract No.47 under Modern Sailing Fishing Vessels.

TECHNOLOGICAL DEVELOPMENTS

Weights and types of sail materials are discussed in more than one abstract. Solar power is treated. A particularly noteworthy paper is that summarized in part in Abstract No.10 by P.D.Priebe. His examination of historical vessels through modern conceptions and comments on historical sailing ship technology are well worth examining.

1. A.Farrar, "The Development of Sailcloth for Commercial Vessels," Symposium on Wind Propulsion of Commercial Ships, The Royal Institution of Naval Architects: RINA, 1980. pp 133-146.

The author reviews the history of sail materials claiming that the earliest record of sail material is of the Phoenicians about 500 B.C. obtaining their flax sail cloth from the Egyptians. He states that the Egyptians are believed to have used woven papyrus strips as early as 3,000 B.C. Unfortunately, he ignores the early Chinese use of fibres for sails. A numer of materials are discussed and their properties compared. Ageing and other deteriorating factors are considered and testing apparati are illustrated and described. Test data area given for: a. flax at 26 oz/sq.yd. (20.6 oz. U.S.); b. Egyptian cotton at 27 oz/sq.yd. (21.4 oz. U.S.); c. Terylene (dacron) 21.5 oz./sq.yd. (16.6 oz. U.S.); d. Terylene 21.5 oz./sq.yd. (17 oz.U.S.); e. Polypropylene; f. glass cloth, teflon-coated 25 oz./sq.yd. (19.8 oz.U.S.). In the ensuing discussion, some other materials were mentioned as: multi-laminates using mylar and Kevlar (r) and nylon for spinnakers.

2. C.C.Herbert, "The Design Challenge of the Wind Powered Ship," ibid, pp 199-214.

This paper presents an attempt to sketch out the sort of background against which wind-powered ships will have to be designed both from the point of view of meeting sensible economic targets, and employing established physical principles. Itis still a sadly sketchy and inaccurate system and draws very largely on the work of others. Nevertheless, it may serve to define what is possible, and what is impossible, and to direct the activities of the very considerable range of talents currently looking into wind power towards the most promising areas of research and investigation. Sections deal with economics, wind conditions and the technology of wind poweer. These are drawn together to define the envelope of characteristics - in particular speed and cost - within which a viable wind-powered ship design should lie, with some indication of how these might be met.

Wind speed profiles are plotted, and a suggested standard wind velocity curve and equation are advanced. Variation in wind direction for the Atlantic is shown.

Three main classes of propulsion are compared and evaluated: a. fixed aerofoils including sails and wing sails; b. Flettner rotors as a sub-class of a; c. windmill ships using rotors. Motor sailing is discussed.

3. R.M.Willoughby and E.C.B.Corlett, "Design Problems of a Commercial Sailing Ship," ibid, pp 215-231.

Principles of square rig design are discussed and illustrated, and the four hold bulk carrier SAILINER is described in considerable detail. The latter is a 137 m. (449 ft.) long auxiliary five masted barque with square sails and a 3900 BHP main engine. Sail area is 6200 sq.m. (66,736 sq.ft.), and DWT maximum is 16,600 tons.

4. C.T.Nance, "The Role of the Engineer in the Windship Revolution," Commercial Sail - Proceedings of a Symposium, Dept. of Industry, London, 1980, pp 42-92.

This is an in-depth appraisal of wind propulsion systems among other topics. Covered are: soft sail rigs such as square, schoner, short-haul and Venetian rigs; exotic systems as: rigid and semi-rigid sails, Flettner rotor and kites; and the wind turbine. The need for a test facility is expressed. Included are a glossary of terms and 16 illustrations. An extensive discussion follows.

5. L.Bergeson et al, "Ship Synthesis, Parametric Study, Analysis of Opportunities for Sail Propulsion, and Conceptual Design," Wind Propulsion for Ships of the American Merchant Marine, Wind Ship Development Corp., 1981. Sections IV, V, VI and VII.

Weight and stability estimates are included as well as engine use strategy, hull form optimization, parametric analyses of 2000, 20,000 and 38,000 CDWT vessels, parametric design optimization of wing sail rig for 20,000 CDWT ships, weight and cost sensitivity, port parameters and conceptual design.

6. "Auxiliary Sail Rig Passes Sea Tests on Cargo Ship," Maritime Reporter/Engineering News, October 1, 1981.

An auxiliary sailing rig installed on a 3,000 DWT cargo ship successfully completed sea trials. The rig was developed by the Wind Ship Development Corp. of Norwall, Mass. The rig is a triangular dacron sail of 3,000 square feet (279 sq.m) attached to a 100 foot (30.5 m) unstayed, rotating mast for furling. Mast and boom weigh over 40 tons. The sail was produced by Hood Sailmakers of Marblehead, Mass. and was specifically designed, woven and finished for this rig. The fabric is in excess of 20 ounce sailcloth with a minimum of five years of useable life. Sail clews were tested to withstand 30 to 35 tons.

7. T.Sullivan, "Hood Makes Sail for a 250 ft. (76.2 m) Freighter," National Fisherman, November, 1981, p.14.

On August 24th, tests were completed on a sail system designed and built by Hood in conjunction with Lloyd Bergeson, president of Wind Ship Development Corp. The sail is over 100 ft. (30.5 m) tall.

8. C.Mudie, "The Practicability of Commercial Sail. VIII - Some Reflections on the Optimal Use of Wind Power," The Royal Institution of Navigation, London. Journal of Navigation, May, 1977, pp 203-206.

Mentioned here are applications of new developments in aerodynamics, sail development and materials. A factor which may be ignored is there is a difference in building new sailing ships in direct economic competition with new motor ships and in building them in competition with a surplus supply of the latter.

9. J.Frye, "Will Boats Run on Solar Power in Far Future?", National Fisherman, ca. January, 1982, p. 95.

Discussed is the potential use of solar collectors and transducers for fishing craft. The article is essentially a review of the book: "A Golden Thread," by K.Butti and J.Perlin, Van Nostrand, New York.

10. P.D. Priebe, "The Evolution of Commercial Sailing Ship Technology," Ancient Interface XI, The Aero-Hydronautics of Sailing, AIAA and SNAME, 1981.

The evolution of American sailing ships is discussed with key individual contributions to their development. Mentioned is the inadequate technology carryover into current developments. A new, powerful sail system is described with potential application to modern, large bulk cargo vessels. It was judged not to be suitable for commercial semi-submerged vessel technology.

In the mid-19th century, designers of commercial sailing vessels utilized a technology which was very nearly optimum within the limits of the purpose of the vessels and the building materials available. No formal theory or mathematics could be applied, so the knowledge could not be formalized. Consequently, very highly developed sailing ship technology was partially lost with the death of the designers. In the early 20th century, builders were forced into ship design errors which would otherwise not have occurred. The historically very short glut of cheap energy prevented any serious design of commercial sail for over half a century.

Meanwhile, leapfrog or step function evolution has occurred in aerodynamics, one of the four major sailing ship disciplines. Since sailing ships were dead, they did not participate in this accelerated evolution. Constructive spillover from sport sailing into commercial sailing has been near absolute zero with racing rating rules having the effect of preventing radical progress. Thus, the weakened effort at application of airplane aerodynamics to sailing, either sport or commercial, has so far been largely misdirected. The author tries to show where we may splice in some advanced technology to the broken sailing ship tradition.

Discussed are: slave trade vessels, revenue cutters, small American schooners, large merchant vessels, barquentines, brigantines and large multi-masted schooners. Dynaship is covered in some detail as are the Woodward and the Bergstrom 1981 reports. Leadership has shifted to the Japanese with their small tanker using sail as auxiliary power.

The author proceeds toi describe his development of "rationalized" sails using high lift technology developed by NACA/NASA during the last 50 years. Polars are compared to those in the Woodward, Bergeson and Dynaship reports.

The following parameters are advanced for commercial sail dsign: a. maximum or useable lift coefficient of sail system; b. equivalent parasitic drag coefficient; c. friction drag coefficient of wetted hull surface; d. effective aspect ratio of sail system which controls aerodynamically-induced drag; e. wave drag induced by hull; f. leeway drag corresponding to aspect ratio of hull - draft to length ratio; g. aerodynamic drag of ship's hull.

A table is shown of 11 sailing vessels from historical through modern conceptions including: estimated lift coefficients, estimated sail system drag coefficients, estimated effective aspect ratio and drag coefficient, sail area dimensions, length, displacement, and sail area to weight ratio. The study concludes with an overall assessment and stating that very good hull forms were developed in the 19th century, but newly developed sails must still be optimized.

11. J.Frye, "Sun-Driven Sloop Lends Concept to Small Work Boats," National Fisherman, August, 1981, p. 88.

An 18 foot (5.5 m) sailboat has been developed with a solar powered auxiliary drive. Two 105 amp., deep-discharge batteries are mounted in the keel. The batteries are charged from two photovoltaic solar collectors recessed under plastic shields in the cockpit seats. A DC motor provides the thrust in forward or reverse. The 2000 lb. (907 kg) hull may be run for two hours at four knots or eight hours at low speed. By installing two additional batteries, range increases to six hours at four knots, 24 at low speed. Price, weight and performance data are given for small work and other boats.

12. "Sailmakers Look to 'Maxi-Boats' to Determine Stress in Sailcloth," National Fisherman, Sept., 1982, p. 29.

The 70 to 80 foot racing sailing yachts are teaching sailmakers about stresses to which sail cloths are subjected. The commercial fisherman needs a less lofty rig and his sails are not under as much strain because he does less trimming and tacking. Shape is not as critical to the fisherman as to the racer. Sails are a money-making proposition to the fisherman and only make sense if they can pay for themselves in a known period of time. Hood sails has been working with cloths that might be used in a number of commercial sail applications. The sails for a recently retrofitted freighter are of 22 oz. cloth. They are uncoated, so the sails are soft and easy to handle, but the elasticity is predictable, and the sail's shape may be maintained. The yarn may be treated so the sun's ultraviolet will not break it down. It should be easy to repair by hand sewing.

13. Kenneth C. Morisseau, "The Age of Sail - Is It Over?" Naval Engineers Journal, April, 1981, pp 145-153.

The author summarizes the history of commercial sail up to the DYNASHIP, the PATRICIA A. and the Bergeson study and points out that ships consume 7.3% of the free world's total. He points out that sail propulsione experiments and applications fall into two categories: high performance small craft and commercial shipping applications. He updates the Woodward study to reflect 1980 costs and prices and shows that now sailing ships are cheaper on all routes than comparable 15 knot steamships. A variety of wind thrusters are discussed: square-rigged sails, marconi-rigged sails, gaff-rigged sails, wing sails, rotors and windmills. Hull forms are outlined, and a sail-driven SWATH ship designed for underway replenishment is shown.

14. "Designer of Automatic Rig Defends its Copyright," Sail Assistance News, V.1, N.4, December, 1982, p.4.

Russell McNab of Victoria, Australia developed a rig featuring remote control of reefing, setting, trimming and furling in 1973. The CARAVEL rig consists of a two-masted roller-reefing staysail configuration with masts of equal height. It has found wide interest among commercial fishermen becukse of its simple and uncluttered design and automatic controlled operation. McNab is currently designing a commercial sailing vessel 115 feet (35 m) in length with another automatically controlled sailing rig invented for use on larger vessels.

15. "Windship's New Wing Sail Has Maximum Lift, Minimum Cost," ibid, p.6.

Early tests indicated the wing generates a maximum lift (sideforce) coefficient of 2.0. Until now, the sail's already attractive economics were based on a value of 1.7. Lloyd Bergeson's tests are continuing and will be extended to a 300 sq.ft.(27.9 sq.m) model of the MINI LACE rig. Her fuel efficiency predictions were too low, so her assumed lift coefficient of 1.5 may have been too low. The prototype wing sail is of wood skin and framing attached to a rotating steel mast. The sail will be trimmed remotely by means of a hydraulic grab and go drive system, will have passive feathering in lieu of conventional furling, and is designed so automatic controls may be added later. The wing section is NACA 0018 with a 20% flap. Design wind speeds are 40 knots operating at maximum lift and 150 knots while idling in feathering mode.

16. "MINI-LACE Powered Commercial Vessel Earns National Recognition as One of Ten Outstanding Engineering Contributions of 1981," New Release, Cone & Co., Inc. and Hood Sailmakers, May 15, 1982.

The project was engineered and developed by Windship Development Corporation, and Hood Sailmakers designed, engineered and manufactured the cloth and sail for the rig. Used since July, 1981, the 3,000 sq.ft.(278.7 sq.m) sail and rig has already reduced fuel consumption by 20%. The mast is 116 ft. (35 m) high and is unstayed and fully rotating. The mast and sail are designed for use in winds up to 35 knots and to withstand winds up to 150 knots when furled. The full sail can be furled in 2 minutes, 20 seconds. The cloth is tightly woven, and has more threads per inch than any other commercially available sailcloth. It is treated with Hood's Eclipse (TM) formula to guard against ultraviolet deterioration. It required more than 11 miles (17.7 km) of stitching and weighs nearly 500 lbs. (227 kg).

ADVANCED THRUSTERS AND SAIL RIGS

Figure 2 illustrates eight types of thrusters to collect wind energy and convert it to useful propulsive thrust ranging from conventional soft sails to rotors. Figure 3 shows a schematic sketch of a hard wing sail with slot and flap as conceived by the Windship Development Corporation. Not covered in Figure 2 is the kite sail concept discussed in Abstract No.2.

There is considerable interest in Magnus effect rotors such as the well-known Flettner rotor, and research is proceeding in England, France and the U.S.S.R. It is unfortunate that details have not been published on the French experiments with rotors. It seems abundantly clear that more research on these and other potential advanced thrusters is needed. Even some modest static experiments could provide a solid basis for full-scale tests on commercial craft. Rotors are appealing for retrofit of commercial fishing craft, as the French have apparently recognized.

Concerning more-or-less conventional sail rigs, there is a considerable difference of opinion as to whether fore-and-aft or square sails are the way to go for large vessels, just as for small craft, there are those who advocate the inefficient, but low heeling moment gaff rigs against the high pointing Bermudian sail plans. There is also controversy concerning the merits of automated furling gear for the smaller vessels vs. simple, mechanical ways of sheeting, reefing and dropping sails. The latter school wants simplicity, minimum deck clutter and maximum reliability. They complain of the icing problems of complicated gears as well. Proponents of the former school can point to minimum crew size, larger sail areas which can be handled per crew member and ease of reefing and furling.

ADVANCED THRUSTERS AND SAIL RIGS

1. R.C.T.Rainey, "The Wind Turbine Ship." Symposium on Wind Propulsion of Commercial Ships, The Royal Institution of Naval Architects, 1980. 97-116.

The appeal of the wind turbine for ship propulsion is that it provides an efficient source of power for voyages in any direction to the wind and does not require a large crew. This paper brings together the various propulsion schemes, with and without a marine propeller, that have been suggested over the years, and presents a unified theory of the subject. The use of a wind turbine working with an auxiliary diesel is analysed with reference to the fuel saving that can accrue.

The analysis is used to make a rational appraisal of the potential of a vertical-axis wind turbine for saving fuel on a 4000 ton passenger/cargo ship on the UK-Cape Town and Cape Town-Ascension Routes. On the basis of official discount rates and fuel price projections, the payback period comes out as 12-22 years on the former route an 5-7 years on the latter. These figures give encouragement for future development of the scheme.

2. G.W.Schaefer and K. Allsopp, "Kite-Sails for Wind-Assisted Ship Propulsion." ibid, 117-132.

This paper compares kites and sails as power generators for ship propulsion, either as additional to motorised propulsion or as the sole propulsive power. Several papers about sail-assisted propulsion are presented to this Symposium, but the case for commercial sail is not obvious, for engineering and financial reasons. If this is so, then there is an even larger credibility gap to be overcome if kite-sails are to be considered seriously. Additional incredibility is created by the common prejudice that kites are very difficult objects to launch and control, that they fly largely downwind and so would be of little general use, and that they are too small.

However, there are very attractive advantages if such objects can be made and controlled. This paper quantifies the expected advantages: (i) higher vessel speeds, of the order of 35%, due to considerable windspeed increase with altitude in the lower 250m (820 ft.); (ii) more flexibility of vessel course due to the ability to choose wind directions other than those at deck level, offered by windveer; (iii) much increased vessel stability and safety, due to traction forces being attached at deck level, with almost no overturning moment or heeling; (iv) ease of attachment to vessels, including large existing fleets; (v) the need for little deck space compared to sails.

These potential advantages have provided the stimulus for the Ecological Physics Research Group to enter upon a research and development program for kite-sails. To overcome the credibility gap, the basics of a science of kite aerodynamics are presented, together with performance calculations for a general kite-ship and a corresponding sailing-ship. Finally, the present state of development of a suitable kite-sail is discussed. The system deserves more attention, primarily because of the obvious advantages.

3. N.Bose, "Windmills- Propulsion for a Hydrofoil Trimaran," ibid. 147-158.

The design of a windmill for the propulsion of a 5 m.(16.4 ft.) trimaran is described. A method is presented for the calculation of the performance of windmills. This method has been adapted from screw vortex theory and applied to the special case of a windmill mounted as a propulsive device on a moving vehicle. A study is made using this theory, to ascertain the optimum geometry for the windmill. Considerations include windmill solidity, blade sections and pitch/diameter settings. Performance curves are presented for the windmill under consideration. Finally, a comparison is made between the predicted performance of the windmill when applied to the trimaran and the performance realized when the boat operates using cloth sails. The last study provides a means of asssessing the value of a windmill against the well proven success of cloth sails. The theory and arguments used in this paper are believed to be applicable to larger installations which may be considered for the propulsion of commercial ships.

4. W.M.S.Bradbury, "An Investigation of Graduated Trim for an Aerofoil Rig," ibid. 159-172.

The advantages of symetric aerofoil sails for wind propulsion of large ships are discusssed. Practical realizations of an aerofoil rig and associated problems are considered. The proposed aerofoil ship, investigated in this paper, is described. A simple two dimensional analysis using a potential flow representation of wind flow through an aeerofoil rig is discussed. This analysis is used to produce various arrays of graduated sail trim angles. Wind tunnel tests of a model aerofoil ship are described. Sail force coefficients are obtained for various graduated and parallel trims. A simple performance model is derived and used for comparative analysis of wind tunnel data.

5. C.C.Herbert, "The Design Challenge of the Wind Powered Ship, " ibid. 199-214.

Advanced thrusters are considered in this paper on pages 205 and 206. Aerofoils are mentioned with lift/drag ratios aproaching 10 and capable of maintaining this efficiency in apparent winds between 5 and 40 knots. Hydrofoils are considered.

6. E.W.H.Gifford, "Improvement of Sailing Techniques in Tropical Countries," ibid. 241-247.

For the past several years, the author has been developing surf beach fishing boats, primarily of the double-hulled form (catamaran) for use in West Africa and the Indian Ocean. Due to the increasing price of diesel fuel, in 1978 a sailing rig was introduced on one. This has a standing lugsail on a bipod mast. The rig has been further developed. Sprit sail and lateen rig are also mentioned.

7. Various, "Commercial Sail - Proceedings of a Symposium," Dept. of Industry, London, 1980. 171-185.

Several comments on the papers of this symposium are here assembled. Air Commodore Nance remarks that there were two Flettner rotor ships: the converted BUCKAU (later renamed the BADEN-BADEN) and the specially designed and built successor: BARBARA. He cites the following limitations: a. it cannot proceed head to wind; b. its windage when shut down is far higher than a wind turbine with stowed or feathered blades; c. downwind performance is not good whereas the wind turbine with it probable ability to exceed wind speed with relatively small inputs of engine power to the wind turbine, seems to have high promise on this point of sailing; d. its efficiency in practise may not be as high as theory suggests. Cited are reports from NASA and the University of Oregon. Prof. Schaefer comments on work on kite sails. Mr. Wynne discusses the Dynaship rig. Capt. Azad discusses four systems he feels are worth testing: a. the Dynaship; b. the fore and aft rig; c. the louvre sail; d. the Magnus drive (Flettner rotor). The University of Hamburg has loaned the original Dynaship model to the Liverpool Polytechnic for further testing, and it can be borrowed for the cost of freight and insurance.

8. L.Bergeson et al, "Wind Propulsion for Ships of the American Merchant Marine," Windship Development Corp., 1981. Sect. II. 1-51.

There is an excellent discussion with illustrations of eight rig alternatives and technical evaluation of these: a. stayed fore and aft rig; b. unstayed cat rig; c. Princeton sailwing; d. square rig; e. wing sail; f. Flettner rotor; g. horizontal axis wind turbine; h. vertical axis wind turbine. Rotors and turbines were ruled out because of insufficient experimental data available at this time. A flapped wing sail emerged as the best choice when compared to all others. 33 references are included.

9. J.B.Woodward et al, "Feasiblity of Sailing Ships for the American Merchant Marine," University of Michigan Report No. 168, 1975. Appendix II: "Some Comments on Wind-Propulsion Devices Other than Sails." 96-98.

Brief remarks are included on the possibility of using Flettner rotors, windmill-electric propulsion with screw propeller and wing-sails. All were judged to have too many negative features to be worth considering at that time.

10. H.S.Noel, "French Fishing Industry is Actively Developing New Boats," National Fisherman, February, 1982.

French experiments with the Flettner rotor to power fishing vessels are mentioned. Rotor calculations show large power economies within a range of wind strengths. But in more than 35 knots of wind, the thrust turns into resistance. At 30 knots of wind, the propulsive effort is equivalent to 344 hp for a power input of only 7 hp to rotate the cylinder. At 37 knots of wind speed, equivalent thrust is minus 42 hp.

11. J.Clemans, "Eight is Enough," Motor Boating & Sailing magazine, March, 1982. p.12.

Discussed and illustrated is YOGHURT, an eight-masted catamaran from Copenhagen. The twin hulls are 40 foot steel pipes braced by steel beams. Both hull pipes have four 50 foot revolving masts, each with a sail area of 215 square feet. The designer claims this sail plan provides 20% more propulsion than conventional sails of the same area.

See also abstracts under: Technological Developments.

12. T.C.Warner, "Sail Power: A Cautious Appraisal," Ship & Boat International, Dec., 1981. 9-1.

The author discusses in some detail traditional sails and compares the sloop with the wing sail and the magnus effect rotor. Older workboats had sail plans concentrating driving power in the main sail with jibs used for balance. Aerodynamics has shown jibs to be more effective than after sails, so overlapping jibs with smaller mains are used on present-day yachts. Effectiveness increases with aspect ratio (span squared divided by area), but there is little advantage in using an aspect ratio of more than 4.0. Rigging must not obstruct deck areas. A typical sloop side force coefficient is about 1.3. The wing sail offers practical advantages. A side force coefficient up to 2.2 may be obtained. Use of a leading-edge slot and a full span flap allows aerodynamic force to be varied to suit conditions, thus minimizing the reefing problem. Changing tack is simplified, and deck area is essentially free. Magnus effect rotors may achieve side force coefficients of 9 or 10 and have been successfully employed. It has several advantages: smaller sail area for a given driving power, smaller demand on the hull for power to carry sail and simple reversal of thrust direction by drive motor reversing gear. It is possible to conceive of a wind generator battery charger being used to supply power for the motor drive. Included are tables of driving power for various vessel types and power to carry sail as well as plots of sail area to wetted surfce area as a function of length to beam ratio, length and type of keel. The author is not very optimistic about the possibility of a return to wind propulsion in the foreseeable future.

13. K.Stewart, "Fly a Kite," Fishing News International, March,

1981.

The advantages of elevated sails (kites) are: 1. Increased wind velocities at higher elevations. 2. Improved safety due to upward pull of kite. 3. Improved upwind performance due to wind direction changes with altitude. 4. One tether line operated by a motorised winch makes for clearer deck space. 5. Retrofit is of minimum cost and time. 6. At higher altitudes there is less wind turbulence. An existing vessel of 100 tons could be retrofitted for motor sailing by using two kites of 50 sq.meters (538 sq.ft.) at altitudes of 100 to 300 meters (328 to 984 ft.) If the Inflatasails are used on this vessel, an estimated 40,000 gallons (181,843 lit) of fuel per year would be saved.

14. Stephen D.Orsini, "Rotorship: Sailing Ships Without Sails," Oceans, Jan., 1983. p.26-29.

This is a history of Anton Flettner's work. The BADEN-BADEN made a transatlantic crossing in 1926 and was equipped with two rotors. This was a conversion of the 160 foot (48.8 m) three-masted top-sail schooner BUCKAU. Flettner conducted research with the backing of the Fredrick Krupp Co. at the University of Goettingen from the early 1920's. The rotorship sailed best in a beam wind and could sail up to 23 degrees from the true wind direction. To tack, direction of cylinder rotation was reversed, and she did not sail well downwind. Rotorships were intended to be motor sailers. The cylinders proved to have inherent stability. Above a wind velocity of about 25 mph (40 kmh), the forces acting on the cylinder ceased to increase and then proceeded to decrease with increasing wind velocities. The BUCAU was outfitted with two rotors made of a double layer of 0.04 inch (1.0 mm) sheet steel. Rotors were 51 feet (15.5 m) high and 9.2 feet (2.8 m) diameter. In a beam wind of 15 knots, rotors alone propelled the vessel at 7.5 knots. In a 22 knot wind with rotors at 100 rpm, she did nine knots. Rotors were each driven by an 11 horsepower electric motor.

The three rotor BARBARA was launched in 1926. She was 294 feet (89.6 m) long. Each rotor was made of an aluminum alloy and was 55 feet (16.8 m) high and 13 feet (4 m.) diameter with 0.0469 inch (1.2 mm) wall thickness. She carried cargo from 1926 to 1933 when she was sold and converted to conventional motorized power.

15. Niedermeyer-Martin Co., 1727 NE 11th Ave., Portland, OR 97212. Makers of custom wood spars up to 150 feet (45.7 m) long with tapering diameters from 4 inches (10 cm) to 3 feet (91.4 cm).

16. John Gardner, "Wind Rotors Look Good for Small Boats ..."; National Fisherman, July, 1982, p.81.

Described is Tom North's trimaran which is planned to be powered by a vertical axis wind turbine - a Darrieus rotor.

17. Jack Manners-Spencer, "Gallant Rig," Arthur Edmunds, Inc.,

NA, 1881 NE 26 Street, Suite 242, Fort Lauderdale, FL 33305.

Described in the manufacturer's and distributor's literature is an elliptical cross-section soft wing sail rig for cruising boats with fast reefing, easy handling, low maintenance and high performance. Sketched is a 24.5 meter (80 ft.) stern trawler with two freestanding masts with a soft wing sail on each. A short brochure presents the advantages of the Gallant Rig for fishing vessels: single sheet to control each sail, one halyard per sail which can be operated from the wheelhouse, self-stowing sails in lazyjacks, sail area varied from wheelhouse, good directional stability and aerodynamic balance, less heeling, efficient sailing, excels in motorsailing mode because sails can be set to smaller angles of attack, reduced drag due to lack of rigging, more area concentrated aloft to catch wind in light airs, no rigging wires to interfere with fishing operations, good forward visibility, especially fail-safe, low maintenance.

18. Denny Desoutter, "Gallant Effort," Practical Boat Owner, Feb., 1980.

Report on the Gallant Rig of Jack Manners-Spencer.

19. Dennu Desoutter, "A Gallant Effort," Cruising World, Oct., 1982.

Essentially a repeat of the above article

20. Danny Greene, "Arthur Edmunds' Illusion is Very Real," Cruising World, Oct., 1982.

Description and photograph of the Gallant Rig on board a 44 foot (13.4 m) steel boat designed by Arthur Edmunds.

21. "The Flettner Rotor," Marine Propulsion, March, 1980.

History of the Flettner rotor showing a cross section of one of BARBARA's rotors and plots of thrust, speed and wind speed.

22. J.R.Flewitt, "Turbines Rather than Sails Appear the Most Promising," Marine Propulsion International, Oct., 1980.

Comprehensive paper on current research on sail assisted power for commercial vessels. Compares expected performance of alternative wind propulsors.

23. "Magnus Concept in Propeller Design," Fishing News International, August, 1982.

Describes the work done by the Borg/Luther Group, 876 Elm Ave., Carpineria, CA 93013 USA, on a magnus effect rudder.

24. "Magnus Effect Borg Rudders."

Description in company pamphlet of the magnus effect rudder.

25. Bruce Sherman, "He Has Big Ideas About Tall Ships - Sailing Tankers Called Feasible," Seattle Post-Intelligencer, August 30, 1982.

Described is the 'Rationalized Sail System,' of Mr. Paul Priebe. See Abstract No.10 under: Technological Developments.

26. Tom Brooks, "Designer Updates Sailing with Modern Aerodynamics," The Seattle Times, September 7, 1982.

Mr. Priebe describes his aerodynamic concepts, and a photograph is shown of his model.

27. F. Von Koenig, "Windkraft Von Flettner Rotor," FDR, Pfriemer, Munich, Germany, book, 143 pp.

PERFORMANCE PREDICTION AND WIND ROUTING

Since speed of any sailing vessel is a function of angle to the wind, wind strength and hull and rig characteristics, speed prediction is no simple matter. Fortunately, the ready availability of computers has made this tedious iterative process considerably easier, and computer programs for such have been prepared in various parts of the world. Sailing vessels are subject to the vagaries of the wind strength and direction, so wind routing has become important to all such. A common criterion for sail-assisted vessels is that the engine will always be turning the propeller(s) both to minimize propeller drag and to guarantee a constant service speed. Thus, it becomes important to the economics to be able to forecast, with some measure of accuracy, the geographical locations of the wind strength and direction at any time of year. Mr.Mays is a specialist in this field, and his paper is a fine piece of work.

While naval architects and those concerned with the science of sailing are reasonably confident of being able to predict sailing vessel performance, and much work has been done on predicting power boat and ship performance, it is not so clear that performance under power and sail - motorsailing - can be predicted accurately. If the engine is operated while sailing, apparent wind velocity is increased giving more thrust, but apparent wind angle is changed as well. If that angle (of attack) becomes too small with respect to the sail, the sail will give rise to more resistance than thrust generated and should be lowered. If at an optimum attack angle, the resulting speed is often more than the algebraic sum of the speed under engine alone and the speed under sail alone. Abstract No.9 relates some recent German motor sailing experiments but without analyzing them.

Similarly, while it is now not too difficult to predict the speed of a sailing craft under sail, it is not at all easy to predict such for a retrofitted power vessel. Speed predictions for the addition of sails to conventional motorized fishing vessels are only very approximate at best.

PERFORMANCE PREDICTION AND WIND ROUTING

1. W.J.Hood, "Using Wind Reliable Routes for Bulk Cargo Transport," Symposium on Wind Propulsion of Commercial Ships, The Royal Institution of Naval Architects, 1980. 17-28.

Results of analyses of routes, distances and speeds for the Capetown to Sydney run are given. A possible route around Antarctica is advanced. Frank MacLear commented on high shock loads produced by jibing.

2. J.E.Atkins and D.J.Painting, "Wind Propulsion of Ships - Climatological Factors," ibid. 67-76.

A very large amount of data on surface wind over the oceans has accrued from the weather observations made from ships on passage over more than a century. Traditionally these data have been summarized diagrammatically for the benefit of the mariner in publications such as marine climatological atlases and routing charts. (Pilot Charts) The variations of wind climate over the oceans of the world are described in general terms with illustrations.

Such diagrammatic presentations are useful, indeed essential, for an initial appraisal of any project involving sailing vessels. Sooner or later, though, the practicalities and economics must be assessed by close numerical analyses of the geographical and temporal variations of wind. Such analyses are facilitated by existing computer archives of the marine observations. Appropriate programming needs, detailed knowledge of the relevant operational and design characteristics-knowledge, for example, of the optimum wind speed range for sailing, as to how close to the wind the vessel can sail.

Frank MacLear commented that in addition to velocity and direction, we are also interested in air temperature. The colder the air the denser and hence the faster sailing vessels can go.

3. J.H.Mays, "Sailing Ship Weather Routing," ibid. 77-96.

The present status of sailing ship weather routing is discussed. Although a sailing ship's performance can be reasonably well specified by the wind and wave field, this information is not sufficient to plan and execute a passage over a body of water with least cost or time. The author takes, as given, a sailing ship speed polar and statistical climatological weather data for the North Atlantic Ocean to generate an array of feasible voyages between New York and the English Channel. The technique of dynamic programming is used to determine the optimal passage as specified by an objective function embodying criteria such as time and fuel consumed. Optimal passages are solved using a Monte Carlo simulation of the weather expected en route. Comparisons of performance and routes across the Atlantic in different seasons are made to great circle routes and among different choices of minimum ship speed. 23 references are given to this excellent paper.

The discussions included a query about ice forecasting and Frank MacLear disputing the use of mathematical modelling and Pilot Chart data for this case. O.Ljunstroem disussed an early Swedish project to study a 2000 ton motor sailing freight ship.

4. P.Schenzle, "Standardised Speed Prediction for Wind Propelled Merchant Ships," ibid. 173-188.

The prediction of weather-dependent ship speed under sails (speed diagram) is based on wind tunnel and towing tank test results. For this deterministic prediction of the equilibrium of drag and cross forces as well as of yawing and heeling moments has to be established, including forces due to hull roughness, seaway and helm adjustment. Under stronger wind conditions, heeling angle and rig loading must be limited, if necessary by reefing or feathering the sails, which means not only reducing the area but also influencing significantly the aerodynamic performance of the wind propulsion system. Based on assumed criteria for the employment of an auxiliary drive in cases of low speed undr sail, auxiliary speed and power can be predicted.

In order to provide statistical information for service considerations, it is common practise to simulate voyages using deterministic speed predictions and real weather data and to evaluate a great number of simulations statistically. Here it is suggested to apply statistical methods to weather data in order to evaluate a standarized statistical environmental model with a limited number of parameters. A statistical speed prediction based on the standard environmental model appears especially suitable for comaring alternative wind propulsion systems. Examples comparing deterministic as well as statistical speed predictions for some of the proposed systems are presented.

M. Saunders commented with regard to motor sailing as did A.R.Claughton. The latter states that at Southampton they are in the process of extending their sailing ship performance prediction program to include turbine ship operation and hence motor sailing.

5. C.C.Herbert, "The Design Challenge of the Wind Powered Ship," ibid. 199-214.

See the abstract under Technology for a complete summary of this paper. Motor sailing is discussed, and a 100 year old formula for predicting speed is advanced as valid. J.H.Mays comments that performance prediction for conventional ships is difficult enough. For sailing vessels, a considerable increase in complexity is introduced. He disputes the simplifying assumptions required to accept this formula such as constant upright hull drag coefficients. C.A.Marchaj comments that the author's assumption of a key requirement being lift to drag ratio approaching 10 does not compare with the experience of the highly efficient C Class catamarans. A chart is presented of the varying speeds made good to windward of historical craft vs. a modern 12 meter yacht. A table of average sailing speeds of historical vs. modern vessels is also presented tending to show that sailing vessel technology advanced not at all from Columbus' SANTA MARIA to the fast clippers when speed is compared on a size basis. The author replies that on a plot of ship speed vs. wind speed, the poor efficiency of ships like the SANTA MARIA is obvious.

6. D.J.Painting, "The Meteorological Office Marine Archive and Its Use to Describe Ocean Climate," Commercial Sail Symposium, Dept. of Trade, London, 1980. 112-128.

The author describes the data bank and computer programs available in the Marine Archive for predicting wind and weather on a worldwide basis from over a hundred years of observations. The exponent for wind shear- variation of wind velocity with height- is taken at 0.12.

7. J.B.Woodward et al, "Feasibility of Sailing Ships for the American Merchant Marine," Section VI 35-51 and Appendix I 78-95. 1975.

Voyage mean times are predicted on a number of ocean routes. Speed polar curves are described together with some of the functional dependencies and a simplified flow chart of the solution process. Some representative values are tabulated and plotted.

8. L.Bergstrom et al, "Wind Propulsion for Ships of the American Merchant Marine," Wind Ship Development Corp., Section III: Performance Analysis, 30 pp. 1981.

The most basic objective of performance analysis is the prediction of the average voyage speed and fuel use one can expect for a given ship on a given route. In order to develop these "voyage statistics," the performance problem is approached in three steps: a. models are developed of the hydrodynamic and aerodynamic forces and moments acting on the ship; b. using these models, ship speed and power setting are determined for a range of wind conditions - performance prediction; c. a statistical model of the route wind applied to these performance predictions yields expected voyage speed and fuel use. The influence on sail force coefficients of five factors is discussed including inter-mast interference. A number of plots are given, and 20 references are cited.

9. K.Lange and P.Schenzle, "Full Scale Trials with Wind Propulsion on a Small Fishing Vessel, " International Council for the Exploration of the Sea, Fish Capture Committee, 1981.

This report relates some 1980 experiments with a 100 ton displacement Baltic fishing vessel equipped with sails of 160

sq.m.(1722 sq.ft.) and 150 hp main engine. Ship speed under a variety of wind strengths, angles and engine speeds was measured and plotted. These were compared with model propulsion tests and calm water runs without sails. Selected results are shown for true wind speeds between 19 and 21 knots vs. relative course angle to the true wind. At a ship speed of nine knots, the power requirement under motor is 100 kw (134 hp) at Force 5 wind (17-21 knots) and 80 kw (107 hp) in calm weather. When motorsailing with full sails in Force 5 wind, the required engine power is 40 kw (54 hp) at 150 degrees to the true wind and only 8 kw (11 hp) at 90 degrees. If the full engine power of 100 kw (134 hp) is maintained after setting sails, ship speed is increased from 9 to 10 knots at 150 degrees and to 10.8 knots at 90 degrees. It is obvious that considerable power reductions are possible when maintaining ship speed in the motorsailing mode, but only small speed increases when maintaining full engine power. At 9 knots ship speed and Force 5 wind, the maximum power saving is about 80 kw (107 hp) at about 90 degrees relative course. Average power saving assuming equal frequency of all courses relative to a Force 5 wind would be about 40 kw (54 hp) thus saving 200 kg (62 U.S.gallons) of fuel per 24 hours -roughly 40%.

10. C.Goudey, "Results of Towing Tests of the Vincie N."; private communication. 1981.

The Vincie N. is a 79 foot waterline offshore fishing vessel being studied at MIT for possible retrofit with a sail rig. The report details a full-scale towing test made with the aid of the U.S.Coast Guard.

11. P.Schenzle et al, "Ein Programmsystem zur Berechnung der Schiff Geschwindigkeit unter Dienstbedingungen," (A Program for the Calculation of Ship Speed Under Service Conditions) Institut fuer Schiffbau der Universitaet Hamburg, Bericht No.303, November, 1974.

Outlines a standard method for the computation of sailing vessel performance.

12. I.Howlett, "Considerations Relating to the Performance of Large Sailing Vessels," RINA Occasional Publication No.1, Royal Institution of Naval Architects, London, England, no date.

This report summarizes the state of the art of predicting the performance of commercial sailing vessels at the present time.

13. John S.Letcher, Jr., "Optimal Performance of Ships Under Combined Power and Sail," Journal of Ship Research, SNAME, V.26, N.3, Sept., 1982, pp.209-218.

This is a fundamental paper on predicting the performance of sailing vessels and yachts in the motorsailing mode. The vessel is described by a characteristic speed, a characteristic fixed-cost rate and five dimensionless parameters - four

hydrodynamic and one economic. The model includes optimization of three control variables: sail side force, throttle setting and course angle. An illustrative example is shown.

RESEARCH VESSELS

There have been a number of proposals for research vessels which can do oceanographic and geophysical work of various kinds or serve as submersible tenders and the like. Pure sail propulsion can provide an almost vibrationless environment for such instruments as electron microscopes which usually cannot be place in a normal shipboard environment. When this is combined with a stable platform, such as in the form of a catamaran, some research tasks become possible that were heretofore only partially possible if at all.

1. Constantine Foltis, Thomas Hooper and John Walter, "Oceanographic Research Vessel Design," National Conference/Workshop Applications of Sail-Assisted Power Technology, May, 1982. Norfolk, Virginia, Virginia Sea Grant Program, Virginia Institute of Marine Science. 1983.

2. George B. Anderson, Raymond H. Richards, "The Design and Expedition FRONTIER CHALLENGER," ibid.

3. Arnie Gray, "FREE ENTERPRISE", 1982.

Folder from the owner showing a profile drawing and giving particulars of this 100 foot (30.5 m), length on deck, 136 ton vessel launched in May, 1982 and intended as a research vessel.

4. Steve Talley, "He's in Love with a Well Built Dreamboat," Suncoast News, August 18, 1982.

An account with photograph of the FREE ENTERPRISE.

5. George B. Anderson, Raymond H. Richards, "A Modern Research Sailing Ship: SRV FRONTIER CHALLENGER," Oceanus, V.25, No.1, Spring, 1982. p.53-63.

The authors outline these advantages for wind propulsion over engine: more stable and comfortable working and living platform, safer ship if engines, propeller(s) or rudder fail as sails provide both propulsion and general directional control, in storm conditions sailing vessel has superior riding and control characteristics, hull lines are finer, offer less resistance and save fuel when engine is used, permits major fuel savings and longer range for exploration, long periods of quiet operation under sail alone are possible for underwater passive bioacoustic studies, steadying effect altering vibration modes radiating through hull and decks may permit the use of newly refined electron microcscopes, eliminate diesel aerosol contamination to permit collection of aerosol particulates, attract many species of marine birds for study. The vessel as designed is 221 feet long (67.45 m), displaces 900 tons and will accomodate 50 people.

6. Dr.John Van Leer, "Sailing Catamaran Research Vessels for the 80s and 90s," Oceanus, V.25, No.1 Spring, 1982. pp. 64-71.

The author advocates a 170 foot (51.8 m) catamaran as a research vessel: SCAT-RV. He cites as an actual example, the 150 foot LOA (45.7 m) catamaran TROPIC ROVER. The author cites a number of design parameters for catamarans and compares them with single hull vessels. He cites the structural problem of connecting the hulls and wing deck, the danger of too much weight, building hulls with too little buoyancy fore and aft of the beams or too little clearance between the waterline and the underside of the connecting beams, fore and aft symmetry and waterplane area. Minimum waterplane area gives a soft ride but not enough righting moment to carry a significant amount of sail.

7. Lloyd Bergeson et al, "Research Report: Analysis of Sail-Assist for Navy Oceanographic Research Ships of the AGOR-14 Class," Windship Development Corp., Norwell, Massachusetts, Final Report, March 1, 1982.

8. "A Sailing Oceanographic Vessel?", Ocean Science News, April 27, 1981, pp 1-2.

9. Dr. Willard Bascom, et al, "The Use of Sailing Ships for Oceanography," Ocean Sciences Board, National Research Council, 1981.

10. Lloyd Bergeson et al, "Yacht RAINBOW WARRIOR Sail-Assist Rig and Technical Analysis," prepared for Greenpeace International, Washington, DC by Windship Corporation, April 30, 1982.

11. "A Sailing Oceanographic Vessel?"; Ocean Science News, April 27, 1981. 1-2.

Summary of a 32 page booklet from the Ocean Sciences Board of the National Research Council. The idea for the study originated with Willard Bascom of the Southern California Coastal Water Research Project. He formed a study team consisting of: Lloyd Bergeson of the Wind Ship Development Corp., Corey Cramer of the Sea Education Assn., R.T.Dinsmore of Woods Hole Oceanographic Institution, Gustaf Arrhenius of Scripps Institution of Oceanography, Frank MacLear of MacLear & Harris Inc., and James Mays of Wind Ship Development Corp. A sailing research vessel will have the following advantages: quieter, less vibration, less roll and at times faster than when under power alone. The proposed vessel will be of steel, 1400 DWT, retractable centerboards, fore and aft roller-reefed sails, power plant which can also generate electricity, length of 250 ft., beam of about 50 ft., masts 160 ft. high, crew of 18 and space for 24 scientists.

12. "The Use of Sailing Ships for Oceanography," Ad Hoc Panel on the Use of Sailing Ships for Oceanography, Ocean Sciences Board, Assembly of Mathematical and Physical Sciences, National Research Council, National Academy Press, Washington, DC, 1981. 32 pp.

SAFETY, STABILITY AND LEGAL CONSIDERATIONS

Stability requirements limit the amount of sail area that a vessel may have and thus limit potential speed under sail. Governments have tended to become more conservative about this than the designers and operators feel is justified, and the situation needs careful examination. In the U.S., fishing vessels, whether designed for power or sail, are not required to have U.S.Coast Guard certification. Most other countries in the world require such. Also in the U.S. research vessels under a certain size are exempted. Otherwise, all commercial vessels in the U.S. are required to have certification if they come under subchapter S or T regulations.

SAFETY, STABILITY AND LEGAL

1. William Cleary, NA, "U.S.Coast Guard Certification and the Stability Criterion," National Conference/Workshop Applications of Sail-Assisted Power Technology, May, 1982. Norfolk, Virginia, U.S.A., Virginia Sea Grant Program.

2. "Hearing Before the Committee on Energy and Natural Resources of the United States Senate, Ninety-sixth Congress, Second Session on S.2992: A Bill to Authorize a Study of Sail-Assisted Technology as a Means of Reducing Energy Costs for Inter-island Transportation in the Trust Territory of the Pacific Islands, and for Other Purposes," Omnibus Territorial Legislation - 1980, Publication No.96-146, August 26, 1980, U.S.Government Printing Office, Washington, DC, 1980.

3. Stability Regulations for Commercial Sailing Ships, Commonwealth of Australia Gazette No. P3, 11 May, 1981.

4. "Standards for the Intact Stability of Sailing Vessels and Sailing Auxiliaries Carrying Passengers," Merchant Marine Technical (MMT) Note No. 3-68 and 1-69; MMT 5941/13, 15 July, 1968, U.S.Coast Guard.

MISCELLANEOUS APPLICATIONS

1.D.M.Taylor, "Sails Assist Jack-Up Rig on 2,400 Mile Tow," Ocean Industry, Sept.,1980. 11-13.

Due to its ungainly shape in the air and in the water, a jack-up rig requires vast amounts of horsepower to move it. The rig's hull is 200 ft.wide. It costs between $80,000 to $100,000 per day in tug costs to move a rig 130 to 150 miles per day. Thus, an increase of only one-half knot in towing speed can save an estimated $160,000 to $230,000 on a 6,000 mile move. On July 13, 1980, rigging and two sails were installed in a period of five days on the jack-up oil drilling rig: ROWAN-JUNEAU. Two, 215 foot long, rotating, furling masts were erected with hydraulic tension rams maintaining 125,000 lbs.tension on each mast. On a previous voyage, it was determined that it took just over a minute to furl a sail if unexpected weather were encountered.

Instrumentation included: Loran C for speed, load cells on sheet blocks for sail load, electronic pitch and roll clinometers and an anemometer. The sail, designed and manufactured by Ratsey and Lapthorn, is 80 x 75 feet. In a 27.5 knot wind from a favorable direction, a sail will produce a thrust equivalent to 20,000 lbs. of bollard pull. Developing and testing the sails and rig cost between $250,000 and $300,000, which will be amortized in one or two long moves.

Savings on long moves were found to be between $6000 and $9500 per day. It required only a minimum number of crew to handle the two sails. The most important economic factor is frequency of utilization. Ordinarily, long tows where sails could be utilized may occur only once every five or six years in the life of a rig. The portability of sails to other rigs is a definite plus.

2. "Sail Assist - Texas Drilling Company Moves Offshore Rigs Using Experimental Method," Compressed Air Magazine, December, 1980. p.31.

The Rowan Company plans to move a 200 by 250 foot drilling rig 2575 miles from Galveston, Texas to Nova Scotia using two, 180 foot tall sails. Experiments began in 1977. Sails tended to increase the rig's speed by stabilizing it and also by sheer propulsion. Two full-scale trials were held before the long journey. Ingersoll-Rand air winches are used to maintain sheet tension. The masts are mounted on two rotary tables powered by I-R air motors.

INTERNATIONAL CONFERENCE ON SAIL-ASSISTED COMMERCIAL FISHING VESSELS

May 16 - 18, 1983
Tarpon Springs, Florida

Sponsors: Florida Sea Grant College, University of South Florida College of Engineering, Virginia Sea Grant Program VIMS, Society of Naval Architects and Marine Engineers Southeast Section. Assisted by: Sail Assist International Liaison Associates: SAILA

PAPERS AND SPEAKERS

1. S.J.Akester, Director MacAlister Elliott and Partners Ltd., Lymington, England, and John Fyson, FAO, Rome, Italy, "Appropriate Sailing Rigs for Artisanal Fishing Craft in Developing Nations."

2. J.L. Armand, Institut de Recherches de la Construction Navale: IRCN, France, A. Morcheoine and D. Paulet, Agence Francaise pour la Maitrise de la Energie: ASME, Paris, France, "Sail-Assisted Fishing Vessels: Results of Full Scale Trials."

3. B.L. Blackford, Physics Department, Dalhousie University, Halifax, Canada, "Design of Windmill Thrusters for Commercial Fishing Craft."

4. Kevin Blem and John W. Shortall III, University of South Florida, Tampa "Computer-Aided Instrumentation for Sailing Vessels."

5. Capt. Jesse A. Briggs, Rebel Marine Service, Inc., Robert Lukens and Jon Lucy, Virginia Sea Grant Program, VIMS, College of William and Mary, Norfolk and Gloucester Point "Initial Performance Analysis of the Specially-Designed Sail-Assisted Tug/Fishing Vessel NORFOLK REBEL With Comments on Fuel Savings and Economic Return."

6. John Caramalis, Roger Hostetler and Brad Smith, University of South Florida, "A Flettner Rotor Design and Experiment." (Tentative title.)

7. Mr. August Ceil et al, Beeline Seafoods (Worrell Industries), Cape Canaveral, Florida "Sail-Assisted Fishing Vessel Experiences in Florida Waters." (Tentative title)

8. Frank Cray and David Olsen, U.S.Virgin Islands Fish and Wildlife Service, "State of the Art Sailing Fishing Vessels."

9. Lock Crowther, NA, Sydney, Australia "Performance of Two Catamaran Fishing Vessels in Pacific Waters." - in absentia

(Tentative title)

10. Arthur Edmunds, NA and Jack Manners-Spencer, Fort Lauderdale, Florida and England "The Wingsail Rig from Aerosystems."

11. E.M.Fay, NA, Seaborn Marine Associates, Inc., Marblehead, Mass., "Present and Future Aspects of Sail-Assisted Vessels - Sail Handling Systems, Design and Economics for Sailing Fishing Vessels."

12. E.W.H.Gifford and C.J. Gifford, Gifford and Associates Ltd. Southampton, England, "Improvement in Hull and Rig of Tropical Fishing Boats - Kattumarams, Vallams and Double Hulled Boats."

13. E.W.H.Gifford, Gifford and Associates Ltd. "The Tunny Rig, A Variable Camber Flexible Wing Sail."

14. C.A. Goudey, NA, Massachusetts Institute of Technology Sea Grant Program, "Retrofit Sail Assist on New England Fishing Vessels."

15. Hendrick W. Haynes, et al, MSE Corp. Seattle, "Low Cost, Micro-Processor Based Power Conversion Instrumentation Applicable to Sail-Assisted Commercial Fishing Vessels."

16. Dipl. Ing.K.Lange of the Institut fuer Fangtechnik, Bundesforschungsanstalt fuer Fischerei, and Dipl. Ing. P. Schenzle of the Hamburgische Schiffsbauversuchsanstalt, Hamburg, Germany. "Some Aspects of Sail Power Application in the German Sea Fishery." (Institute for Fishing Gear Technology, Federal Ministry Facility for Fisheries).

17. S. Langevin, Consulting Naval Architect, Paris, France, "Characteristics of Multihulls: Hull and Propulsion Systems for Sail-Assisted Work Boats"

18. Robert Lukens, Capt. Jesse Briggs and Jon Lucy, Gloucester Point, Virginia "Limitations of Manual Data Collection Methods Associated with the Performance Analysis of the Tug/Fishing Vessel NORFOLK REBEL: A Discussion of Actual and Preferred Instrumentation Configurations."

19. H.F.Morin Scott, Square Rigged Associates, Ltd., Bognor Regis, England "A Modern Practical Seaman's Views on Commercial Sail."

20. K.C.Morisseau, U.S. Naval Sea Systems Command, Washington, DC "Advanced Wind Propulsion Devices- Current Status and Potential."

21. L.N.Nevels, Jr., Nevels & Conrad, Honolulu, Hawaii "A Sailing Fishing Vessel for the Pacific Islands."

22. Richard C.Newick, Multihull Yacht Designer, John Todd, Ph.D., Ocean Arks International, Sherill B. Smith, Jr. Massachusetts Division of Marine Fisheries,"Preliminary Fishing Trials of a Sail-Powered Trimaran in New England Waters."

23. John Nickelsen, Jeff Dunlap, David Luke and Thomas Watts, University of South Florida, "A Windmill Thruster Experiment."(Tentative title)

24. Mr. Dag Pike, Ship and Boat International, Stroud, England. "The Philosophy of Fishing Boat Sail Assistance."

25. Cdr. William Remley USCG, Jacksonville, Florida "Safety and Stability Requirements for Sail-Assisted Commercial Fishing Vessels."

26. Prof. John Sainsbury, Florida Institute of Technology, Melbourne, Florida. "Review of Potential Sail-Assist Applications to Fisheries and Influence of Fishery Operations on Design."

27. Dr. John Sainsbury and R. Sewell, Florida Institute of Technology, "Performance Measurements Aboard a 25 Foot Sail-Assisted Fishing Vessel."

28. C.J.Satchwell, Butler Verner, Ltd. at Southampton University, England, and J. Mays, Ocean Routes, Inc., Palo Alto, California "Linearised Performance Analysis of Sailing and Motor Sailing Vessels."

29. John W. Shortall III, University of South Florida, "Sail-Assisted Fishing Vessels for Gulf of Mexico, Caribbean and Near-Atlantic Waters."

30. C.David Veal, Mississippi Sea Grant Advisory Service and William Hosking, Alabama Sea Grant Advisory Service, "Cost Effectiveness of Sail Assist in the Gulf and South Atlantic Shrimping Fleet."

31. Stuart Wilkinson, University of Southampton, England, "Investigations into 2D Mast/Sail Interaction".