ATLANTIC ESCORTS 1939–1945

BY

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ABSTRACT

In preparing for war, the Royal Navy assumed that it would be a continuation of the campaign of 1917–1918, fought in the Western approaches to the United Kingdom. The early months of the war justified this approach but when, following the fall of France, the battle spread across the Atlantic, it was realized that more ships were needed with longer endurance and better weapon systems. The rapid introduction of new technology such as HF/DF, radar, improved asdics and ahead throwing weapons in numerous and better ships, swung the balance though the skill of individuals on both sides remained important.

Introduction

In 1918 the German U Boat offensive had been defeated without the help of Asdic and it was not unreasonable to assume that the hunters had a greater advantage since submarine technology had changed little (TABLE I), geographical constraints still forced the U boats to take a long and vulnerable passage to the Western Atlantic and there were few U boats in service. It had been appreciated that the objective was the safe arrival of cargoes rather than sinking U boats and that even forcing them to submerge, greatly limiting mobility, contributed greatly to the objective. Surface raiders were seen as a greater threat than submarines, as were aircraft in coastal waters.

TABLE I—*Submarine technology*

Boat	*Date*	*Dispt.*	*Length*	*Speed*		Gun	*Torp. Tubes*		*Crew*	*Range*
		tons		Surf. kts	*Sub.* kts	mm	No.	*Diam* mm		mm
U 161	1918	820	71.6	16.8	8.6	105	6	500	39	8500 at 10 kts
U 69	1939	749	67.1	17	7.6	88	5	533	44	8500 at 8 kts

This article deals mainly with the escort vessels of the Allied navies which sank 225 submarines. From early 1943 onwards, after the crisis of the battle was over, aircraft took an increasing share of kills with a total of 228 sunk at sea. The ability of Asdic to detect submarines was over-rated, as was the ability of depth charges to destroy them. Even in good conditions, the range of detection was so small that many escorts were needed to screen a convoy and little thought had been given to the detection of submarines attacking on the surface at night.

It was a war of rapid technical development, in which it was vital to identify quickly a change in enemy tactics or weapon fit and to introduce countermeasures. The U boat command failed repeatedly in this, failing to accept that their codes had been broken or that HF/DF could be carried in ships, and they were slow to appreciate the importance of radar. The allies were very quick at getting new equipment into service, even if this meant that early versions were primitive. Even so, the individual still counted; a very high proportion of U boat successes were scored by a few aces, whilst Captain Walker's 2nd escort group was outstanding.

PART I. BUILD UP TO WAR

Lessons of World War I

The lessons read from World War I had an important bearing on the RN's capability in the later war. First and foremost, the German attack on the allied supply routes had been defeated; it was not the stalemate suggested by some recent writers[1,2]. The German objectives were to stop supplies reaching the United Kingdom and US troops from reaching the Western Front and they failed in both. It is likely that the loss of their best commanders was a major factor in the defeat of the U boats in 1917–18 (and in World Ward II); as the saying goes 'There are old captains and bold captains but no old, bold captains'.

The main reason for the allied victory in World War I was the introduction of the convoy system which made it more difficult to find targets and also concentrated escorts against the attacker. The U boats were unable to concentrate their own attacks, probably impossible with contemporary radios. This success made the RN over-confident in their ability to counter a new offensive despite the lack of any new measures against surface attack which, by 1918, accounted for two thirds of all sinkings. It should also have been noted that, in 1918, there were few sinkings in areas with air cover, often in the form of airships.

Between the Wars

Attempts to ban submarines or to limit the way in which they operated were made but all failed as, indeed, it is likely they were expected to. There was a major review of the RN's ASW capability in 1930[3] which concluded that sloops, then being built at 2 or 3 a year, together with the older destroyers, to be fitted with Asdic, would be available in sufficient numbers for ocean escort. A perceived weakness in coastal escorts would be made good by Asdic-fitted trawlers, and a number of prototypes were converted and tried in exercises. Air attack was seen as a more serious threat to coastal traffic and some V & W destroyers were converted to AA ships and the small HUNT class, with a powerful AA armament, was commenced.

A few 'coastal sloops' were built but, though both beautiful and effective, they were too expensive. Instead a vessel based on a large whale catcher, bigger and better than a trawler, was developed for coastal escort; to become famous as the FLOWER class corvette. Later, for want of anything else, the corvettes were used as ocean escorts.

In the early thirties the potential threat from submarines was small; Germany commissioned her first overt submarine in 1935 and not until 1938 did their increasing numbers and capability pose a threat. The speed with which U boats were built and their crews trained in World War I was forgotten, even though there was little technical advance in submarines.

Operations during the Spanish Civil War showed the problems of Asdics in warm waters, where density layers were important, but it does not seem that the problems these would cause was appreciated[4].

Though there were few convoy exercises during the thirties, there were many exercises in which submarines penetrated the screen of the main fleet, scoring a high proportion of hits, despite the stringent safety precautions enforced in such exercises[5]. Though there was some complacency, preparations had been made for convoys, there were just enough escort vessels, and Asdics were in store for the conversion of trawlers.

1939–1940

This was the war the RN had planned for and the figures show that the planning was sound. Up to March 1940, when the U boats were diverted to support the Norwegian campaign, they had sunk 854,719 tons of shipping, mainly independents. Seventeen U boats had been sunk, a high proportion of the operational boats, and the ratio of the merchant ships sunk to U boat losses of 16.6 was very similar to 1918. The German torpedo problems, teething troubles in new submarines and their slow refits contributed to the British success.

German plans, too, were a little confused[6]. They do not seem to have intended an all-out 'sink at sight' policy but were forced into it by over-enthusiastic commanding officers and by the impossibility of observing the Prize Rules. When war broke out they had a total of 57 submarines of which 39 were suitable for operations. A big building programme was started and frequently increased. At first, there were too few boats at sea for 'Wolf Pack' attacks. The Germans, too, saw the war as confined to the western approaches, not realizing the endurance of the Type VIIs or of their crews.

Britain Alone

From August 1940, U boats were able to use French bases which increased their time on station by about 25%. Shorter refit times, particularly in France, helped to get more boats at sea. Despite this and the increased building programme, there were no more boats on station in the Atlantic since more were needed for training and the operational areas had moved west giving longer transit times, while the bad weather in the winter of 1939–40 reduced effectiveness. On the other hand, the need to keep many destroyers on the east coast as a defence against invasion greatly reduced the number of escorts available. The odds swung heavily in favour of the submarine and showed the need for a number of changes in the escort force to meet these new conditions. The most significant technical aspects needing attention are listed below and discussed in detail in later sections:

- Inadequate number of effective ships.
- Weapons and sensors with inadequate capability against submarines running deep or on the surface.
- Poor endurance.
- Speed.
- Seakeeping and habitability.

Operational and training aspects are not discussed.

PART II. QUANTITY AND QUALITY

Numbers of Ships

Sufficient escorts were needed for a convoy to ensure that there was a high probability of a submarine being detected by Asdic before reaching a firing position. The effective range of early sets varied considerably with the weather, motion of the ship, temperature, etc., as well with the skill of the operator but an average value was about 1300 yards. From 1942 onwards it was realized that big convoys increased the effectiveness of the escort force since the perimeter to be watched increased only as the square root of the number of merchant ships.

Once a submarine was detected the aim was to force it down; sooner or later it would have to surface for air or to charge batteries and could then be destroyed. Even if the escort could not wait for the submarine to surface, the speed of the submarine was reduced from 17 knots on the surface to about 3 or 4 submerged (9 knots for one hour). An escort might loiter over a submerged U boat for hours, trying for a kill, after which it needed high speed to rejoin the convoy quickly—a speed which would be greater than the surface speed of a contemporary submarine.

The short range of Asdic meant that large numbers of escorts were essential but the resources of the United Kingdom were limited. There was a shortage of labour, particularly skilled men, which got worse as the war went on, and basic materials such as steel were in short supply. Inevitably, there was a conflict between the resources needed to build merchant ships and to build escorts.

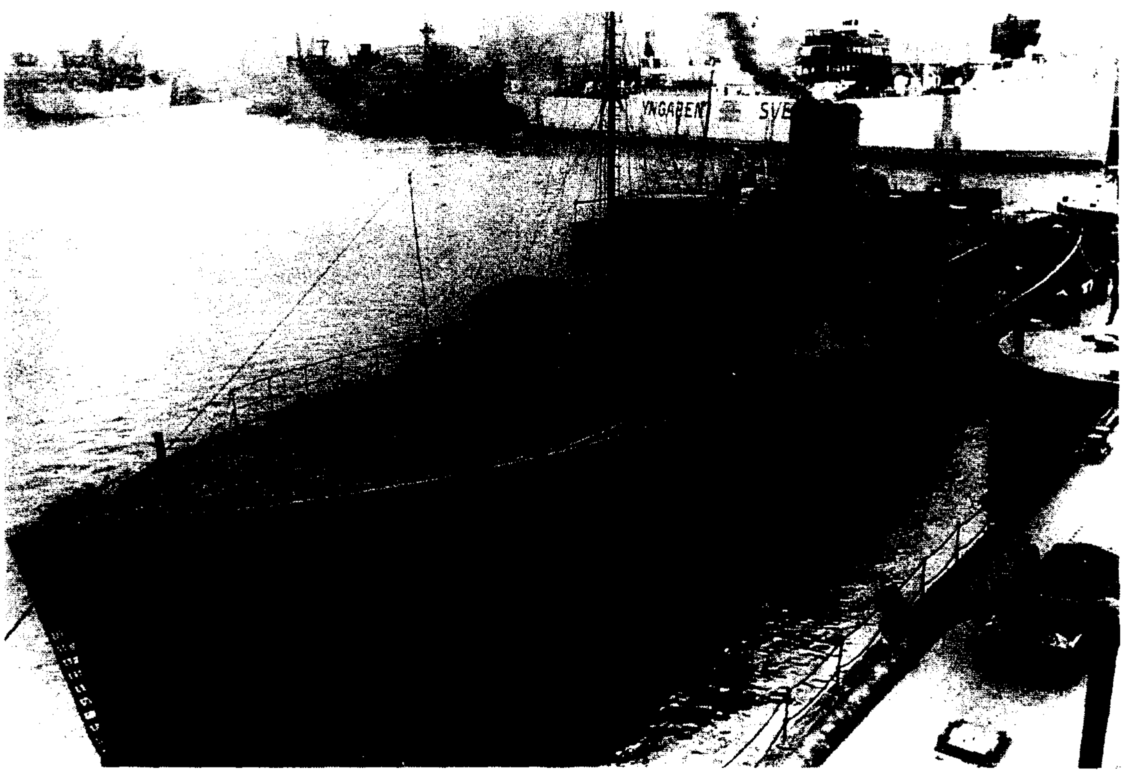

FIG. 1—'CLEMATIS', A FLOWER CLASS CORVETTE IN ORIGINAL CONDITION IN 1940

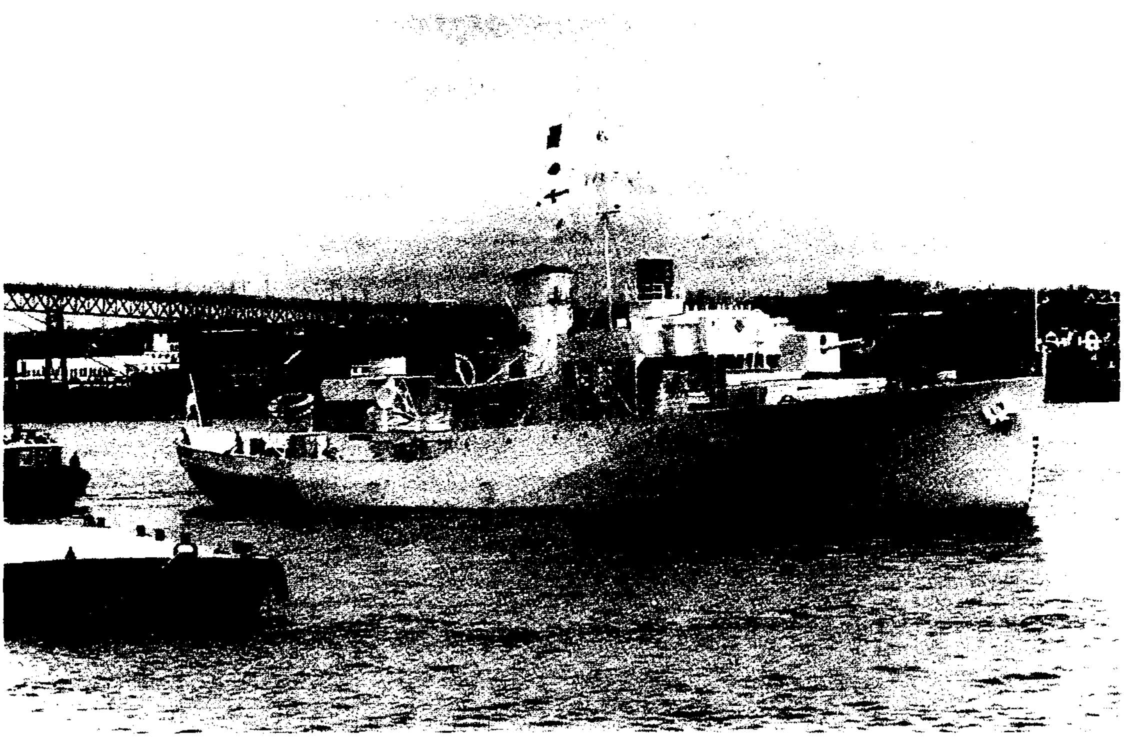

FIG. 2—THE ONLY REMAINING FLOWER CLASS, HMCS 'SACKVILLE' PRESERVED AT HALIFAX, WITH WARTIME MODIFICATIONS. HER HEDGEHOG IS CLEARLY VISIBLE ON THE UPPER DECK FORWARD OF THE BRIDGE

Shipbuilding

The FLOWER class corvettes (FIGS. 1 and 2) were very simple ships which could be built almost anywhere: Eighteen yards were involved in the UK and sixteen more in Canada[7] (TABLE II).

TABLE II—*Flower orders*

UK Flowers		*Canadian Flowers*	
Number	Ordered	Number	*Programme*
30*	July 39	64	1939–40
30	Aug 39	6	1940–41
30	Sept 39		
20*	Dec 39	Modified	
2	June 40	10	1940–41
7	Aug 40	15	1942–43
2	Oct 40	12	1943–44
1	Dec 41		
1	Feb 42		
2	May 42		
6	July 42		
151		107	TOTAL 258

*Includes 2 + 6 French contracts taken over in June 1940.

There was a remarkable variation in building times both from yard to yard and in the same yard (TABLE III). Variations within a yard were usually the result of bombing, which also accounts for some of the variation between yards. It is interesting that later ships usually took longer than earlier ones, contrary to the usual effects of the 'learning curve'. The longer time reflects the combined effects of bombing, shortages of labour, materials and of war weariness.

TABLE III—*UK Flower class building times in months*

Quickest individual ship	5
Slowest	22
Best average, Smith's Dock	6.5
Worst average, Ailsa	19

Management, labour relations, trade union practices and capital equipment were all old-fashioned. At one meeting Lithgow said that shipbuilding practises were out of date; Goodall (the Director of Naval Construction) remarked, wryly, in his diary 'Satan rebuking sin!' (2 June 1942[8]). During the depression few men had joined the industry and these sometimes not of the highest quality and there had been very little capital investment[9,10]. Comparison of building times with those in the USA and Canada is embarrassing, even allowing for the very real problems of blackout and the call up for the Forces of most young men (TABLE IV).

TABLE IV—*Comparative building times (months/days)*

Nation	*Class*	*Fastest*	*Slowest*
British	RIVER	7/5	24/17
Canadian	RIVER	5/3	17/6
Australian	RIVER	16/8	24/15
US	COLONY	5/0	21/8
British	LOCH	7/25	17/10
US	EVARTS	3/3	21/20
US	BUCKLEY	1/23	13/21
British	FLOWER	4/3	20/3
Canadian	FLOWER	7/26	17/24
British	CASTLE	5/12	17/24

FIG. 3—HMCS 'SWANSEA', A TYPICAL RIVER CLASS FRIGATE. BIGGER AND FASTER THAN THE FLOWERS BUT REQUIRING MORE RESOURCES TO BUILD.

The RIVER class frigates (FIG. 3) were bigger than the FLOWERS and the structural style was a little more refined but they were only slightly more difficult to build. In 1942, a large programme of LOCHS (FIG. 4) and CASTLES was started, the intended numbers varying from time to time, but some 120–145 Lochs and 70–80 Castles were expected to complete by the end of 1944[11]. More detailed plans, matching hulls to individual building slips, seem to have envisaged 133 LOCHS and 69 CASTLES. A total of 226 sets of machinery were ordered in December 1942.

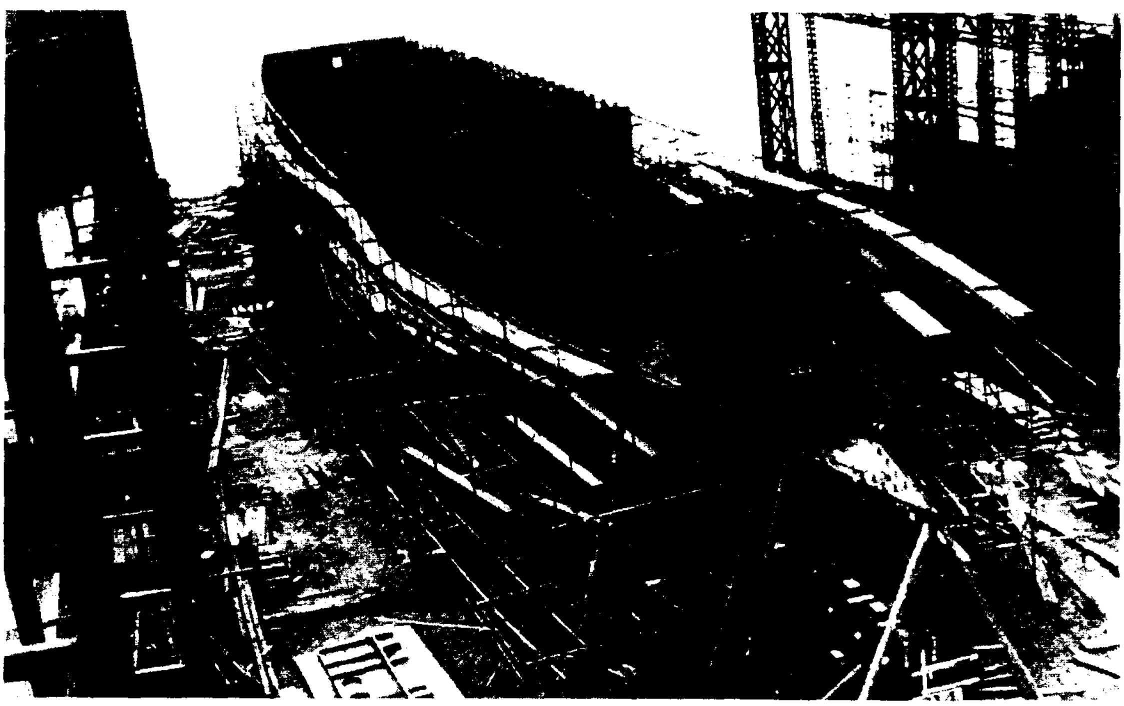

FIG. 4—'LOCH FADA' BUILDING AT JOHN BROWN IN 1943. DRAWINGS WERE PREPARED WHICH ENABLED STRUCTURAL CIVIL ENGINEERS TO BUILD MOST OF THE HULL OF FOLLOW-ON SHIPS

TABLE V—*Costs and installed electric power*

Class	*Cost (£ × 1000)*	*kW*
Flower	90	15 (15 added later)
River	240	180
Castle	190	105
Loch	300	180
Black Swan	360	190–360

Most of the problems in this programme were foreseen at the start but few were solved. These later classes had more complicated electrical installations (TABLE V) and it was estimated that 400 additional fitters would be needed but few were found and many were lost to the army. Installed electrical power was a good measure of the complexity of the ship and was directly proportional to the cost. There was also a steel shortage (Goodall, 3 April 1943) but, with the problems in fitting out, late delivery of hulls was welcome. Goodall said it was sticking out a mile that presently we should have these ships ready to be fitted out but insufficient labour to do so.

The frigates were to be built 'on American methods', i.e. prefabricated. The first of class was built by a traditional shipbuilder and a team of structural steel workers prepared from it the drawings which they would need to use. Records show that the building *time* was reduced through the number of *man-hours* increased.

Centralized outfitting yards were set up at Dalmuir for ships built on the Clyde and at Hendon Dock for the North East coast but, mainly due to the shortage of skilled labour, they could not keep up with the delivery of hulls. By 1945, the yards were full of ships whose fitting out was delayed but, since the Battle of the Atlantic was almost over, such delay was not serious.

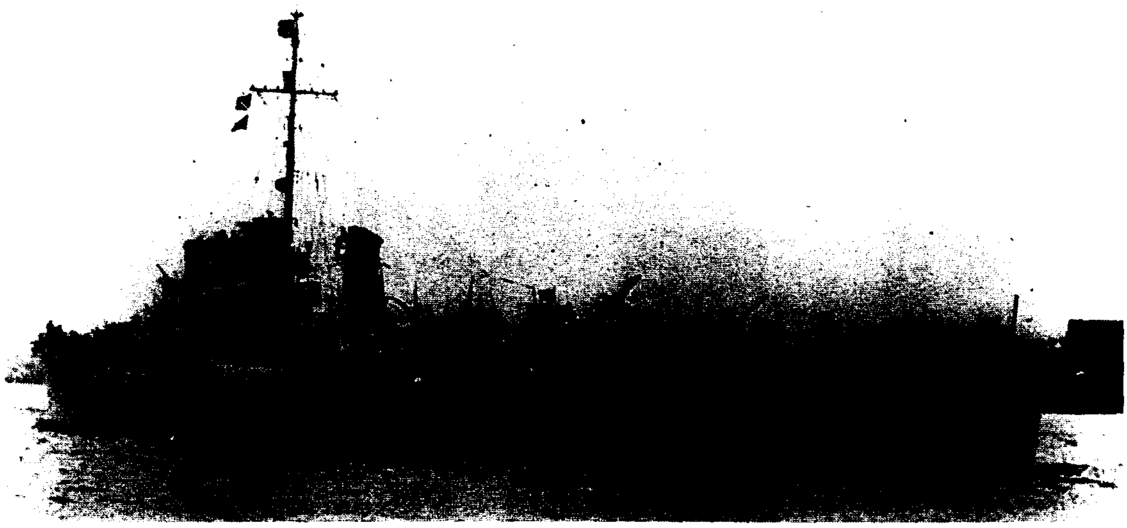

FIG. 5—HMS 'CURZON', A STEAM TURBO ELECTRIC CAPTAIN CLASS FRIGATE. FAST, RELIABLE AND ECONOMICAL IN FUEL BUT VERY COSTLY.

The CAPTAIN class (USN 'DE') (FIG. 5) derived from BuShip studies from 1939 onwards for small destroyers which could be built quickly and cheaply[12]. These ideas had begun to crystalise when, in 1941, the RN asked for 100 escort vessels with a dual purpose armament. As the 5 inch/38 was scarce, they were armed with three 3 inch/50, even though their shells would be unlikely to penetrate a pressure hull. The RN also asked for 112 depth charges, later increased to 180, with 8 throwers and a hedgehog. A tall, open bridge of British style was also required.

Engine supply was a problem and the first class (USN EVARTS) were fitted with four 1500 bhp diesels, driving twin shafts through DC generators and motors in a hull 283 ft 6 in long with a speed of 21 knots. The next class (BUCKLEY) had turbo-electric machinery giving 24 knots in a 306 ft hull. They had 400–600 kW generating capacity and, in 1943, cost \$5.3–6.1 million. Twin rudders giving a reduction of 25% in turning circle (TABLE XII) were fitted after model testing. The CAPTAINS (some with diesels, some with turbines) were flush decked with considerable sheer forward to reduce wetness and were unduly stiff which led to rapid rolling. They entered service (TABLE VI) from the first quarter of 1943, missing the worst of the battle, but still had many successes.

TABLE VI—*'Captains' entering service*

	1943				*1944*
quarters	*1st*	*2nd*	*3rd*	*4th*	1st
Diesel	4	2	9	15	2
Turbine	0	2	8	28	10

Marine Engineering

During the depression, when many shipyards closed, supporting industries suffered as badly or worse. Marine engineering firms capable of building turbine plants were fully occupied with major warships and there was no possibility of building the many sets needed for escorts. There seemed no alternative to the steam reciprocating engine and from 1939 to 1945, 942 sets of 1.8 million ihp were produced[13]. It was also believed, probably wrongly, that reservists manning these ships could not cope with more advanced machinery. Later, it took only six weeks to convert such men to the advanced steam turbo electric and diesels of the CAPTAINS.

Even the resources for reciprocating engines were limited and during 1943 Goodall was worried that engines and boilers were limiting factors in frigate production. The marine engineering labour force (TABLE VII) did increase but mainly by taking on unskilled labour (Goodall, 20 March 1943).

TABLE VII—*Marine engineering labour force*

June 1939	58 000
Jan 1940	66 000
Jan 1941	77 000
Mar 1942	85 000

Availability[14]

The number of escorts with the convoys could be increased quite considerably by reducing the time taken for maintenance in harbour. Initially, as many as 50% of escorts were unavailable at any one time.

TABLE VIII shows clearly the impact of damage during the evacuations of 1940 and brings out the effect of weather damage in the winter months. The early corvettes often completed with poorly aligned crankshafts causing early bearing failure. The older British destroyers had no intrinsic problems but old age led to continual difficulties with leaking rivets making life unpleasant for the crew and causing problems with contaminated feed water and fuel. The TOWN class suffered from incurable condenseritis as the tube plates were weak and not parallel, from bearing problems due to corrosion of the cast iron housing as well as leaky rivets and bridges too weak to withstand the impact of heavy seas[16].

TABLE VIII—*Percentage of escorts not available for operations*[15]

Year	*Winter/Spring*	*Summer/Autumn*
1939		17
1940	20.7	25
1941	8.3	19
1942	19.3	18.8
1943	24	19
1944	24.8	18.6
1945	24.6	—
Whole war	23.3	19.3
Overall average	22%	

The CAPTAIN class with either machinery fit had few maintenance problems. The reciprocating engines of the COLONY class were troublesome, showing that it is a mistake to think that simple machinery is necessarily reliable.

Weapon Systems[17]

Underwater

At the outbreak of war, attack on a submerged submarine depended on location by Asdic followed by a depth charge attack. The Asdics in use were in the 121–128 series which differed little in performance, the hull outfits for the faster ships having retractable domes. In average weather conditions detection would be at about 1300 yards with up to 2500 yards in ideal conditions. All forms of depth charge attack suffered from a long blind period from the time the approaching target left the Asdic beam until the charges, dropped over the stern, fell to the set depth. The deeper the submarine, the longer was this dead time giving more time for evasion, a problem not fully appreciated before the war.

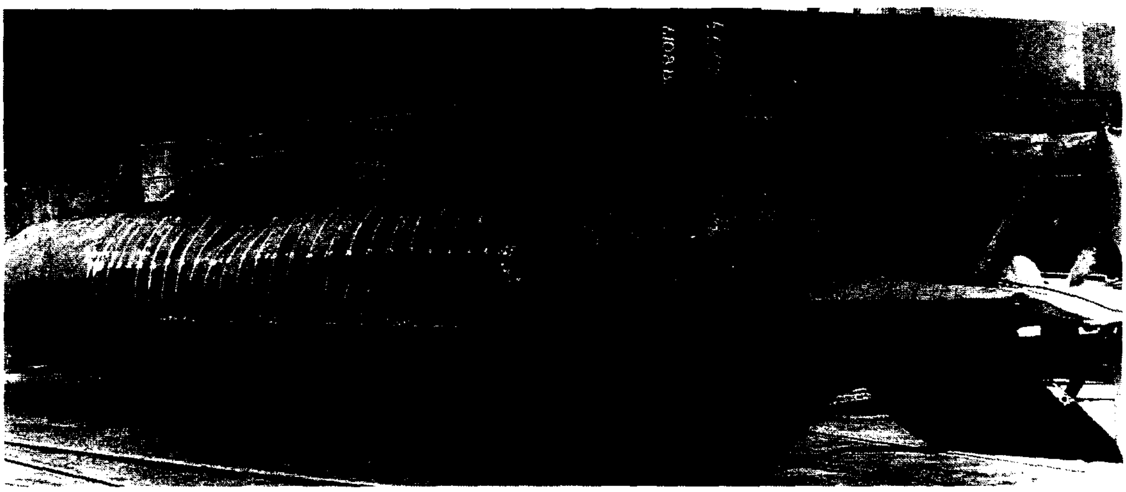

FIG. 6—WHAT IT FEELS LIKE TO BE DEPTH CHARGED. A NEAR MISS ON AN X CLASS MIDGET, WITH SEVERE BUCKLING OF PLATING BETWEEN FRAMES

Depth charges had entered service in January 1917, but with only two per ship at first and the thrower was introduced in August 1917. The Mark VII charge of 1939 had a charge of 290 lb of Amatol and was thought to have a lethal radius of 30 feet. In fact, 20 feet was a more realistic figure though, even at 40 feet, the U boat might have to surface due to damage to systems. It is worth noting that, at full speed, the U boat would move a distance equal to the lethal radius in three seconds (FIGS 6 & 7).

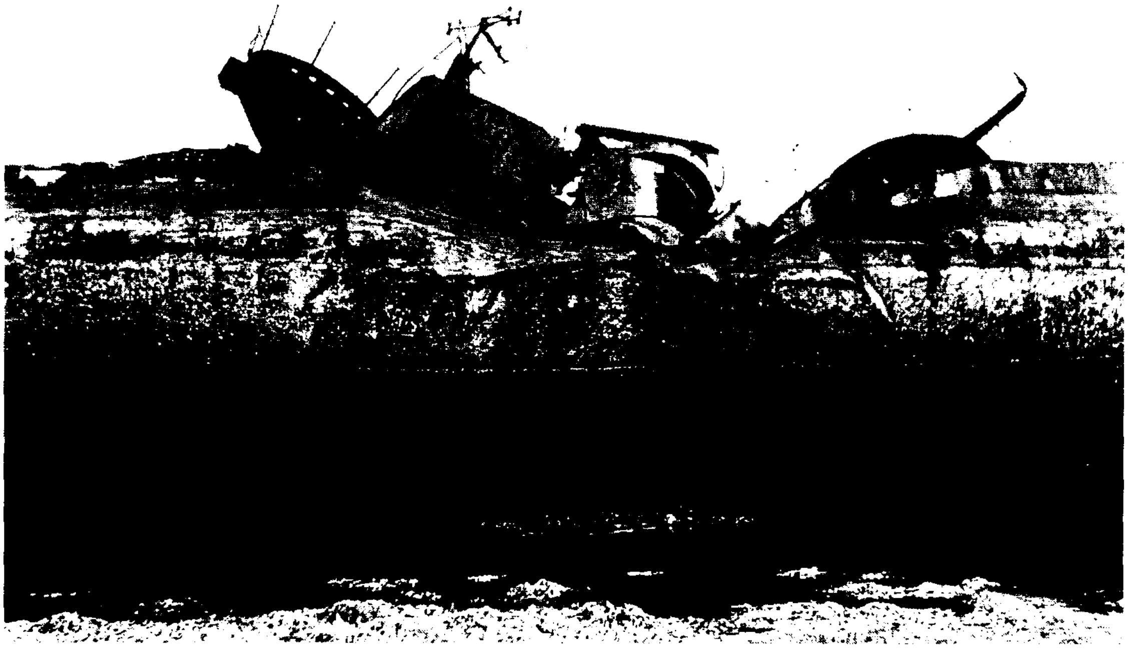

FIG. 7—LETHAL DAMAGE FROM DEPTH CHARGING. HMS 'STYGIAN' DESTROYED IN A POST-WAR TRIAL.

The Mark VII charge sank at an initial rate of 7 ft/sec, increasing to 10 ft/sec at 250 ft. It was not very effective; in the first six months of the war there were 4000 depth charge attacks giving 33 sinkings. In late 1940 the Mark VII 'heavy' was introduced which sank at 16 ft/sec and had a Minol charge, lethal at 26 ft and capable of inflicting severe damage at twice that range. The effectiveness of depth charge attacks was also improved by increasing the number of charges dropped in an attack from 5 to 10. Fourteen charge patterns were tried but the '10 pattern', with 5 exploding above and 5 below the target was seen as the most cost-effective. The 'One ton' depth charge, fired from a torpedo tube, was introduced in December 1942 with a 2000 lb charge, supposed to be as effective as a 10 pattern of Mk VIIs. It sank at 6 ft/sec, later increased to 21 ft/sec.

Attacks on deeply submerged submarines were greatly assisted by the 'Q' attachment, introduced in 1943, which could hold contact to much closer range; it was added to the earlier Asdics. The 144 set, introduced in 1943, was a much more capable set with ancillary equipment making detection and classification more certain. Many of its features were incorporated into earlier sets.

The real answer to the problem of dead time lay in the ahead throwing weapon and it must be a matter of regret that trials of such a weapon were abandoned in 1934. Wartime experience clearly showed the need and a number of weapons were hastily devised, some of which were tried. Of these, two were selected for production and proved successful in service. The first was Hedgehog which fired 24 contact-fused bombs, each weighing 65 lb, forming a circular pattern, 40 yards in diameter, centred 200 yards ahead of the ship. The charge weight was a matter of heated debate; its over-enthusiastic inventor in DMWD proposed 5 lb, but eventually constructors showed that 30 lb was the bare minimum to rupture a pressure hull.

The Hedgehog was not very successful at first as in some cases it was badly installed and poor maintenance was a problem—excusable since few ships had received a handbook. Operators were also concerned that the bombs only exploded if they hit and hence the shattering effect on morale of a near miss depth charge was lost. Once these problems were overcome, faith was restored and the Hedgehog became a more effective weapon. (TABLE IX).

TABLE IX—*Effectiveness of various weapons*

Period	*Depth Charges*			*Hedgehog*		
	Attack	*Success*	*%*	*Attack*	*Success*	*%*
1943 2nd half	401	15	3.7	49	4	8.2
1944 1st half	404	30	6.5	70	10	14.3
1944 2nd half	98	5.5	5.6	37	13	35.1
1945	107	7.5	7	59	15.5	26.3
	Double Squid			*Single Squid*		
	Attack	*Success*	*%*	*Attack*	*Success*	*%*
1943 2nd half						
1944 1st half						
1944 2nd half	6	2.5	*	17	4	23.5
1945	21	8.5	40.3	3	2	*

*numbers insufficient for a meaningful percentage

The Squid was a three-barrelled mortar firing depth fused bombs (207 lb Minol) to a range of 275 yards where they formed a triangle with 40 yard sides. They sank at 43½ ft/sec to a maximum depth of 900 ft. If two squids were fitted, the bombs were usually set to explode 60 ft apart in depth. Squid was fitted in the LOCHS (twin) and CASTLES (single) and also in a few destroyers.

The success of Squid depended on advances in Asdics. A true depth-finding set, the 147, was introduced in September 1943 which automatically set the fuses on squid bombs. The development of these and other weapon systems is fully described by Hackmann and their success is illustrated in TABLE IX.

The introduction of the German Naval Acoustic homing Torpedo (GNAT), first used in the torpedoing of *Lagan* on 19 September 1943 led to the introduction of a number of decoys such as Foxer—well after the introduction of the US homing torpedo, Fido [Mk 24 'mine'], which sank U 266 on 15 May 1943. The early decoys were clumsy and seriously interfered with the escorts' own Asdic but later versions, such as Unifoxer, were less of a problem. An alternative countermeasure was to operate below the speed at which cavitation commenced, about 8 knots for a propeller in good condition.

Surface Attack

U boat attacks on the surface in World War I were almost entirely on single, unescorted merchant ships. Only one attempt was made, in May 1918, to bring a concentration of U boats together and this was very different from the later Wolf Pack tactics. The first real pack attack was on convoy HX 72 in September 1940 and then, and for some time, the only means of detection was the human eye.

Radar began to enter service in the Atlantic very early in 1941, first the Type 286, mainly in destroyers, and initially with a fixed aerial which would only detect objects within about 50° either side of the bow and could detect a surfaced submarine at some 6000 yards. The much superior centimetric Type 271 first entered service in the *Orchis* in March 1941 and by the end of the year 50 sets were at sea. It could pick up a destroyer at 12 000 yards, a surfaced submarine at 5000 or a periscope (8 ft showing) at 1300. This set was updated as the 271Q in 1942.

These early sets were perhaps even more valuable in helping escorts to maintain station when zigzagging on a dark night than in detecting submarines, whilst the introduction of 'Talk Between Ships' radio in early 1941 also eased the problem of the escort commander. The number of first contacts by radar only exceeded visual sightings at the end of 1942 and eyesight remained important until the end of the war.

Bridges

The layout of bridges was an emotional subject but RN opinon was unanimous in advocating open bridges and, with 30–50% of first contacts made visually (up to the end of 1942), it seems that they were correct. There was an unrecognized price to pay in exhaustion leading to impaired decision-making. The USN tended to favour enclosed bridges and gun houses.

U boat Command relied extensively on two-way communication with boats at sea using HF radio. They believed that direction-finding from shore would be too inaccurate and that shipborne HF/DF sets were technically impossible. In fact, the first British ship set went to sea in late 1941 and fitting was rapid in 1942 leading to the sinking of U 587 on 27 March 1942. There was only a vague and inaccurate indication of range but, as more ships were fitted, cross bearings enabled precise locations to be obtained. By 1944 HF/DF accounted for about 30% of first detections, almost as frequent as from Asdic, and it was particularly effective against shadowers. HF/DF at sea contributed greatly to the Admiralty tracking room's knowledge of U boat dispositions.

A surfaced U boat was not easy to destroy. A shell would hit the tough, curved pressure hull at a very oblique angle and would usually glance off before exploding—a problem revealed during tests with captured U boats in 1919 but forgotten. Ramming was a more certain means of sinking and by May 1943 some 24 U boats had been disposed of in this way (about half had already been disabled by depth charge attack). On average, 7–8 weeks was required to repair the ramming ship and, though this was a profitable exchange, the use of shallow setting depth charges was encouraged as they became available[18].

Quiet propulsion

The RN relied almost exclusively on Asdic (active sonar) and hence there was little perceived need to quieten ships. The simple but efficient propeller would begin to cavitate at about 8 knots if in good condition; more usually minor damage—nicks in the leading edge—would reduce this to about 5–6 knots. Machinery, too, was noisy. Noise, particularly cavitation, became important with the introduction of homing torpedos in 1943. It is unfortunate that the development of hydrophones leading to passive sonar and the associated 'quiet propulsion' techniques such as pump jets and air bubble screening were abandoned with the introduction of Asdics[19].

PART III. SHIPS AND THE SEA

O Lord be kind, thy sea is so big and my ship so small

Endurance

The Atlantic is big (FIG. 8 and TABLE X). The typical convoy had about 3000 mile to travel, taking some 14 to 19 days along a route always close to a great circle. Escorts would travel considerably further, zigzagging and searching for contacts and they would also use higher speeds from time to time. Refuelling at sea only came into use in 1942 and was a slow and unreliable operation compared with today's procedures. The older destroyers were unable to cross the Atlantic without refuelling and some other classes had only a marginal capability (TABLE XI). The Long Range Escorts (mainly V & W conversions (FIG. 9)) lost a boiler room and a little speed to get increased fuel stowage. In many classes the need to conserve fuel limited the use of high speed.

TABLE X—*Atlantic distances*

New York to Liverpool	3043 n
Halifax to Liverpool	2485 n
Panama to Liverpool	4530 nm

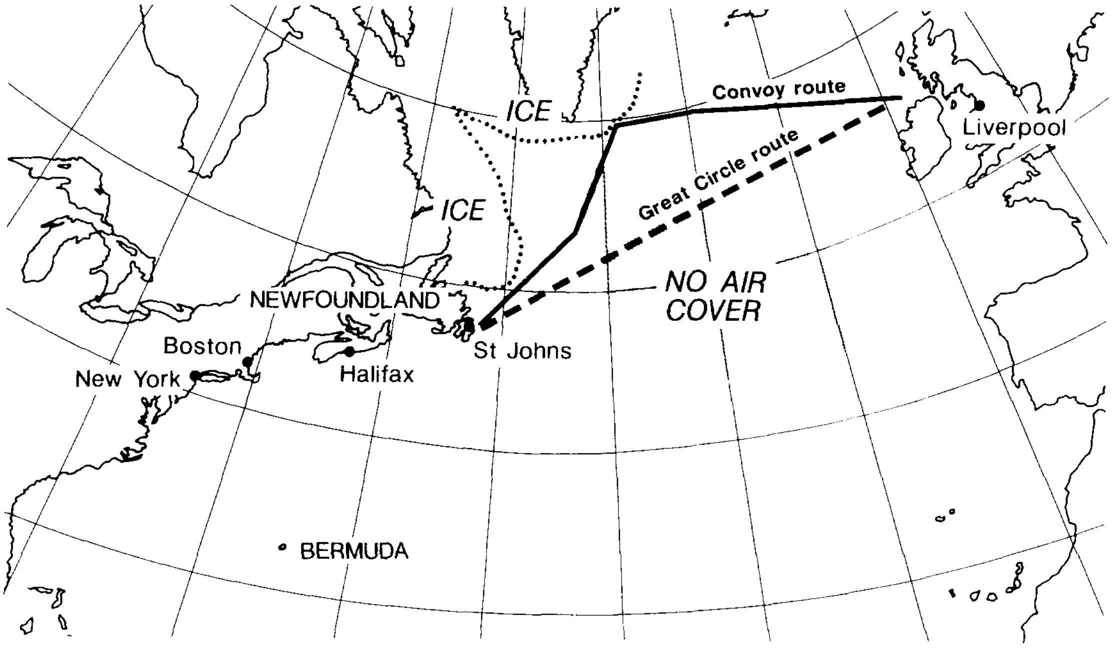

FIG. 8—DESPITE DIVERSIONS, CONVOY ROUTES DID NOT DEPART GREATLY FROM A GREAT CIRCLE ROUTE. THIS CHART IS A *GNOMONIC* PROJECTION ON WHICH A GREAT CIRCLE APPEARS AS A STRAIGHT LINE. THE ROUTE SHOWN IS THAT OF CONVOY $HX_2 29A$ AND AIR COVER IS AS FOR EARLY 1943

TABLE XI—*Endurance. Note that figures differ from source to source and these are nominal figures. The actual endurance was much less*

		Standard Version		*Long Range Version*	
	Class	*Range/ Speed* nm kts	*Fuel* tons	*Range/ Speed* nm kts	*Fuel* tons
Destroyers	V & W	2180/14	450	2680/14	450
	B	2440/14	390		
	E	3550/14	480		
	H	4000/14	329		
	TOWN	2000/14	284	2780/14	390
Sloops	FOWEY	4000/14	329		
	BLACK SWAN	4710/14	425		
Frigates, etc.	FLOWER	3850/12*	233		
	CASTLE	7800/12	480		
	RIVER tripl.ex.	4630/14	470	6600/14	
	RIVER turbine	4920/14	470	7000/14	
	LOCH	4670/14	730		
	CAPTAIN diesel	4670/14	197		
	CAPTAIN turbine	3870/14	335		

*5650 nm with water tube boilers

FIG. 9—HMS 'WHITEHALL', THE VERY EFFECTIVE VERY LONG RANGE CONVERSION OF THE WWI DESTROYER. ONE BOILER WAS REMOVED, GIVING MORE FUEL AND LIVING SPACE

Speed

The normal submerged speed of a World War II submarine was 3–4 knots and, in the hunt, the speed of the escort vessel was unimportant. The maximum speed at which Asdic could be used was about 15 knots. Speed was important to rejoin the convoy after a prolonged hunt astern and it seems that it was the faster ships which were detached to kill a submarine. With convoy speeds of 7–9 knots, new Staff Requirements looked for speeds of about 25 knots but, because of the lack of engines, only the destroyers and the turbine CAPTAINS reached such speeds. Sloops and frigates with speeds approaching 20 knots were barely adequate but the FLOWERS were not. In particular, the FLOWERS were slower than a surfaced U boat, important during a wolf pack attack. It is interesting that the much bigger CASTLE class corvettes, with the same engine as the FLOWERS, were at least half a knot faster due to their greater length and better form, developed at the Admiralty Experiment Works.

Turning Circle

A small turning circle (TABLE XII) was needed for a successful depth charge attack so that the stern could be positioned over the U boat. The FLOWERS were outstanding, short and with a fair-sized rudder in the slipstream of the propeller. The British twin screw ships were less good and it is now hard to understand why there was such reluctance to use twin rudders in the RIVERS and LOCHS (compared with the CAPTAINS).

TABLE XII—*Turning circles*

Class	*Diameter* yards	*Speed* knots
FLOWER	136	
RIVER & LOCH	330–400	12
CAPTAIN diesel	280	16
CAPTAIN turbine	350	18
RN destroyer	370	10
	405	15
	600	30
TOWN	770	15

Seakeeping

The North Atlantic is big, cold, wet, rough—sometimes very rough—corrosive and hard when it hits you (TABLE XIII). In bad weather the fighting effectiveness of a ship falls off quite quickly, mainly due to the degradation of the physical and mental abilities of the crew. Damage to the ship can also occur; Asdic domes were vulnerable and some destroyers had their bridge fronts pushed in. The effectiveness of radar was greatly reduced in big waves. Surface attacks by submarines would normally be made with wind and sea astern and periscope depth keeping was very difficult in high sea states.

TABLE XIII—*Relationship between wind speed and size of waves in the North Atlantic.*

The figures for probability of occurrence are averaged for the whole North Atlantic over the whole year. In winter, and in the more northerly areas, weather and seas are much worse, far more often

Sea State	*Wave Ht* m		*Wind Speed* kts	
	range	*mean*	*range*	*mean*
0–1	0–0.1	0.05	0–6	3
2	0–0.5	0.3	7–10	8.5
3	0.5–1.25	0.88	11–16	13.5
4	1.25–2.5	1.88	17–21	19
5	2.5–4	3.25	22–27	24.5
6	4–6	5.0	28–47	37.5
7	6–9	7.5	48–55	51.5
8	9–14	11.5	56–63	59.5
9	14	14	63	63

Sea State	*Probability of Sea State* %	*Wave Period* sec		*Likely Wave Length* m
		range	*most probable*	
0–1	0.7	—	—	—
2	6.8	3.3–12.8	7.5	90
3	23.7	5.0–14.8	7.5	90
4	27.8	6.1–15.2	8.8	123
5	20.6	8.3–15.5	9.7	148
6	13.2	9.8–16.2	12.4	238
7	6.1	11.8–18.5	15	350
8	1.1	14.2–18.6	16.4	424
9	0.05	18.0–23.7	20.0	615

The cause of seasickness was not fully understood in the war, but it is now recognized as primarily associated with vertical acceleration from the combined effects of pitch and heave. It is less certain, but probable, that vertical acceleration is also a prime cause of impaired judgment in those not actually vomiting[20] (FIG. 10).

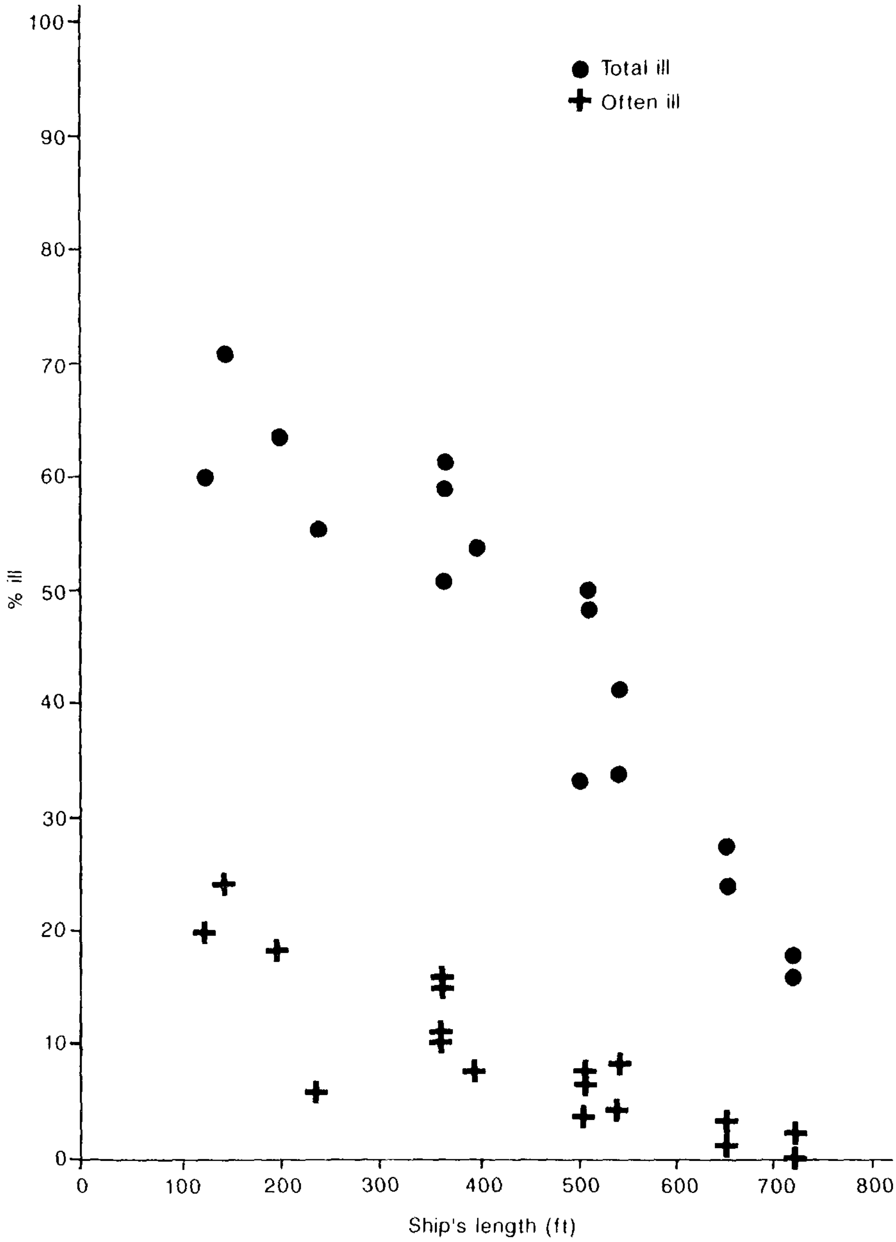

FIG. 10—SEASICKNESS IS MORE LIKELY IN SMALL SHIPS. THE GRAPH SHOWS THE NUMBER SOMETIMES SICK AND (LOWER BAND) THOSE OFTEN SICK, AS A FUNCTION OF LENGTH

The amplitude of both pitch and heave is governed mainly by length; long ships having smaller motions. Vertical acceleration will also depend on the longitudinal position, as pitching will lead to high accelerations towards the ends. Conversely, the effects of motion can be reduced by placing vital spaces, such as the bridge, operations room, etc., close to amidships. Sickness is also dependent on the frequency of the motion, being most likely between 0.15 and 0.30 Hz. More recent work (for the new CASTLE OPV) shows that the CASTLE Class of World War II was the shortest ship that would be effective in North Atlantic weather.

The effect of motions on the crew's fighting ability depends on the degree of acclimatisation as well as on ship size. The figures in TABLE XIV are based on experienced with the LEANDER class, at 360 ft, much longer than the ships under discussion.

TABLE XIV—*Effect of motions on fighting capability*

Sea State	*Loss of capability* %
0–4	0
5	10
6	30
7 & over	95

In recent years a single parameter, Subjective Motion Magnitude (SMM), combining the effects of acceleration and frequency has been derived. It is found that an instantaneous value of 12 for SMM will cause the captain to alter course or speed to reduce motions[21].

It is also possible to average SMM over the weather pattern of a whole year and over the length of the living and working spaces, an approach used in the design of the CASTLE class OPV where an average SMM of 4 was selected[22] (FIG. 11).

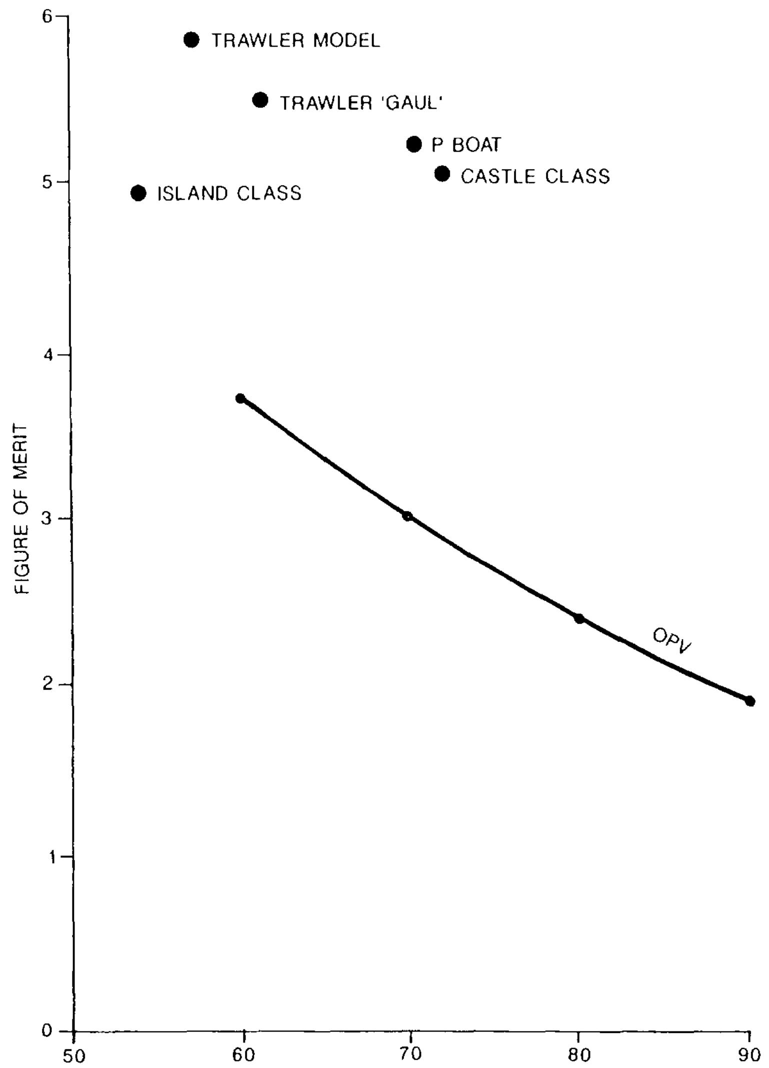

FIG. 11—THE 'FIGURE OF MERIT' ON THE VERTICAL SCALE IS THE SUBJECTIVE MOTION MAGNITUDE AVERAGED OVER THE LIVING SPACES AND OVER A YEAR'S WEATHER PATTERN. THE CONTINUOUS LINE REPRESENTS STUDIES FOR THE OPV 'CASTLE' CLASS

Such an approach shows that the FLOWERS were too short, a suggestion fully supported by many subjective accounts such as *The Cruel Sea*[23].

Severe pitching will cause the bow to come out of the water and, when it re-enters fast, the ship will slam. Slamming can damage Asdic domes and even the hull. It is a very complicated phenomenon but (FIG. 12) below, based on more recent ships, indicates the speeds which might be reached without intolerable slamming, as a function of draught. In general, slamming would be rare in corvettes, frigates and sloops at the speeds which they could mainain in sea state 6. Surprisingly, many accounts refer to the FLOWERS as superb sea boats and it can only be assumed that this refers to their lack of slamming.

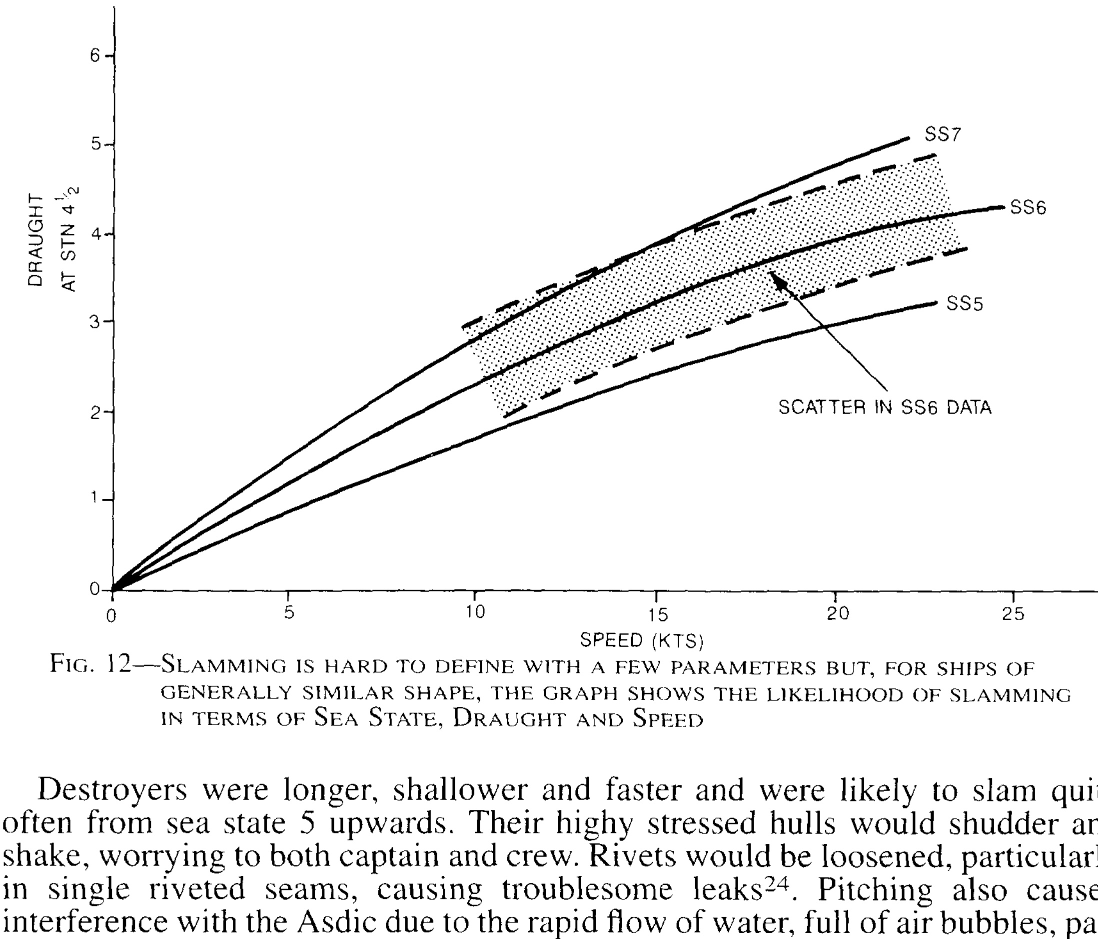

FIG. 12—SLAMMING IS HARD TO DEFINE WITH A FEW PARAMETERS BUT, FOR SHIPS OF GENERALLY SIMILAR SHAPE, THE GRAPH SHOWS THE LIKELIHOOD OF SLAMMING IN TERMS OF SEA STATE, DRAUGHT AND SPEED

Destroyers were longer, shallower and faster and were likely to slam quite often from sea state 5 upwards. Their highy stressed hulls would shudder and shake, worrying to both captain and crew. Rivets would be loosened, particularly in single riveted seams, causing troublesome leaks[24]. Pitching also caused interference with the Asdic due to the rapid flow of water, full of air bubbles, past the dome.

Sailors have always said 'One hand for yourself, one hand for the ship'. More recently, it has been shown that the ability to carry out manual work, such as loading depth charges, is mainy affected by the lateral acceleration associated with rolling. Rolling is a complicated motion influenced by the size and frequency of the waves meeting the ship (which depends on course and speed), on the metacentric height and resistance to roll provided by bilge keels, etc. Though sufficient metacentric height is needed to ensure that the ship will not capsize, in extreme seas excessive values are to be avoided. A considerable amount of experimental work had been carried out on rolling before the war although there was still much that was not understood or at least not quantified.

A ship that is too stiff will roll to only slightly greater angles than one with a smaller metacentric height but the roll will be much more rapid, increasing the lateral acceleration and hence making work more difficult. It is clear that the older destroyers were marginal and needed strict control of topweight and some ballasting[25]. On the other hand, the CAPTAIN class was too stiff, making work on deck dangerous and had to be taken out of service for bigger bilge keels and more topweight. The FLOWERS, too, had to be fitted with bigger bilge keels.

By today's standards, the other classes of escorts had bilge keels which were too small. It seems to have been thought that ships always roll, that sailors are tough—and naval architects were well aware that big keels needed to be very strong and would reduce speed appreciably. The sloops of the BLACK SWAN Class had active fin stabilizers, first tried in the *Bittern* in 1936. These were quite effective, though, because control theory was undeveloped, less so than modern stabilisers.

Wetness due to green seas over the deck or from spray over the fore end of the ship could make open gun mountings and Hedgehog difficult and even dangerous to work and would lead to exhaustion on open bridges. Adequate freeboard is the main factor in keeping ships dry, though flare in moderation, knuckles and even breakwaters can help.

Human Factors

North Atlantic escort duty in small ships was inevitably exhausting, particularly in winter. Today, it is recognized that the combat efficiency of a crew is increased if they are well fed and can rest properly when off duty but this was not understood during the war and British ships fell well short of what was possible and desirable. There was an impression that sailors were tough and almost revelled in discomfort; in particular, it was thought that discomfort was necessary to keep men awake when on duty. It was also claimed that hammocks were more comfortable than bunks in rough weather though there was no obvious desire among officers, most of whom had used hammocks, to give up their bunks. The traditional RN messing was unlikely to produce a balanced diet.

The early, short forecastle FLOWERS were the worst. They had bunks in the forecastle where the motion was worst and to reach the bridge or engine room meant crossing the open well deck, inevitably getting wet in bad weather. Worse still, the galley was aft and food had to be brought along the open upper deck to the mess, getting cold, if not spilt on the way. As more equipment was added, overcrowding became worse. The following quotation sums up conditions very well:

> It was sheer unmitigated hell. She was a short fo'c'sle corvette and even getting hot food from the galley to fo'c'sle was a tremendous job. The mess decks were usually a shambles and the wear and tear on bodies and tempers was something I shall never forget. But we were young and tough and, in a sense, we gloried in our misery and made light of it all. What possible connection it had with defeating Hitler none of us bothered to ask. It was enough to find ourselves more or less afloat the next day and the hope of duff for pudding and a boiler clean when we reached port.[26]

Ventilation was grossly inadequate, contributing to the high incidence of tuberculosis, and in the first 56 ships the side was unlined. From 1940 onwards the side was sprayed with asbestos which would lead to the deaths of many dockyard workers in later years. Washing and toilet equipment was crude and inadequate in number.

The frigates were a little better as they were bigger, reducing the vertical accelerations, had covered access fore and aft and their later design remedied some of the defects of the FLOWERS. With a little thought and some slight increase in cost, much of this unnecessary discomfort could have been avoided. Monsarrat[27] compares two ships which he commanded, the US build COLONY with the RIVER Class on which it was based. The American ship had a laundry, ice water in each mess, a dish washer, potato peeler, cafeteria messing, good insulation and ventilation, an internal communication system and was still built more quickly—and no one can suggest that USN sailors were soft.

One cannot leave the subject of human factors without re-emphasizing the importance of the ace, on both sides. Men such as Walker and some other escort commanders and, on the other side, Kretschmer, Prien, etc., were good enough to distort all statistics. The difference was that escort commanders lived to improve their skill and to pass it on whilst U boat aces had a short life.

Life Saving

The question of escape is closely related to habitability. Losses of escort vessels were not unduly high but many of their crews found sleeping difficult in the lower mess decks and cabins with a long and tortuous route to the upper deck and preferred to rest, if possible, close to the deck. Adequate escape routes add greatly to peace of mind, when sinking may be rapid (TABLE XV), and men will stay at their posts longer when they know they can get out.

TABLE XV—*Time to sink*

Class	*Time to sink* (minutes)				
	under 10	10–20	20–30	30–60	over 60
Destroyer	28	12	1	1	2
Frigate	3	—	—	1	4
Sloop	2	1	1	3	3
Corvette	13	2	1	2	5

Very little consideration had been given to lifesaving gear before the war. Boats could not be lowered in time and neither they nor the carley float gave any protection from exposure. The inflatable life belt was shown to be dangerous in tests just before the war but was put into production without change. A very high proportion of those who escaped from sinking ships died in the water. Picking up survivors from the sea was a frequent task and one to which little thought had been given.

Vulnerability

World War II escorts were small ships and, in consequence, had only a limited ability to survive major damage such as a torpedo hit. Indeed, it is remarkable that so many did survive. The Battle of the Atlantic was so wide ranging that it is difficult to say which losses are specific to that battle. Some ships lost in the Atlantic were merely on passage and the geographical boundaries are unclear. TABLE XVI can only be seen as an approximation.

TABLE XVI—*Losses of escort vessels in the Atlantic*[28]

Type	RN	Allied
Destroyer	15	13
Sloop	9	—
Frigate	4	7
Corvette	7	4

TABLE XVII—*RN destroyers and escorts sunk (S), seriously damaged (SD) and slightly damaged (D)*

Weapon / *Ship*	*Shell*			*Bomb*		
	S	*SD*	*D*	*S*	*SD*	*D*
Destroyers	13	40	74	44	81	118
Other Escorts	2	2	10	16	28	33
Weapon / *Ship*	*Mine*			*Torpedo*		
	S	*SD*	*D*	*S*	*SD*	*D*
Destroyers	18	35	4	52	15	2
Other Escorts	17	39	10	50	19	2
Weapon / *Ship*	*TOTAL*					
	S	*SD*	*D*			
Destroyers	127	171	198			
Other Escorts	85	88	53			

The effect of various weapons is only available on a world wide basis (TABLE XVII). The figures for other escorts are probably more representative of the Atlantic and show that the majority of sinkings were due to torpedo hits. It is not often realized that the main cause of sinking of smaller warships was a broken back. Broken backs accounted for 44% of destroyer losses, 40% of frigates and 21% of sloops. The destroyer, highly stressed and with a break of forecastle amidships exacerbating the stress, was most likely to break, the lower stress and deeper hull of frigates and sloops reducing the risk, but only slightly. Fire was a less serious risk: of 496 destroyers hit, only 60 reported fire, usually started by bombs.

PART IV. HOW GOOD WERE THEY?

It is almost impossible to measure the relative effectiveness of different types of escort in the overall task of ensuring safe arrival of cargoes. It is possible to relate the secondary task of sinking U boats by escort type (TABLE XVIII) but there are so many anomalies that the results are not very meaningful. These figures must be associated with the numbers of ships of each class operating in the Atlantic (TABLE XIX). This number fluctuated rapidly and, since the Atlantic boundary is not easy to define, the numbers given are typical rather than precise.

TABLE XVIII—*U Boat sinkings by class*

Escort category	*Total number of kills in N Atlantic*
Destroyers	
modern	9
inter-war A-I	39
old (WWI)	26
TOWNS	8
HUNTS	8
Sloops	
BLACK SWAN	28
older	12
Frigates	
RIVER	22
LOCH	12
CAPTAIN	28
COLONY	5
Corvettes	
FLOWER	38
CASTLE	5

TABLE XIX—*Escort vessels in service in the Atlantic by class*

	Flowers		*Rivers*		*Loch, Castle, Captain, Black Swan*	*TOTAL*	
Date	RN	RCN	RN	RCN	RN	RN	RCN
1.1.41	47	13	—	—	2	49	13
1.1.42	110	67	—	—	3	113	70
1.1.43	108	70	17	9	7	132	79
1.1.44	117	79	41	25	87	245	104
1.1.45	117	88	57	47	131	305	133
7.5.45	111	95	59	61	144	316	160
3.8.45	23	4	40	42	108	151	50

Destroyers of all classes were fast; even the long range escort conversions (LRE), mainly V & Ws, could still reach 25 knots with one boiler removed but they were designed to achieve their speed on trial in sheltered waters. Their draught was inadequate to prevent slamming at operational speeds and they had insufficient freeboard to keep them dry. As built, their endurance was insufficient for Atlantic escort work but the LREs were outstanding; at the cost of six months' work their fuel stowage was increased to 450 tons and there was more living space as well. Turning circles were large, particularly in the TOWNS. Their armament, in almost all, was Hedgehog and depth charges.

The earlier pre-war sloops seem to have been generally satisfactory. The somewhat similar ex US Coast Guard cutters suffered from poor stability and very poor subdivision. The heavy AA armament of the BLACK SWANS (FIG. 13) enabled them to venture into the Bay of Biscay where they scored many successes; even though their fire control was poor, the volume of fire would put most bombers off their aim. The figures are greatly distorted by the genius of Captain Walker. (There are indications that the BLACK SWANS were a prize appointment for the most skilled officers).

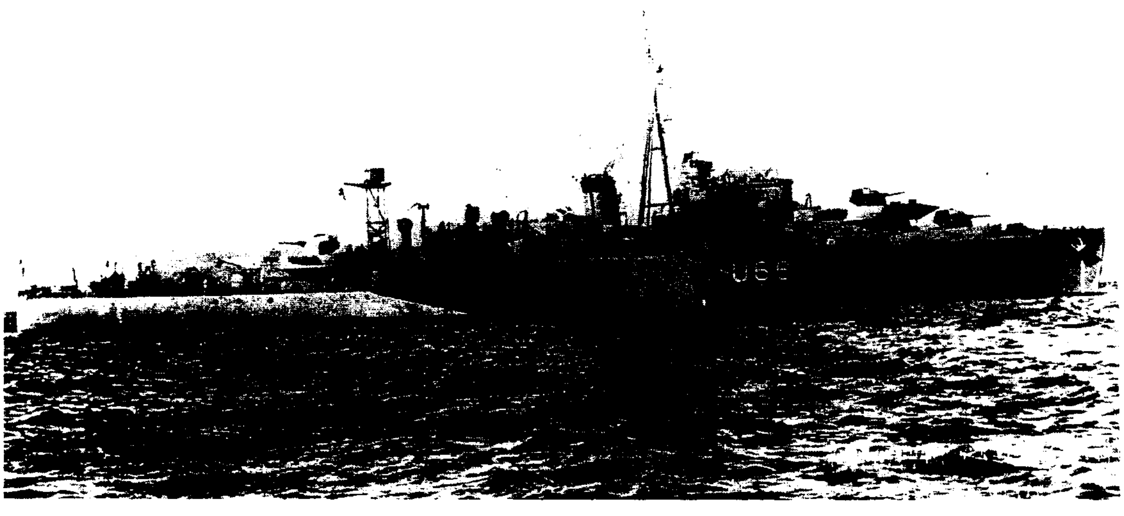

FIG. 13—HMS 'STARLING', THE 'IMPROVED BLACK SWAN' WHICH WAS CAPTAIN F J WALKER'S LEADER OF THE 2ND ESCORT GROUP. 'STARLING' PARTICIPATED IN THE SINKING OF 16 U BOATS

The FLOWER class were intended for coastal work and had many drawbacks for ocean work. They were short so that pitch and heave motions were severe, which led to a high incidence of sickness and, in all probability, of poor decision-making, while their standard of habitability was low. Inadequate bilge keels led to heavy rolling and they were too slow to keep up with a surfaced submarine or to return quickly to station. On the other hand they could be built quickly and cheaply and hence were available in considerable numbers, so important with short range Asdic. The concept of the small, cheap escort was sound in 1939 but the FLOWERS were not a good design. A ship similar to the CASTLES of wartime or, even better, the CASTLE class OPV would have been preferable.

The RIVERS, originally known as twin screw corvettes, were bigger, a little faster but with a similar weapon fit. It is not easy to compare the effectiveness of these classes as kills were often shared between ships of more than one class. TABLE XX compares the successes of the RIVERS and FLOWERS in the RN. A kill is credited if a ship of that class participated.

TABLE XX—*Flowers/River successes*

Year	*1940*	*1941*	*1942*	*1943*	*1944*	*1945*
Average No. in Atlantic	18/0	50/0	74/8	65/17	47/20	31/19
Kills	1/0	7/0	6/1	16/7	2/5	1/1
Kills per ship (%)	—	14/–	8/12	25/41	4/25	3/5

Figures shown as Flowers/Rivers

Though there is an indication that the RIVERS were appreciably more effective in sinking U boats than the FLOWERS, it must be recognized that the bigger ships used twice as many scarce engines, cost twice as much and do not seem to have been twice as successful. By virtue of their greater numbers, it would be expected that the FLOWERS should be more effective in keeping submarines submerged. Numbers count, and as Goodall wrote; 'Moral is, don't try and force cheap ships on the Navy, which, as Winston says, 'always travels first class''. The CASTLES were longer than the FLOWERS, making them better seaboats and a little faster than the earlier ships. They carried Squid, very effective even in single form.

The COLONIES were the US version of the RIVERS with the usual excellent American living standards but were handicapped by unreliable reciprocating engines. The CAPTAINS were expensive ships but their advanced machinery was very reliable and easy to operate. Once the initial problems with rolling were overcome, they were good seaboats and fast, especially the turbine ships.

The LOCHS were outstanding as they were the only class with 144 and 147 fire control Asdic, by far the most effective weapon system. They were rather slow but remained the most effective anti submarine ships well into the 1950s.

LESSONS

The lessons perceived at the time were summarized in the requirement for the '1945 Sloops'[29]:

- 25 knots in rough weather
- double squid—later Limbo
- good turning circle
- twin 4.5 in gun
- easy to build.

After many changes, these ships completed as the LEOPARD, SALISBURY & WHITBY classes. These were all good designs, the WHITBYS being outstanding, and one can only agree with the committee which drafted the 1945 requirement—though they were hardly easy to build.

It is more interesting to reflect on what should have been built before the war. The FLOWERS were seen as superior to trawlers for coastal work but a larger ship, like the CASTLE class corvette (or better, the new OPV) would have been more effective and little more expensive. Since the fall of France was unexpected, the need for open ocean escorts did not seem pressing but it would have been sensible if effort had been available to design and build a prototype or two of a more capable ship with turbine machinery, perhaps using sets removed from the S class on scrapping. A ship of 1500–2000 tons would have reached 26–27 knots and carried 450 tons of oil. In the late 1930s such a ship would have had a RIVER Class weapon fit but a big growth margin would have been wise. It should have had a high freeboard over most of its length, a deep draught and twin rudders. It might have looked like a two funnelled BLACK SWAN. However, hindsight is easy, the staff and constructors did the best they could with very limited resources and the war before France fell appeared to justify their work.

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