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The Fortification of the Firth of Forth 1880–1977

'The most powerful naval fortress in the British Empire'

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Chapter 5

THE FIRST WORLD WAR, 1914–19

'In the case of those ports which are vital to the maintenance of our naval and military power, no risks can be taken …'[1]

5.1 Introduction

The coast defences were brought to action at about 2 p.m. on Thursday 6 August 1914, two days after war was declared, when a gun of the Inchgarvie Battery was fired to bring to a Danish cargo steamer going upstream towards the bridge. Later in the afternoon, the vessel proceeded upriver, followed on shore by crowds of townspeople and visitors who had followed events from the moment the shell from Inchgarvie was fired.[2]

As would happen again in the early months of the Second World War, the second half of 1914 saw the appearance of some absurd fears. By November 1914, 54 cases of 'enemy' aircraft had been reported, mainly at night. The supposed appearance of enemy aircraft over Scapa Flow, Invergordon and Loch Ewe in the first months of the war, and the impossibility of these being based in Germany, led to an extraordinary John Buchan-type story gaining credence: that the enemy had established secret air bases and/or wireless stations in remote parts of Orkney, Shetland or the northern mainland, or that seaplanes were working from a 'depot ship'. There were also reports of aircraft in the Forth in the second week of September, at Leven, Carlingnose Battery and Inchkeith, where an airship was supposedly heard at 1.20 a.m., and again at 2.33 a.m., on the 14th. After close enquiry by an officer of the Royal Flying Corps, he concluded that all the reports in Scotland 'were based on quite unreliable evidence, and might be regarded as unfounded'.[3]

The defences of the Forth during the war can be considered broadly in two phases: first, from 1914 to early 1916 and, once it was decided to move the Grand Fleet to the Forth, from 1916 to 1918. The defences in the later period were significantly stronger and more complex, but the changes were more incremental than has often been stated.

After the German raid on the east coast in December 1914, Britain's battle cruiser fleet of ten ships was moved from Cromarty to the Forth as a 'sop to public opinion'.[4] Battle cruisers were large capital ships but provided with lighter armour than the fleet's battleships to allow them to make higher speeds. The battle cruisers were accompanied by three squadrons each of four light cruiser, and two flotillas each of 20 destroyers. In addition, there were minesweepers, colliers (one per capital ship, one collier between two cruisers), depot ships for the destroyers, drifters and other auxiliary vessels.[5]

5.2 The state of the defences in the early months of the war

In the autumn of 1914, the mobile phase of the land war on the Western Front had settled into the stalemate of trench warfare, and the possibility of a speedy military victory by either side had receded. It was only as the war began to enter this phase that the defences of the Forth were brought up to an appropriate state of readiness (Table 8). A conference to discuss anti-submarine defences was convened in late October 1914, and in early November Scottish Command was asked to appoint officers to command the Forth's Outer Defences and the overall fortress. In late November, the Forth was closed to commercial traffic west of Oxcars for the security of the anchorage and bridge and also to prevent neutral shipping from entering, possibly to gather intelligence.[6]

In October 1914, a revised *Manual of Coast Defence* was published by the War Office, setting out all the necessary information required for a Fortress Commander to manage every aspect of the defences of a fort, and we can see that the Forth defences were built or adapted in line with these published instructions.[7]

Within the estuary, from the bridge to Inchkeith, the defences were at first split between the Inner Defences, at the bridge, and the Outer Defences, on Inchkeith and at Kinghorn. The Middle Line, at the line of islands, Cramond, Inchmickery and Inchcolm, was put in place from 1914 onwards. As will be seen below, the Forth presents an interesting contrast between the speed with which changes were implemented and Dobinson's account of the slowness of developments elsewhere, in some cases with defences not reaching their wartime planned state until 1921.[8]

On 16 December 1914, the coast defences of Britain were tested when the Imperial German Navy, as part of a plan to draw the British Grand Fleet into an ambush, bombarded

Table 8
The state of the defences of the Forth in August 1914, as reconstructed from a number of different documents

Name	Armament (intended)	DELs	Notes
Dalmeny	2 x 4.7-inch QF Mk IV	2 fixed beam	
Inchgarvie	2 x 12-pdr (12cwt)	none	Work in hand on the first two of four 4-inch emplacements
Coastguard	2 x 12-pdr (12cwt)	2 moveable beams; 1 fixed beam (experimental – see Part D)	
Carlingnose	2 x 6-inch Mk VII 2 x .303 Maxim on field carriages	none	
Downing Point	Not yet armed	1 moveable beam; 1 fixed	2 x 4.7-inch work started September
Hound Point	Not yet armed	2 or possibly 4	2 x 6-inch Mk VII under construction
Braefoot	Not yet armed		2 x 9.2-inch Mk X under construction
Inchkeith	3 x 9.2-inch Mk X	Nil	
Kinghorn	1 x 9.2-inch Mk X 2 x 6-inch Mk VII† 2 x 4.7-inch QF†	Nil	6-inch guns brought into approved armament 8 August. 4.7-inch guns moved to Downing Point, November 1914

† mounted for drill and practice only on 4 August 1914

three towns, two undefended: Scarborough, Whitby and Hartlepool.[9] Hartlepool was defended by three 6-inch Mk VII guns, a pair at Heugh Battery and a single gun at the Lighthouse Battery. Having received warning of the attack, live ammunition was issued at 4.30 a.m. At 7.46 a.m. two German battle cruisers (SMS *Seydlitz* and *Moltke*) and an armoured cruiser (SMS *Blücher*) were sighted, and at 8.10 a.m. they began to bombard the town. Two shore guns fired at the leading ship, while the third fired at the armoured cruiser. The gunners were hampered by a rising cloud of smoke and dust around them, affecting visibility, and found that their shells had no effect on the armoured sides of the ships, so instead aimed at masts and rigging. The coast batteries fired 143 shells. To avoid the accurate firing of the third gun, SMS *Blücher* moved behind the lighthouse to prevent further hits. Two of her 6-inch guns were disabled, while the ship's bridge and another 8-inch gun were damaged.[10]

5.3 Guns, nets and booms 1914–16

'Once the lines were established in the Forth, no submarine ever succeeded in penetrating the inner waters …'[11]

Obstructions

While the heavy guns on Inchkeith and at Kinghorn were intended to tackle any large surface ships, attacks by submarines or light torpedo craft were more likely, and the key element of the defence against these threats was the complex of obstructions created in the estuary and the systems put in place to detect submerged intruders. Many of the more substantial First World War obstructions were still marked on the 1919 Admiralty charts and, as late as April 1921, captains of vessels proceeding up the estuary were complaining about the failure of the authorities to remove them.[12]

There were three inter-related parts of the system: *Offensive Obstructions*, which came into use first, in the 1870s; *Passive Obstructions*, which were first put in place in the early 20th century; and forms of *Detection*, which were developed during the First World War. The first category included mines and torpedoes controlled from the shore;[13] in the second were booms and nets to prevent submarines, small surface boats and torpedoes from penetrating the anchorages; in the last were various mechanisms for detecting the presence or passage of enemy craft, either submerged or when the river could not be observed, at night or in poor visibility. The second and third categories were later combined, for example, from 1918, when submarine detection had become precise enough to determine when controlled mines might be detonated.

The Forth had three kinds of *Passive Obstruction*: anti-boat booms (A/B), anti-submarine nets or booms (A/S) and anti-torpedo (A/T) nets. These were supported in a variety of ways, depending on the depth of the water, the weight of the obstruction and the strength of the tides. Booms or nets were supported by 'trots' or in shallower water by 'dolphins' or 'hurdles' set on the seabed.[14]

Anti-boat booms were formed of heavy baulks of timber, or later by steel hawsers fitted with star-shaped, spiked cutters (Fig 10.52), forming a continuous barrier on the surface

designed to stop light, fast vessels (especially motor torpedo boats) from rushing the anchorage at speed. In the Forth, permanent anti-boat defences of concrete pylons or blocks and of steel rails were also built in both wars.

Anti-submarine nets were designed to force a submerged vessel to the surface, where she could be dealt with by the supporting craft. The nets were usually formed of, at first, a 12ft (*c* 3.7m) square steel mesh (after 1929, 8ft (*c* 2.45m) diagonal mesh) hung to various depths from floating supports or, in shallower water, from dolphins (Fig 5.1).[15] They were placed to cover channels that were deep enough to allow a submerged submarine to enter the anchorage. Most nets were fixed and were intended to withstand a submarine hitting them. To overcome this, submarines were fitted with cutters of various kinds to try to penetrate the nets. In the First World War, many nets and booms were constructed on the 'yielding principle'; when a vessel hit the obstruction, its tension would be released slowly, to absorb the vessel's momentum. For this reason, winch-houses were built on Inchcolm, Inchmickery and Cramond Island, to tension and manage the nets and booms.

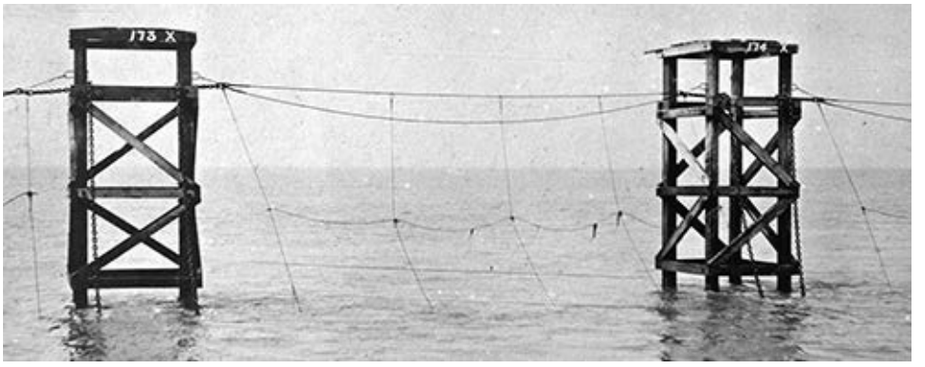

Figure 5.1
A section of anti-submarine net suspended from the line of 'dolphins' between Leith and Inchkeith, 1917 (Reproduced by permission of MOD Naval Historical Branch)

'Indicator nets' were a sub-type of A/S net, designed not to stop a submarine, but to break off in sections when hit by one (Fig 5.2). These usually had a 12ft (*c* 3.7m) square mesh, in 300ft (91.4m) sections and up to 120ft (36.6m) deep. The sections were joined by clips designed to part when a strain of 150lb (*c* 68kg) was applied. They were deployed from the holds of fishing drifters, and either moored to the seabed or held in position temporarily by drifters. Floats kept the top of the net at surface level or at a set level below the surface (for example, to allow surface vessels to pass unimpeded over the top of the net), and the nets were fitted with a variety of devices that would alert the boats guarding the net, first, that a submarine had broken the section of net off and, second, where the submarine was. The most successful was a 'pram buoy' that held 1.8kg of phosphide of calcium, which would catch fire when wetted and be towed behind the net on the surface. The intention was that the submarine would then be chased down and sunk or forced to the surface. Tests against 9ft (2.7m) and 12ft (3.7m) mesh indicator nets in the First World War showed that the broken off section would wrap itself round the submarine and might foul rudders and diving vanes. Some indicator nets were fitted with contact mines, which contained 20.4kg of TNT, designed to explode when the net wrapped itself round the submarine.[16] There was a total of 18 miles (*c* 29km) of permanent indicator net deployed in the Forth.[17]

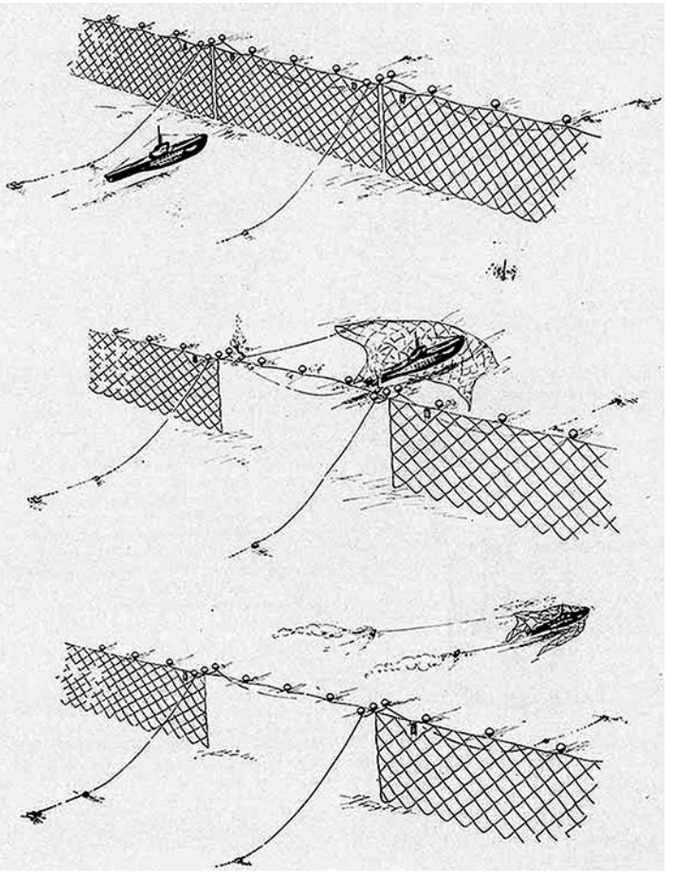

Figure 5.2
How indicator nets work: (top) the submerged submarine approaches the moored net; (middle) the submarine hits the net and the clips holding the net sections together part; (bottom) the 'pram buoys', filled with phosphate of carbide, burn on the surface, showing the location and course of the submarine (US Bureau of Ordnance 1944 *Net and Boom Defenses*)

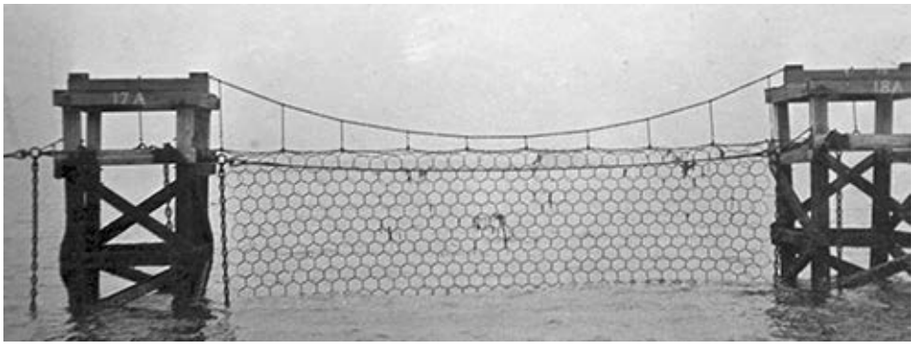

Figure 5.3
A section of anti-torpedo net suspended from two 'dolphins' on the Drum Sands–Inchmickery boom line (Reproduced by permission of MoD Naval Historical Branch)

In the Forth, A/B and A/S booms were placed at several points in the estuary. 'Gates' were provided through the nets and booms that were opened when vessels needed to enter or leave the anchorage. Gates were of two types: either a 'swinging or pivoting gate', where a section of net opened like a hinged door, or a 'vertical gate' dropped and raised by winches. The latter type was quicker to open and close but provided a less sure defence when closed and could foul a passing vessel when open at low tide.[18]

The final net type was the anti-torpedo net, designed to stop torpedoes being fired into an anchorage. A/T nets were of a much smaller mesh size (Fig 5.3). They were generally hung from floats or from dolphins. In the First World War, mobile A/T nets were moved around by the naval trawlers to screen the fleet while it was exercising in the outer part of the estuary.[19]

The Forth nets and booms

The fixed gun batteries at the bridge had first been mounted at the beginning of the century to prevent an enemy from grappling and clearing the controlled minefield. When, in the First World War, obstructions were built to impede submarines and torpedo craft, these obstructions also required protective batteries and accompanying fighting lights.

An A/S net was planned for the two spans of the Forth Bridge (Fig 5.4 (a and b)) and, by late October 1914, the net for the south span was already in place.

Some months before, in May 1914, Admiral Lowry had raised again the need for the defence of the Inchcolm–Inchmickery–Cramond Island line, armed with 4-inch QF guns, and he renewed his efforts in the early months of the war. His argument was that the Forth should be able to accommodate the whole Grand Fleet at once for coaling and supply. The current Commander, Jellicoe, did not agree, but this had been the view of Jellicoe's predecessor. There were, according to papers on file, only 16 berths for large vessels west of the bridge at that time, and more could only be made available east of the bridge if that area could be defended.[20] Lowry's concern was that the fleet had been driven to the west coast to seek shelter from the submarine threat, and 'It appears to me to be essential that the defence of the Ports on the East Coast should be sufficient to render safe the supplying of the Grand Fleet when it is required to re-enter the North Sea'.[20]

Lowry's representations bore fruit, and in October 1914 the Admiralty told the War Office that an anti-submarine net would be established to protect the anchorage downriver (that is, to the east) of the Forth Bridge, armed with 14 12-pdr QF (Naval) 18cwt guns on pedestal mountings, with four searchlights. Although these guns were significantly more powerful than the normal 12cwt naval 12-pdrs used in coast defence, they lacked the auto-sights (see Section 2.1 above) needed to track fast-moving vessels.[21] The 18cwt naval guns were very much a stop-gap in the absence of what he believed to be the more appropriate 4-inch guns.

Admiral Lowry suggested that the net, its gate and guns mounted on light vessels should be manned and maintained entirely by the Navy. He justified this because no military force had been trained for the purpose and he thought it desirous that the men operating these defences should have some sea knowledge. He was also of the view that the guns and lights on the islands should be manned by Royal Marines.[22] While the General Officer Commanding Scottish Coast Defences felt it was desirable that the defences of the Fortress should be entirely under the control of the (Army) Fortress Commander, Forth Defences, he agreed; as the guns were not fitted with the automatic sights that Royal Artillery coast defence gunners were used to, they should be manned by Royal Marines until more permanent arrangements could be made.[23]

In early November 1914, Lieut-Colonel E R Poole, RGA, and H Cartwright-Reid, Superintending Civil Engineer, surveyed the islands for the new defence scheme. Inchcolm was to receive eight 12-pdr (Naval) 18cwt guns, six of which were to be sited on the elevated plateau at the island's east end, while the remaining two were to be sited on the south side of the island's western lobe. Three searchlights were also to be mounted at the east end, two of which were to be fixed-beams, while the third was to be moveable. The fixed lights were to illuminate areas in front of the net defences to the north and south of the island, while the searching beam was to face eastwards to sweep the approach channels. At Inchmickery, four 12-pdr (Naval) 18cwt guns were to be sited on the elevated part of the island to command the net defences. Two

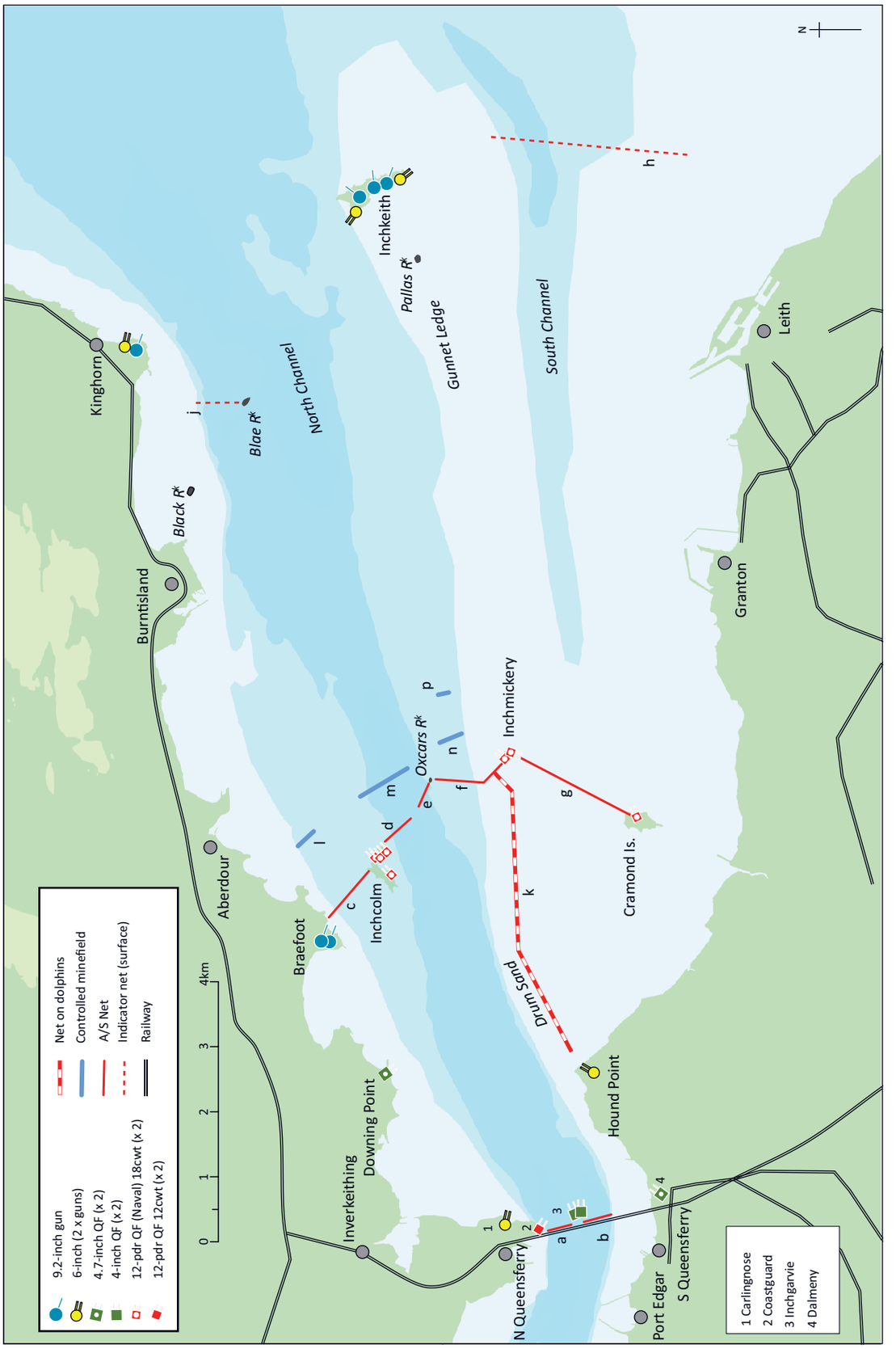

Figure 5.4
Map of inner estuary in 1915 showing the location of anti-submarine nets, anti-boat booms and built obstructions (© Gordon Barclay)

searchlights were also to be mounted, one being fixed and the other being moveable. The fixed light was to illuminate the area in front of the nets between Inchmickery and Oxcars Rocks to the north, while the other was to search the eastern approach. Cramond Island was to be armed with two 12-pdr (Naval) 18cwt guns at its north-eastern corner, along with one fixed searchlight to illuminate the water between Cramond Island and Inchmickery.[24]

Of the six searchlights required, four were to be provided by the Navy, while the other two were (reluctantly) transferred from Hound Point. By 11 November, four 36-inch searchlights and gear had been assembled at the new line.[25]

In addition to providing the guns and four lights, the Admiralty agreed to provide 500 rounds of high-explosive Lyddite shell per gun, which was the normal allowance for anti-torpedo craft guns. Unfortunately, no Lyddite shell was then available and 300 rounds of less powerful 'common pointed' shell were provided instead.[26]

Work began before the end of 1914. There were practically no buildings for the accommodation of officers and men on any of the islands, nor any suitable piers.[27] The islands' natural water supplies were also extremely limited and quite inadequate for the war-time garrisons. Even with water collected from the roofs of buildings, 2,000 gallons per day had to be taken to the islands in a small tank vessel capable of working close in under the lee of the islands, from which hoses were run up to the tanks. It was felt necessary always to have a seven-day supply in the islands' tanks in case supplies were interrupted by bad weather or enemy action.[28]

By 19 November 1914, arrangements were being made to construct a 'Challenge' Signal Station at the highest point at the west end of Inchcolm to ensure that enemy torpedo craft were not tagging along into the port with a swarm of British torpedo craft. The station was in operation before March 1915.[29]

In February 1915, the net under the south span of the Forth Bridge was damaged, probably having become entangled at low water with scrap metal discarded during the construction of the Forth Bridge. While it was being repaired, three lines of indicator nets were laid to provide some defence.[30]

In January 1915, Admiral Lowry wrote again about the need to improve the Forth's defences to tackle destroyers. He requested that four 6-inch guns be mounted in the existing 6-inch emplacements at the North and South Batteries on Inchkeith, empty since 1909. The earlier requests he had made for new batteries in 1913 and in 1914 had now all been met (two 6-inch guns at Kinghorn; two 6-inch at Hound Point; two 4.7-inch QF at Downing Point) and the new Inchkeith guns were rapidly approved; work was in hand by 1 March. [31]

On 2 April 1915, Lowry informed the Admiralty that some of the indicator netting supplied to Rosyth had been used to block permanently the channel south of Inchkeith. The accompanying *Note to Mariners* noted that the net ran from two cables south of Briggs to the 3-fathom (*c* 5.5m) line north of Big Bush shoal, 1.5 miles in length (Fig 5.4 (h)). On 14 April, the Admiral wrote again, noting the laying of permanent indicator nets from Blae Rock (on the north edge of the North Channel, south-south-west of Pettycur) to the 3-fathom line on the North Shore, a distance of *c* ½ mile (Fig 5.4 (j)).[32]

Three, or possibly four, controlled minefields were established in the river just east of the Middle Line, the control stations on Inchcolm and Inchmickery being recorded on War Office maps of the islands published in 1918 (see the entries for both batteries, below) (Fig 5.4 (l–p)).[33]

In July 1915, Lowry suggested that a minefield should be laid between Cramond Island and Inchmickery to prevent a 'rush' of hostile destroyers, which might reach this area without facing the heavy guns at Kinghorn or Inchkeith.[34] By September 1915, an alternate proposal had been approved for a physical barrier of dolphins laid across Drum Sands (along similar lines to the scheme proposed in 1911, described above). Work on this structure was well under way in November (Fig 5.4 (k)).[35]

By November 1915, the defences of the anchorages west and east of the bridge had been transformed: the rearming of Inchgarvie with four 4-inch guns was now complete; the two 6-inch guns at Hound Point, the two 4.7-inch guns at Downing Point, and the two 9.2-inch guns at Braefoot were now in place. Additionally, the Middle Line was now armed with 14 12-pdr (Naval) 18cwt guns. And Inchkeith and Kinghorn had had six 6-inch guns installed or returned to the approved armament since 1914 (Table 9).[36]

The construction of the dolphin boom across Drum Sands was already in hand by 23 November 1915 and almost complete by 10 March 1916.[37] The local defence commander and Admiral Lowry wished to ensure that it was adequately illuminated at night and proposed that five new 16° dispersed beams lights should be built on Inchcolm and one on the north-west corner of Inchmickery.[38] These seem to have been installed.

The discussion in late 1915, concerned as it was with the risk posed by a destroyer attack, prompted reconsideration of the purpose of the Middle Line, hitherto understood to be for defence solely against submarines, not destroyers. The Admiralty decided that an anti-destroyer capability might be provided either by altering the mountings of the 12-pdr (Naval) 18cwt guns to take auto-sights, or, better still, to substitute 4-inch guns.

In mid-March 1916, Lowry again pressed for the upgrading of the armament of Inchcolm to 4-inch and 6-inch guns, but not at the expense of weakening the Inner Line at Dalmeny and Carlingnose. Although he was strongly opposed to the 4-inch guns on Inchgarvie being removed to Inchcolm, the Admiralty agreed to the weakening of the Inner Line to reinforce the Middle Line. These were the last changes planned

Table 9
The peak armament of the defences of the Forth prior to the re-organisation of 1916–17, in April 1916 (WO 33/746; WO 33/755)

Name and Group	Armament	DELs
Inner		
Hound Point 'A' Group	2 x 6-inch Mk VII	2 or possibly 4
Dalmeny 'B' Group	2 x 4.7-inch QF	2 fixed beam
Inchgarvie 'F' and 'H' Groups	2 x 4-inch QF	none
Coastguard 'L' Group	2 x 12-pdr (12cwt)	2 moveable beams; 1 fixed beam (experimental)
Carlingnose 'M' Group	2 x 6-inch Mk VII	none
Downing Point 'O' Group	2 x 4.7-inch QF	1 moveable beam; 1 fixed
Middle		
Inchcolm	8 x 12-pdr (18cwt)	3
Inchmickery	4 x 12-pdr (18cwt)	2
Cramond	2 x 12-pdr (18cwt)	2
Braefoot	2 x 9.2-inch Mk X	none
Outer		
Inchkeith	3 x 9.2-inch Mk X 4 x 6-inch Mk VII	none
Kinghorn	1 x 9.2-inch Mk X 2 x 6-inch Mk VII	none

before the decision was made to upgrade the defences of the Forth to allow it to become the base of the Grand Fleet.

Outermost defences

The first anti-submarine obstruction in the outer part of the estuary was a line of indicator nets placed in April 1915 on a line between Ruddon's Point (Largo Bay) and Still Point (Inchkeith), *c* 3.2km long and starting *c* 800m off Ruddon's Point. This obstruction was removed in May 1915 (Fig 5.5 (q)).[39]

In May 1915, Admiral Lowry requested the supply of indicator nets to create:

- a line of 60ft (18.2m) indicator nets, two miles (*c* 3.2km) in length, from East Vows to 'Position Y'; (Fig 5.5 (r));
- a line of 60ft indicator nets, two miles in length, supplemented by 84ft (25.6m) nets where necessary, from Eyebroughy to 'Position X'; (Fig 5.5 (s));
- between 'X' and 'Y' four miles (6.4km) of 84ft indicator nets with their tops submerged to a depth of 40ft (12.2m) below the surface at low tide (Fig 5.5 (t)).

These nets were in place by November 1915 but it was expected that they would have a life of only ten to 12 weeks.[40]

From at least late 1915, the Army Council and the Admiralty were in consultation over a new line of defences at the mouth of the Firth of Forth consisting of four heavy guns to be sited on the Elie–Fidra line. These would prevent enemy heavy ships lying off the mouth of the Forth and bombarding naval and commercial shipping and docks, Edinburgh or the coast defence guns. After preliminary surveys suggested a cost of about £100,000, no further work was done.[41]

The armoured train

The defences of the Forth were strengthened for most of the war by an armoured train armed with two 12-pdr QF guns and two Maxim machine-guns (Fig 5.6). The train, 'Norna', or 'No. 1 Armoured Train', was the second of two built and operated in Britain. The train was first mentioned in the Annual Return of Fixed Armaments dated 21 February 1915; by 1 April 1916 it was still recorded as 'mounted' although no longer 'approved', and at that date was temporarily reinforcing the defences of the Nobel factory at Ardeer on the Ayrshire coast. We know that its complement in July 1916 was two officers and 13 other ranks. It was recorded in April 1918 as still being 'additional' to the approved armament and based at Craigentinny in Edinburgh. It was formally attached to No. 19 (Forth) Fire

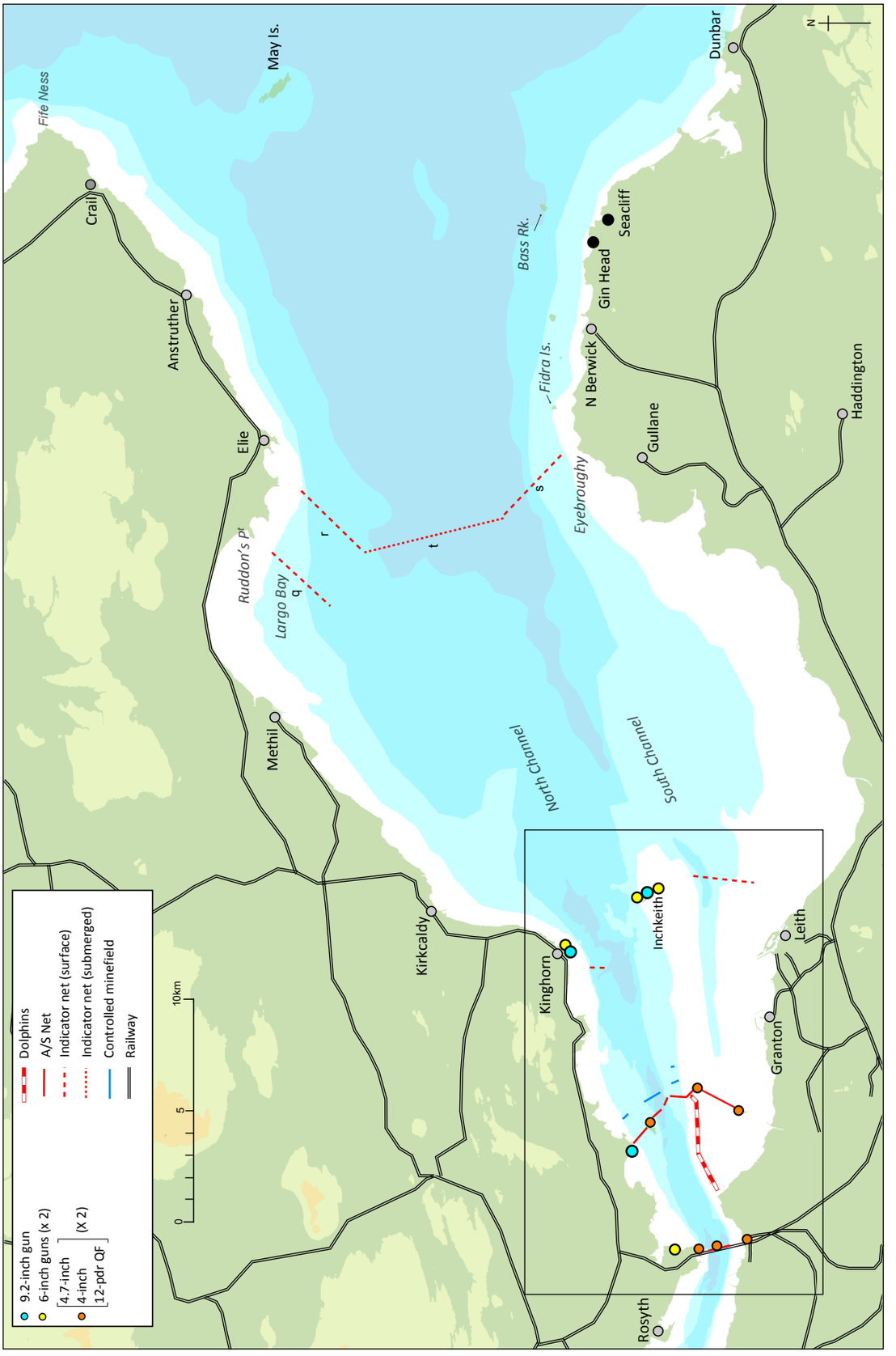

Figure 5.5
Map of the outer estuary in 1914–16 showing the location of anti-submarine nets, anti-boat booms and built obstructions. The defences of the inner estuary are shown only in general (the area covered by Figure 5.4 is marked). The short length of indicator net protecting Largo Bay was only in place in April–May 1915 (© Gordon Barclay)

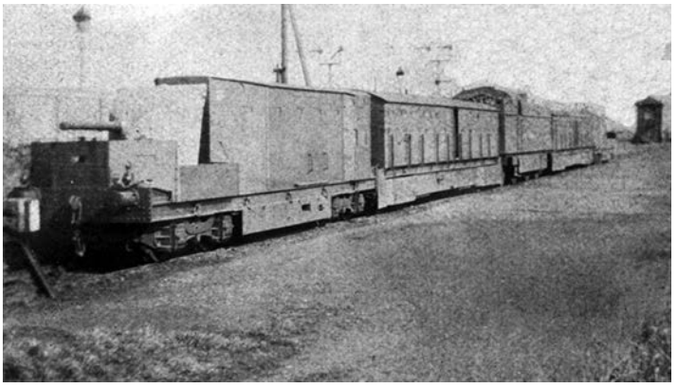

Figure 5.6
The armoured train attached to the Forth Defences, at the Craigentinny Depot (© Bruce Stenhouse Collection)

Command (that is, the Outer Defences, with its HQ on Inchkeith) and the Bruce Stenhouse collection contains copies of the formal authority for the train unit to draw 3lb of tea from the Professional & Civil Service Stores in George Street, Edinburgh in March 1918.[42] Two photographs of the train are known, showing one of the standard coast defence 12-pdr QF 12cwt guns mounted in the open portion of an eight-wheel wagon, the rest of which was steel-sided and provided with firing loops. The Maxim gun occupied a compartment at the other end of the wagon in which the 12-pdr was mounted.[43]

Submarine mining in the First World War

When, towards the end of 1914, it was realised that shipping was at severe risk from attack by submarines or raiders, the Admiralty proposed to revive the former system of controlled minefields, but this time under naval control. A new unit was raised within the Royal Marines, based on a cadre of retired former Royal Engineer Submarine Miners. Colonel F G Scott, a former submarine miner, was appointed to command the Royal Marine Submarine Miners, which came into existence on 5 February 1915. The relatively small force (in 1917, 300 men) had its HQ in Newcastle-upon-Tyne.[44]

The reputation of the unit was, unfortunately, marred by corrupt behaviour by Colonel Scott and others. Membership of the Corps conferred benefits: special rates of pay; being able to live near home; and, above all, avoiding the dangers of front-line combat; and evidence was gathered that men could pay a fee to Scott to enter the Corps. Scott, one of his captains and a RMSM private were all convicted and imprisoned.[45]

During the First World War, progress was made using hydrophones and magnetophones in conjunction with controlled minefields, the former giving the shore-based operator a better chance of blowing a set of mines when a submerged submarine was in the minefield, the latter a sound-operated minefield.[46] But it was the development of detector loops that brought controlled minefields into their own in the closing months of the First World War (see below).

The first use of hydrophones, 1915

The development of hydrophones – devices capable of detecting vessels by the noise they made passing through the water – took place largely in the Forth, at HMS *Tarlair*, near Aberdour. *Tarlair* was also the training centre for hydrophone operators.[47]

Table 10 lists the hydrophone stations established in the first phase of deployment in the Forth with their dates of operation. The hydrophones were withdrawn in May–August 1915 because Vice-Admiral Beatty believed they were giving too many false alarms.[48]

5.4 '. . . a matter of the first Naval importance':[49] defences for the Grand Fleet, 1916–18

According to Lord Jellicoe's memoirs, towards the end of 1915 or early in 1916 he discussed with Sir Henry Jackson (then First Sea Lord) the disadvantages of basing the Grand Fleet so far north as Scapa Flow. Both men felt that with the fleet at the northern base, the difficulties in intercepting the German High Seas Fleet during coast raids and of dealing with landing raids covered by the High Seas Fleet were so considerable as to make it desirable to base the whole fleet further south. A discussion of the defences necessary to secure the Forth Estuary took place at Rosyth on 5 April 1916 (see below), and Jellicoe recorded that he suggested a scheme of submarine obstructions across the Firth of Forth that would allow berthing the whole Grand

Table 10
The first phase of hydrophones installed in the Forth (after Hackmann 1984)

Station	Established	No. of Instruments	No. of Operators	Closed
Oxcars	March 1915	4	4	May 1915
Inchcolm	May 1915	5	4	August 1915
Elieness	May 1915	5	4	August 1915

Fleet in that anchorage and allow gunnery and torpedo practice to be carried out with a considerable degree of safety in the Forth. Despite the concerns of some senior officers, Jellicoe decided that the strategic advantage outweighed the objections, and the scheme was proceeded with.

The Germans were aware that the dockyard was nearing completion and tried to damage it. Three Zeppelins set off to raid Rosyth on the night of 5/6 March 1916, but were diverted by high winds; on the night of 2/3 April four airships set off to bomb the dockyard and the bridge. Two reached the Forth: L14 failed to find the intended targets and bombed Edinburgh and Leith; L22, having bombed empty fields near Berwick-upon-Tweed, dropped its few remaining bombs on Edinburgh.[50]

The 5 April 1916 conference was attended by representatives of the Admiralty, GHQ Home Forces, Commander-in-Chief Rosyth and GOC Scottish Coast Defences, who discussed the strengthening of defences to allow ships to anchor below (east of) the bridge. It was decided that heavier guns from the Inner Line would be moved eastwards to strengthen the Middle Line, with lighter guns from the Middle Line being moved west: two 6-inch guns would be moved from Carlingnose to a new battery at Pettycur; four 4.7-inch QF (two each) from Dalmeny and Downing Point to Inchcolm; four 4-inch QF Mk III from Inchgarvie to Inchmickery, these four being replaced by two 12-pdrs from Inchcolm and two from Inchmickery.[51]

Lowry also suggested that extra guns were needed: two 4-inch QF to replace the remaining two 12-pdr QF on Inchcolm (this was not done); two 6-inch on the north end of Inchkeith – a site for one 6-inch already existed, and there was room near it for a second. There were also changes in the DELs: lights were moved from Carlingnose and Dalmeny to the Inchcolm line, and two more were added. There was also to be a new 48-inch searchlight at the south end of Inchkeith to cover the observation minefield.

As noted above, the plans to strengthen the boom and net defences of the estuary, in particular to reduce the vulnerability of ports to a 'rush' by a pack of fast destroyers, had been developed in 1915. These plans were now given added impetus to prepare for the Grand Fleet. The conference now decided that an anti-destroyer boom should be placed in every channel, except where piling would provide both an A/B and A/S obstruction.

At the end of April 1916 and again in May, the Admiralty stressed the extreme urgency of making the improvements to the defences: 'The early completion of the Defences is a matter of the first Naval importance, as upon it depends the redistribution of the Fleet in Northern waters'. But by late June 1916 the Admiralty was expressing concern that, 'Military Authorities unable to give any approximate date for completion of work on new defences'.[52]

Concerns about delays continued to grow in July and August, prompting explanations from the War Office of the considerable difficulties faced: the want of workmen and transport; the absence of piers to land 30–40 tons of materials safely every day; and the dependence on good weather. It was even difficult at this stage of the war to source adequate lengths of suitable timber in the UK for the dolphins. Despite drafting in additional works companies, it appeared that all the military labour available would be absorbed at Inchcolm and Inchmickery. The War Office felt that the best way the Admiralty could assist was to take over entirely the work on Inchmickery from the Army. The Admiralty agreed on 29 July.[53]

In mid-September 1916, Admiral Lowry reported to the Admiral Commanding-in-Chief, Grand Fleet, that the Admiralty works department would complete all the work on Inchmickery in January 1917 (if 5,000 tons of materials could be safely landed over the autumn and winter). The War Office estimated, in November, that all work would be completed by the end of the year, except the gun on the West Stell of Inchkeith, which would not be finished until early January.[54] Work did not progress as quickly as hoped, and it was only at the end of May 1917 that the Outer Line of defence was approaching readiness: all the new 6-inch guns (two at Leith, two on Inchkeith, and two at Pettycur) were mounted, even if not formally 'in action'. On the Middle Line, the new 6-inch and 4-inch guns on Inchcolm were 'practically in action', six of the seven DEL emplacements were near complete or well under way, and two of the four 4.7-inch guns would be ready to fire by late June; on Inchmickery, the four 4.7-inch guns were in action, with temporary lights. The Inner Defences (Inchgarvie and Coastguard) were ready.[55]

The new Commander-in-Chief Rosyth, Admiral Hamilton, in January 1917 proposed amendments to the scheme of obstructions then under construction, including the omission of the anti-destroyer boom between Inchcolm and Inchmickery, because the risk of an attack by destroyers or other surface craft was now considered negligible. The abandonment of the duplicate destroyer boom was approved by the Admiralty in February.[56] By mid-July 1917, an A/T net had been affixed to the Mickery Pile Boom. In the same month, a new concern began to occupy those responsible for the defence of the Forth – the threat of 'skimmers', coastal motor boats. The booms in the Forth did not have hawsers at the surface that could obstruct such shallow-draft boats, and it was considered that the existing jackstays would have to be raised. The part of the scheme of obstructions that would protect the fleet while exercising was completed by December 1916, and the whole scheme of new obstructions was in place by July 1917. Jellicoe, in his memoirs, suggests that this was a year later than planned, but this is an unjustified criticism, as the scheme of obstructions had only been put in train in May 1916.[57]

The formal completion of the revision of the defences of the Forth was marked by an exchange of letters between the Admiralty and the War Office in November 1917.[58] Table 11

shows the changes in gun strength and location between 1915 and 1917. The Battle Fleet, as it was by then known, finally sailed into its new base on 12 April 1918. The fleet that sailed out from the Forth on 24 April comprised 193 ships. The Grand Fleet assembled in the Forth on 11 November 1918 comprised 246 ships: [59] the Battle Fleet of 30 battleships, three armoured cruisers, 15 light cruisers, and six aircraft carriers; the Battle Cruiser Squadron, of 11 battle cruisers, 19 light cruisers; Destroyer Command comprising two light cruisers and 160 destroyers, divided into seven flotillas.

All these ships could be accommodated behind the defences of the Forth.

Figure 5.7 and Figure 5.13 summarise the location of A/S, A/B and indicator nets in 1916–18 and show the moorings protected by them. We have not found any chart that shows the locations of controlled minefields.

The final arrangement of obstructions was strong and comprehensive. We describe them using the contemporary terminology and with reference to Figure 5.7.

Inner defences

Figure 5.7 (a) and (b) the '*Bridge Boom*': below the two spans of the Forth Bridge were heavy A/S nets, both of which (from 1916) could be lowered to allow ships to pass through.

Middle defences

Figure 5.7 (c) – (g) The '*Islands Boom*': comprising five elements.

(c) the '*Mickery Pile*' or '*Drum Sands*' boom which ran west–east across the Drum Flats from Hound Point to Inchmickery (Fig 5.8). Formed of a line of dolphins set 60ft

Table 11
The armament of the Inner and Middle Defences of the Forth before and after the re-organisation of 1916–17 (WO 192/100; WO 192/108; WO 33/746; WO 33/755; WO 33/828)

Battery	1915	1917
Inner		
Hound Point	2 x 6-inch Mk VII	2 x 12-pdr (Naval) 18cwt
Inchgarvie	2 x 4-inch Mk III QF	2 x 12-pdr (Naval) 18cwt
Inchgarvie 'B'	2 x 4-inch Mk III QF	2 x 12-pdr (Naval) 18cwt
Coastguard	2 x 12-pdr (12cwt)	2 x 12-pdr (12cwt)
Downing Pt	2 x 4.7-inch QF	2 x 12-pdr (Naval) 18cwt
Carlingnose	2 x 6-inch Mk VII	Disarmed
Dalmeny	2 x 4.7-inch QF	Disarmed
Middle		
Cramond Island	2 x 12-pdr (Naval) 18cwt QF	2 x 12-pdr (Naval) 18cwt QF
Inchmickery	4 x 12-pdr (Naval) 18cwt QF	4 x 4-inch QF Mk III
Inchcolm	8 x 12-pdr (Naval) 18cwt QF	2 x 6-inch Mk VII
		4 x 4.7-inch QF
		4 x 4-inch QF Mk V
		2 x 12-pdr (Naval) 18cwt QF
Braefoot	2 x 9.2-inch Mk X	Removed
Outer		
Inchkeith	3 x 9.2-inch Mk X	3 x 9.2-inch Mk X
	4 x 6-inch Mk VII	6 x 6-inch Mk VII
Kinghorn	1 x 9.2-inch Mk X	1 x 9.2-inch Mk X
	2 x 6-inch Mk VII	2 x 6-inch Mk VII
Pettycur	–	2 x 6-inch Mk VII
Leith	–	2 x 6-inch Mk VII

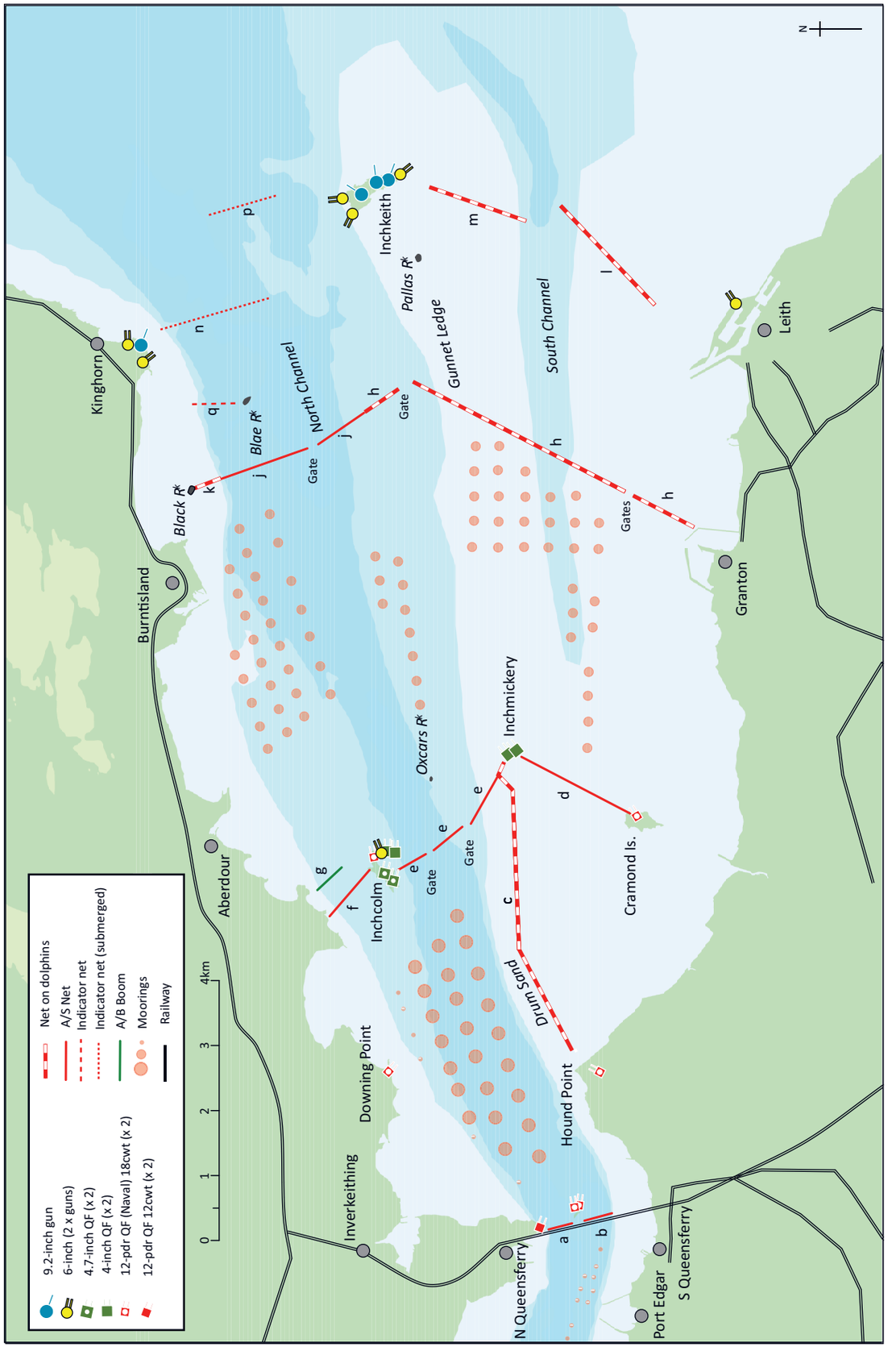

Figure 5.7

Map of the inner estuary in 1917, showing the location of anti-submarine nets, anti-boat booms, and built obstructions. The additional moorings for warships (between the Forth Bridge and the Middle Line) and the Fleet Auxiliaries (between the Middle Line and the Black Rock – Granton boom) recorded on the 1919 Admiralty chart are also shown. There had been a further 48 warship moorings above the Bridge in 1913, and over 90 by 1918 (© Gordon Barclay)

(18.3m) apart linked by steel hawsers and supporting 'T' type A/T net, providing both A/T and A/B defence.

(d)–(f) the '*Oxcars Boom*', in three segments from Cramond Island, (d) a floating A/S boom/net; (e) a floating A/S boom/net, to the south side of Inchcolm, with two gates through the nets, for the channels north and south of Oxcars; (f) a floating A/S boom/net from Inchcolm to Braefoot Point. (g) In advance of (f) there was a length of A/B boom, anchored at the north at Vault Point, where the northernmost section of the boom was formed of concrete blocks and steel girders.

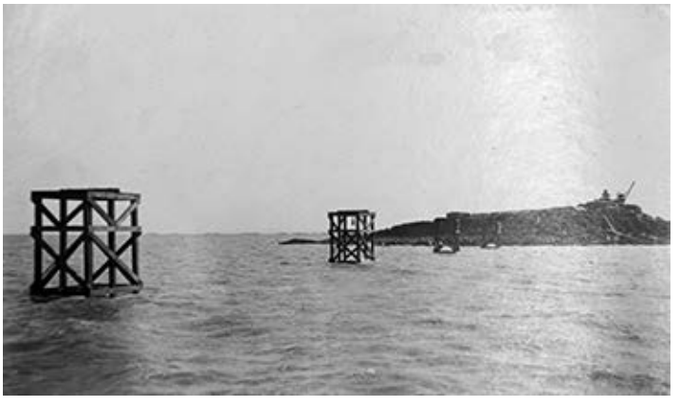

Figure 5.8
The easternmost section of the Drum Flats – Hound Point dolphin boom – where it turned south towards Inchmickery, which is in the background. The island is clearly in the throes of its major rebuilding of 1916–17 (Reproduced by permission of MOD Naval Historical Branch)

Outer Defences

Figure 5.7 (h) – (k) The '*Black Rock Boom*', which ran from the north-east corner of Granton Harbour to the Black Rock on Burntisland Sands. The southern section, 6.7km long (Fig 5.7 (h)), was a barrier of dolphins set on the bottom of the river, linked by 5-inch hawsers and supporting A/S nets, with two gates immediately beside each other, on both sides of a Gate ship (Fig 5.9). A second '500ft [*c* 152m] gate' was located near the northern end of the dolphins. The next section, some 2.5km long, ran from the northern end of the dolphin line, and was formed by a floating net supported by a line of 12 moored trawlers (Fig 5.7 (j); Fig 5.10) There was a '500ft [*c* 152m] gate' where the net crossed the North Channel. The northernmost part of the barrier, across Burntisland Sands to the Black Rock, was formed by dolphins (Fig 5.7 (k); Fig 5.11).

Figure 5.7 (l) and (m) The '*Inchkeith Pile Boom*' was in two parts (Fig 5.12), both comprising a line of dolphins linked by steel hawsers and supporting A/S nets, forming a continuous boundary between Big Bush rocks at Leith and Inchkeith, a gap of *c* 570m between them, at the South Channel (the main approach to Leith Docks).

Figure 5.7 (n) – (q) Up to three lines of indicator nets (surface and submerged) restricted the width of the North Channel north of Inchkeith.[60]

The strengthening of the Outer Line of defences between Granton and Black Rock provided moorings for Fleet

Figure 5.9
The Gate Ship at Granton, painted by Charles Pears in 1918. The scarlet-painted ship that operated the gate is passed by a sailing ship entering the river. The anti-submarine boom, supported on 'dolphins' set into the bottom of the river, is clearly visible (Imperial War Museum. Art 1358)

Figure 5.10
A portion of one of the Forth A/S nets held in place by a line of trawlers (Reproduced by permission of MOD Naval Historical Branch)

Auxiliaries between the Outer and Middle Lines. Figure 5.7 shows the moorings recorded on the 1919 Admiralty chart (29 moorings in four lines, south-west of Burntisland; ten moorings in two lines along the Oxcars Bank, east of Oxcars Rock; 31 moorings in six lines north and north-west of Granton).[61]

The outermost defences

Immediately after the April 1916 meeting about the strengthening of the defences, it was proposed that an anti-submarine net should be established in two sections between Elie Ness and Fidra (Fig 5.13 (v and x)), with a two-mile-wide (*c* 3.2km) gap (the 'Fidra Gap') in which an indicator net would be run, its top 40ft (12.2m) below the surface (Fig 5.13 (w)). This barrier was described as running approximately parallel to, and one mile to the east of, the existing lines of indicator nets (Fig 5.13 (s, t and u)). The position was considered too exposed for gate-vessels, moored stem and stern, to be used. The line of the boom was established at a conference at Rosyth on 12 May 1916, chaired by the First Sea Lord. Its purpose was to 'enable vessels of the Home Fleets to carry out gunnery practices, etc in the Firth of Forth'. Material for the boom was identified in nets, buoys and other material recovered from the Dover Straits Boom, which was being replaced by a minefield. The barrier was to be 'as nearly as possible on the Dover Strait lines'; the Dover Boom was described in a US Navy history of boom and net defences as consisting of 'heavy baulks … to be connected by heavy jackstays and support anti-submarine nets',[62] and later as 'a heavy boom of considerable strength, with large square iron bound floats of Oregon pine attached to each other by an upper and a lower jackstay' (Fig 5.13 (v and x)).[63]

Figure 5.11
The northernmost section of the Black Rock Boom, showing the final 'bracing' of the hawser, with Black Rock in the background. Dated 30 May 1917 (Reproduced by permission of MOD Naval Historical Branch)

Figure 5.12
The northern section of the Inchkeith Pile Boom, under construction, with Inchkeith in the background. Dated 20 June 1917 (Reproduced by permission of MOD Naval Historical Branch)

When the fleet was exercising, a two-mile length of surface indicator nets was to be drawn across the Fidra Gap; together with the permanently installed deep water indicator net, this would close the Firth to submarines.[64] Personnel were to be diverted from the Folkestone and Boulogne boom depots, which were being closed.

The North Sea was the site of offensive and defensive mining by both sides on a large scale. The 1919 Admiralty chart of the east coast from St Abb's Head to Aberdeen marks areas as 'Prohibited (Sunken Mines)'. The largest of these occupies a slightly dog-legged area measuring 11.5km by 4.5km running a little east of north from the East Lothian coast towards the May Island (Fig 5.13). We believe that this marks the site of a First World War minefield, the effect of which would be to restrict the width of the navigable channel (over 20 fathoms; that is, *c* 36.6m) south of the island. The channel to the north, between Crail and the May Island, is nowhere more than 20 fathoms.

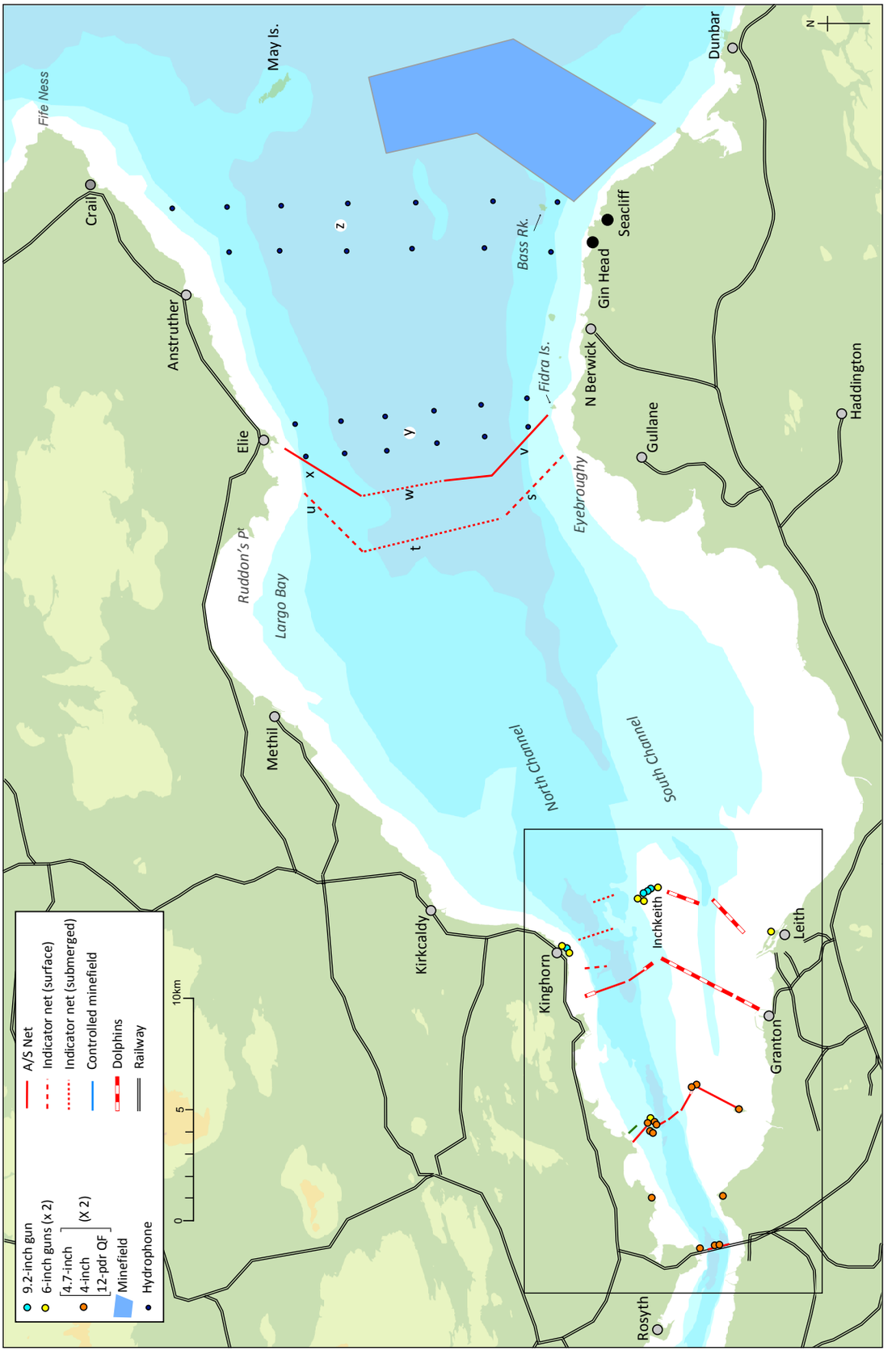

Figure 5.13
Map of the outer estuary in 1916–18 showing the location of anti-submarine nets, anti-boat booms and built obstructions. The positions of hydrophones is approximate, based on a written description of their location. The extent of Figure 5.7 is indicated (© Gordon Barclay)

The Fidra Boom was refurbished between November 1917 and March 1918 and proposals were revived in November 1917 for the provision of heavy gun defences for the Elie–Fidra line; 9.2-inch guns could not, however, be ready for a year or more. The need for these heavy guns was restated in July 1918 by the Commander-in-Chief, Scottish Command, supported by the naval Commander-in-Chief Rosyth, 'As the FIRTH OF FORTH has become probably the most important Naval base in the United Kingdom … I consider it absolutely vital that this additional protection be given to the Fleet and Dockyards and am of opinion that nothing less than this will suffice'. The Armistice in November 1918 saw the sudden end of discussion of the proposals.[65]

Hydrophones, 1916–18

In 1916, Vice-Admiral Beatty suggested that hydrophones should be reinstalled in the Forth, given the level of submarine activity detected off the estuary in June. Although they had originally been withdrawn in 1915 at Beattie's request because of the level of false alarms, the technology had improved.[66] Hydrophones could detect a vessel at ranges of up to three miles (4.8km) in good weather. The new hydrophones were positioned in two arrays just west of the May Island, between Crail and Seacliff, and between Elie Ness and Fidra, in November 1916 (Fig 5.13 (y and z)).

Hackmann records that the outermost hydrophones were arranged between Crail and Seacliff, where the control stations were established (seven operated from Crail, six from Seacliff).[67] Our best approximation of the location of the hydrophones is shown on Figure 5.13.

The other array of hydrophones was laid between Elie Ness and Fidra in conjunction with the A/S boom on the same line, with listening stations at Elie Ness and at Fidra. Three huts were to be provided at each station for two officers and six Chief Petty Officer operators.[68] The location of the lines was described as follows, on 18 July 1916:

> From the stations at Elieness and Fidra, a double line of Hydrophones each consisting of six instruments should be laid … 3 of the instruments on each line being connected to Elieness and Fidra stations respectively. The two lines should be about 4,000 yards (*c* 3,660m) apart and the Hydrophones in each line about 2,330 yards (*c* 2,130m) from each other …

Both stations were manned by a Lieutenant RNVR, a Sub-Lieutenant and six Chief Petty Officer operators, to allow a continuous watch. The stations were linked to each other by a submarine telephone line so that the operators could compare the sounds picked up by their instruments and so determine the course and direction of a submarine moving in mid-channel. Both stations had telephone links to the Extended Defence Officer at Inchkeith, who was responsible for the anti-submarine defences in the Forth.

A further set of three hydrophones was proposed in the spring of 1916, to lie south of Inchkeith, to 'act as a sentry to the Pile Boom and Net Obstruction which will block the gap across the "Narrow Deep"' and to act as sentry to a controlled minefield proposed to north and south of Blae Rock'. In the end, it was decided in September 1916 that these hydrophones were not needed.[69]

Detector loops

The physics of the detector loop (the induction of a current in a cable as a magnetised vessel moved over it), was first applied experimentally in the Firth of Forth by the Scottish physicist Alexander Crichton Mitchell at HMS *Tarlair* in 1915. Unfortunately, his report on the potential of the technology to detect submarines was misunderstood at the Board of Investigation and Research (BIR). William Bragg of BIR suggested the re-examination of the report in 1917, and a successful detector loop was developed at the research establishment at Harwich by mid-1918. Its first operational use was at Scapa Flow, when, in combination with controlled mines, it led to the sinking of the German submarine U-116 in October.[70]

5.5 Anti-aircraft defence

In February 1915, the anti-aircraft gun defence of the Forth (at least that element of it under Army control) comprised

Table 12
Hydrophones operating in the second phase of deployment, 1916–18 (after Hackmann 1984)

Station	Established	No. of Instruments	No. of Operators	Closed
Inchkeith	November 1916	5	6	December 1918
Elieness	December 1916	6	6	December 1918
Fidra	February 1917	6	6	December 1918
Crail	May 1917	7	6	December 1918
Seacliff	August 1917	6	6	December 1918

Table 13
Anti-aircraft defences of the Forth, mainly for the defence of naval installations and the anchorage, and for Edinburgh, at two dates in the First World War (ADM 137/1170; WO 33/828)

Site	May 1916	June 1917
Crombie	3-inch	18-pdr QF
Culross	–	18-pdr QF
Hillock Point	3-inch	3-inch (20cwt)
Rosyth	3-inch	–
East Camps (near Dunfermline)	–	18-pdr QF
Mastertown (near Rosyth)	–	3-inch (20cwt)
South Fod (near Rosyth)	–	18-pdr QF
Inverkeithing	3-inch	–
Inchmickery	3-inch	–
Inchcolm	–	3-inch (20cwt)
Inchkeith	3-inch	3-inch (20cwt)
Leith	–	3-inch (20cwt)
Arthur's Seat (east Edinburgh)	3-inch (site uncertain)	3-inch (20cwt)
Corstorphine (south-west Edinburgh)	3-inch	18-pdr QF
Borrowstown (Bo'ness)	–	18-pdr QF
Easter Dalmeny (south-east of Forth Bridge)	–	18-pdr QF
Mannerston	–	3-inch (20cwt)
Echline (south of Port Edgar)	–	3-inch (20cwt)
Ferry Hill (North Queensferry)	–	3-inch (20cwt)
Polmont (south of Grangemouth)	–	18-pdr QF
Grangemouth	–	18-pdr QF
East Fortune Aerodrome – Sherriff Hall	–	3-inch (20cwt)
East Fortune Aerodrome – East Linton	–	3-inch (20cwt)

two 6-pdr QF guns at Rosyth (one for the dockyard and one at the oil tanks) and two 1-pdr pom-pom guns on travelling carriages at the Armaments Depot at Crombie. A map of 1915 shows the Crombie guns on the raised beach north of, and higher than, the ammunition sheds.[71]

In the spring of 1916, the AA defence for the Rosyth dockyard comprised four 6-pdr guns manned by naval ratings. Revised arrangements under Army control provided, by May 1916, eight AA sites armed with 3-inch guns (Table 13). All of the AA sites were at least 20 miles from the mouth of the estuary, and Admiral Lowry suggested that the redundant 6-pdr guns could be deployed with naval ratings at St Abb's Head, Fife Ness and on the May Island and on the Bass Rock or at Seacliff. Zeppelins had made landfall near these places to fix their position before carrying out raids over the east of Scotland. The request was turned down.[72] By 1 June 1917, the number of AA guns in the Forth had increased to 20 (Table 13).

Notes

1 WO 33/515.
2 *Fife Free Press*, 8 August 1914.
3 ADM 137/992.
4 Hough 2000: 130.
5 Andrew Kerr, pers comm.
6 ADM 137/992.
7 WO 33/697.
8 Dobinson 2000: 45.
9 Eighty-six civilians were killed and 424 wounded in Hartlepool, along with seven soldiers killed and 14 injured.

10 Massie 2004: 321–31.
11 Girvin and Cosens 1919: 57.
12 *Fife Free Press*, 30 April 1921.
13 In the early years of mines and torpedoes, until the 1870s, all forms of explosive apparatus for use in the water could be termed 'torpedoes', and the two terms could be used interchangeably.
14 Office of Naval Intelligence, Navy Department 1917.
15 Bureau of Ordnance 1944.
16 ADM 186/377; ADM 137/1045.
17 Girvin and Cosens 1919: 61.
18 Office of Naval Intelligence, Navy Department 1917.
19 Girvin and Cosens 1919: 59, 61.
20 ADM 137/994.
21 ADM 137/1170.
22 ADM 137/994.
23 ADM 137/994.
24 ADM 137/994.
25 ADM 137/994.
26 ADM 137/994.
27 ADM 137/994.
28 ADM 137/994.
29 ADM 137/994; ADM 137/1075.
30 ADM 137/1075.
31 ADM 137/1075.
32 ADM 137/1075.
33 ADM 137/1075.
34 ADM 137/1170.
35 ADM 137/1170.
36 ADM 137/1170.
37 ADM 137/1264.
38 ADM 137/1170.
39 ADM 137/1075.
40 ADM 137/1045.
41 ADM 137/1892.
42 WO 33/873.
43 WO 33/766; WO 33/755: 814; Osborne 2017: 90–1.
44 ADM 137/1075.
45 ADM 178/26,
46 Magnetophone-controlled mines were laid at Cromarty and Scapa Flow; Friedman 2014: 342.
47 Maxwell 2014: 6. 1,090 officers and 2,731 naval ratings were trained at Tarlair.
48 ADM 137/1217.
49 ADM 137/1170.
50 Robinson 1971: 137; Cole and Cheesman 1984: 122–3.
51 WO 192/101; WO 192/108.
52 ADM 137/1170.
53 ADM 137/1217; ADM 137/1892.
54 ADM 137/1170.
55 ADM 137/1892.
56 ADM 137/1280.
57 Jellicoe 1918: 78.
58 ADM 137/1372.
59 Andrew Kerr, pers comm.
60 ADM 137/1217.
61 Hydrographic Office 1919 *Admiralty Chart 114b, Firth of Forth – Fisherrow to Port Edgar 1919*; ADM 137/1217.
62 Bureau of Ordnance 1944: 6–7.
63 ADM 137/1170; ADM 137/1372.
64 Morris et al 2007: 36.
65 ADM 137/1372.
66 ADM 137/1217.
67 Hackmann 1984: 65, table 3.2
68 ADM 137/1217.
69 ADM 137/1217.
70 Walding 2009: 140–5.
71 WO 33/706; WO 78/4396.
72 ADM 137/1170.