The Revitalisation of Japan's Submarine Industry: From Defeat to *Oyashio*

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Abstract

On 15 June 1959 the *Oyashio* surfaced to the applause of the crew and engineers onboard: Japan completed the trials of its first post-war indigenously developed submarine. There is little English literature that explains how Japan successfully constructed the *Oyashio*. United States support has been highlighted, but what about Japan's indigenous efforts? In addition, with *Oyashio* Japan created a World War II era fleet-type submarine, but the tear-drop hull submarine had already been developed. Why was this approach adopted and what significance did *Oyashio* represent? This paper demonstrates that *Oyashio* was primarily an indigenous Japanese effort. Japan successfully built the *Oyashio* because the Imperial Navy's technological legacy continued in the form of infrastructure, personnel and know-how: there was a strong degree of continuation in Japan's pre- and post-war submarine programs. The limited capability of the *Oyashio*, including its non-tear drop hull design, is explained by Japan adopting a conservative long-term approach to submarine development, prioritising the indigenisation of capability at the short-term cost of a less capable product. This approach is consistent with what has been described in broader literature as Japan's 'technonationalist' approach to technology. This paper concludes that *Oyashio* represented an important technological and political milestone. Despite being a fleet-type submarine, the *Oyashio* was a technological achievement as new and old indigenous and foreign technologies were assimilated and applied lifting the capability of Japan's submarine industry beyond pre-war levels. In addition, the development of *Oyashio* did not take place within a political vacuum, but in post-war Japan where Article IX of Japan's Constitution did not unequivocally settle the position of the Japanese Self Defense Forces (JSDF). *Oyashio* was therefore also a political milestone as an indigenous submarine capability was reestablished during a time when the existence of the JSDF was being questioned.

Kokusanka, Ship Building and Submarines

Technonationalism and 'Normative' Politics

A driving aspect of *Oyashio*'s development was the desire for the indigenisation of an important capability. This is consistent with the view that the general ideological underpinning of Japan's approach to national security and technology is closely linked with its sense of vulnerability:[1] that is, Japan's 'technology and security thinking posts Japan in a hostile, Hobbesian world in which

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Disclaimer: The views expressed in this paper are the author's, and do not represent the views of the Australian Government, the Department of Defence, or the Australian Defence Force.

[1] Richard J. Samuels, *Rich Nation, Strong Army: National Security and the Technological Transformation of Japan*, New York, Cornell University Press, 1996, pp. ix-x, 42-44.

interdependence inevitably leads to dependence, and dependence eventually results in domination.'[2] This approach has its historical basis towards the end of the Tokugawa-era when the arrival of Commodore Perry's black ships, signing of unequal treaties and foreign intervention in China, led to fears that Japan may be a victim of foreign domination. To avoid dependence and domination Japan would rally under the slogans of 'rich nation strong army' (*fukoku kyōhei*), and production promotion or industrial development (*shokusan kōgyō*). In essence, these slogans capture the philosophical basis of 'kokusanka' (indigenisation) – or put plainly security through being able to create. Samuels and Green both refer to this as 'technonationalism', where 'technology is an asset of national security'.[3] It will be shown that this focus on indigenisation would see Japan prioritise the fostering of a long-term indigenous capability even at the expense of a less capable submarine.

The development of a large military project like a submarine does not take place within a political vacuum, and Japan's post-war domestic political context represents the second broad factor shaping *Oyashio*. Katzenstein's notion of Japan's 'normative context' is a useful guide here. This normative (or 'cultural') context manifests itself in the form of post-war uncertainty and sensitivity towards the role and existence of the Japan Self Defense Forces (JSDF). With Article IX of Japan's constitution failing to unequivocally settle the role and position of the JSDF post-war, Governments were compelled to carefully justify the requirement for and define the role of certain capabilities, including submarines. Some capabilities would even be determined as impermissible, such as long range strategic bombers or intercontinental ballistic missiles. The two notions therefore of technonationalism and normative politics can and do coexist but pull in opposite directions creating policy tension. Katzenstein too recognises this phenomenon in Japan, where in his words 'uncontested norms of economic security favour policy flexibility', as opposed to 'deeply contested norms of military security' which 'encourage policy rigidity.'[4] It will be shown that submarine development in the form of the *Oyashio* represented a practical manifestation of this tension.

Ship Building

Japan's ship building industry is an example of kokusanka, where 'every effort was made to stimulate indigenisation, even if the immediate result was inferior products.'[5] Governments sought to foster ship building since the opening of Japan's self-imposed isolation of the Tokugawa-era and policy manifested itself in the form of both restrictions and incentives. Dockyards built by the bakufu were 'transferred to private hands for fractions of the initial investment.'[6] Regulation was used to ban the creation of obsolete vessels (e.g. wooden) and to encourage the development of iron and later steel ships. Significant subsidy payments were made to foster the industry: some 75 percent of all subsidies between 1897 and 1913, rising to above 90% before World War I.[7] Throughout this

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2 Ibid., p. 43.

3 Michael Green, *Arming Japan: Defense Production, Alliance Politics, and the Search for Postwar Autonomy*, New York, Columbia University Press, 1995, p. 11.

4 Peter J. Katzenstein, *Cultural Norms and National Security: Police and Military in Postwar Japan*, New York, Cornell University Press, 1996, pp. 112-121.

5 Samuels, *Rich Nation, Strong Army*, p. 44.

6 Tuvia Blumenthal, 'The Japanese Ship Building Industry', Hugh Patrick, ed., *Japanese Industrialization and Its Social Consequences*, Berkeley, University of California Press, 1976, p. 134. Also in Samuels, *Rich Nation, Strong Army*, p. 84.

7 Ibid., p. 136.

process foreign technical assistance was sought – but the objective was to gradually develop self-reliance. Japan gained access to Dutch machinery and manuals (1849), Russia ship designs and technical help (1853), Dutch instructors for its Naval Training School (1855) and French supervisors for its ironworks (1863).[8] The culmination of these efforts was the construction of the Chiyodagata in 1866, Japan's first domestically built naval steamship without foreign assistance.[9]

Spurned by the 1895 Sino-Japanese, Russo-Japanese wars and World War I, Japan would increasingly develop its indigenous ship building capability. By 1915, 80.8% of Imperial Japanese Navy (IJN) warships were produced domestically, and 60.1% of all steamships, up from 34.9% and 26.4% respectively between 1874-1884.[10] Through this approach the ship building industry, then chief customer of which was the IJN gradually climbed the technological ladder drawing on foreign expertise and assistance. Blumenthal observes that Japan was able to draw on the advantages of adopting 'the most advanced techniques, rather than going through all the steps taken by forerunners'.[11] While this author does not dispute this categorisation, as shall be seen below the challenges Japan faced in developing an indigenous submarine capability should not be understated. Submarines were more experimental for all countries even in the early 1900s and brought significant risks: Japan would learn along with everyone else and this would come at a cost.

Submarines

As with ships, Japan was relative late comer to the adoption of submarines, purchasing five Holland-class submarines from the U.S. Electric Boat company in 1904 with the intention to put them to use during the Russo-Japanese war.[12] The boats in the form of knock-down kits were brought to the Yokosuka Naval yard and constructed under the guidance of American expertise.[13] The petrol engine boats were problematic for Japan, and when Kawasaki constructed two further boats based on the Holland-class design one would sink (No. 6.) along with the captain and fourteen crew.[14] In 1907 Japan would turn to the United Kingdom (U.K.), which it was then in an alliance with, and gained access to the C-type petrol engine submarine mainly used for coastal defence. Three C-class submarines were constructed for Japan in the U.K. and two at the Kure Naval yard. Japan would then engage France and acquire Schneider-Laubeuf designed submarine, giving Japan access to a diesel powered double hull submarine for the first time. In 1915 Japan purchased from Italy the Fiat-Laurenti or F-type diesel submarine. The IJN experienced many difficulties with the Fiat diesel engine which was 'good in design', but many operational accidents led to the crew operating the submarine conservatively.[15] Production of the F-type stopped after five and the IJN switched to the

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8 Ibid., pp. 132-134.

9 Ibid., p. 134.

10 Ibid., p. 137.

11 Ibid., p. 152.

12 At the time France possessed 32 submarines, England 9 and the U.S. 7. See The Society of Naval Architects of Japan ed., *Showa Zōsenshi*, Vol. 1: *Senzen- Senji-hen* [The History of Showa-period Japanese Ship Building, Vol. 1: Pre-war and War-time], Tokyo, Keibundō, 1981, p. 439 (hereinafter, cited as *Showa Zōsenshi*, Vol. 1).

13 Shizuo Fukui, *Nihon Sensuikan Monogatari* [The Story of Japan's Submarines], Tokyo, Kōjinsha, 2009, p. 70.

14 Submarine No. 6 was captained by Lieutenant Tsutomu Sakuma and is seen as a model of dedication to one's duty. Sakuma wrote a detailed account of the accident in a journal which was recovered and the crew were found manning their respective stations to the end.

15 Motomi Hori, *Sensuikan: Sono Kaiko to Tenbō* [Submarines: Thoughts and Recollections], Tokyo, Harashobō, 1987, p. 87.

improved Vickers L-class, which ran on superior diesel engines and was of greater tonnage.[16]

By now Japan had gradually gained experience with larger submarines, moving from the 100 tons (Holland), 300 tons (Vickers C-class), 500 tons (Schneider-Laubeuf), 750 tons (Fiat-Laurenti) and 900 tons (Vickers L-class). Japan also moved from petrol to diesel engines, and gained access to single and double hull submarine designs. The emphasis, as with ship building, was on adopting foreign technology and then seeking to create a 'superior domestic product'[17]. This was a difficult learning process and the incremental accrual of technology came with significant cost as Table I shows.

Table I: Non-Combat Imperial Navy Submarine Incidents (Meiji-Showa period)

Incident Type	Occurrences
Sinking	12
Subsurface collision	44
Surface collision	75
Fire/explosion/gas release	43
Hull armament damage	32
Serious Incidents	22
Other	23

Source: First Submarine Division Headquarters, *Meiji-Showa Nihon Kaigun Sensuikan Jiko Tekiroku: Daiichi Sensuitai Shireibu* [Meiji-Showa Accident History of Imperial Navy Submarines], National Institute for Defense Studies Military Archives, August 1966. Compiled by author.

Japan's international submarine cooperation focus would begin to shift away from the above countries at the conclusion of World War I and be directed increasingly towards Germany. Japan received seven submarines from the Germany as war reparations, which were 'thoroughly and totally examined'.[18] The Japanese concluded that Germany had made significant advances in submarine technology. The Treaty of Versailles restrictions on Germany, and the end of the Anglo-Japanese alliance for Japan, led to a 'conducive…political environment for cooperation between the Japanese and German navies in the area of military technology'.[19] Japan sent the president of Kawasaki Ship Building to Europe for negotiations and began constructing submarines with German assistance. Over an approximately three year period some 800 scientists, employees, commanders and officers would conduct exchanges across various submarine related areas.[20] Of these exchanges in 1924 Japan invited Hans Techel, the 'father' of German submarine technology to Japan, who directly supervised submarine construction at Kawasaki Ship Building.[21] In this next period Japan

16 Ibid.

17 Ibid., p. 88.

18 Fukui, *Nihon Sensuikan Monogatari*, p. 76.

19 Nobuo Tajima, 'The Origins of the Berlin-Tokyo Axis Reconsidered: From the Anti-Comintern Pact to the Plan to Assassinate Stalin', *Seijō Hōgaku*, Issue 69, December 2002, p. 14.

20 Tsuneya Kawamura, 'Tehyeru Teisei Doitsu wo Daihyōsuru Sensuikan Gijutsusha [Techel, The Submarine Technology Representative of the German Empire]', trans. Tohru Kizu, *100 Trivia of Submarines, Sekai no Kansen* [Ships of the World], No. 766, September 2012, p. 141. See also Carl Boyd and Akihiko Yoshida, *The Japan Submarine Force and World War II,* Annapolis, Naval Institute Press, 2002, pp. 13-15.

21 Ibid. Techel also contributed to the development of the *Kaidai*-class.

constructed the *Kaichu* (1919-1926) and *Kaidai*-class (1924-1932) submarines. The *Kaichu*-class (750 tons) was the first designed by the IJN and built upon the technology and experience gained to date and incorporated a double-hull design and more reliable diesel engines.[22] The *Kaidai*-class (1,500 tons) would take Japanese submarines above 1,000 tons for the first time and with greater endurance and speed enable the submarine to support the IJN fleet at greater distances.

Cooperation with Germany would continue late into the war and include the *I-201* which would later be a reference point for *Oyashio*'s designers. In 1943 Germany sent the *U-511*, an all-welded boat, designs and technical specialists on a three month submarine voyage to Japan. The Japanese at that time were struggling with the adoption of welding and the use of high tensile steel, which the *U-511* pressure hull and hull was constructed from.[23] Dr. Hans Schmidt would lecture the Japanese, including a number of personnel that would later work on the *Oyashio* (discussed later), on welding and developing high tensile steel (ST-52 or Stahl 52), and then travel to Kure Naval Yard and discuss the *U-511*. On studying the *U-511*, the Japanese concluded that their industry did not possess the technological sophistication required for its construction. Japan did not have the large castings or special steel required for the diesel engines, and the level of precision was beyond what Japanese machinery could manufacture. The main motors and batteries were assessed as undoable. Initial thoughts that by drawing on German designs that Japan could mass-produce submarines were wrong as the level of part standardisation was also not found in Japan. Despite these deficiencies, Schmidt assisted the IJN accomplish the welding of the *I-201* pressure hull and in the development of a high tensile steel similar to ST-52, but the used material was medium steel. This would serve as a basis for post-war research which was applied to the *Oyashio*.[24]

In summary, from the early 20th century Japan viewed an indigenous submarine capability as a national security priority and aggressively pursued international cooperation in developing an indigenous capability. With little indigenous technology or experience Japan was reliant on adopting foreign technology and seeking to gradually develop its own indigenous capability: between 1904 and the end of World War II Japan engaged the U.S., U.K., Italy, France and Germany. Throughout this process Japan had paid in both blood and treasure for the development of an indigenous submarine capability, with one former IJN officer in 1960s describing the magnitude of the endeavor as akin to developing a modern nuclear submarine or space rocket.[25]

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22 *Showa Zōsenshi*, Vol. 1, p. 442.

23 Takanori Maema, *Senkan Yamato Tanjō*, Vol. 2 [The Birth of Battleship Yamato, Vol. 2], Tokyo, Kōdansha, 1997, pp. 264-266. See also *Showa Zōsenshi*, Vol. 1, p. 614. Assistance by Germany regarding the development of high tensile steel is dealt with on page twelve.

24 Ibid. Here, U.S. reports refer to the *I-201* hull as being made from medium steel, whereas some Japanese sources refer to high tensile steel 'similar to ST-52'. U.S. reports also state that 'in some submarines 'D' steel, a high tensile steel developed from British Ducal steel but with a lower yield point, was used…but welding was not attempting because of fear of cracking'. See U.S. Naval Technical Mission to Japan, 'Characteristics of Japanese Naval Vessels Article 1 – Submarines', January 1946, p. 12. Either way ST-52 was not fully complete and welded until the construction of the *Oyashio*.

25 Fukui, *Nihon Sensuikan Monogatari*, p. 71.

The Legacy of the Imperial Navy and Post-War Shipbuilding

The fact that England has one thousand warships does not mean that she has one thousand warships only. If there are one thousand warships, there has to be at least ten thousand merchant ships, which in turn require at least one hundred thousand navigators; and to create navigators there must be naval science. Only when there are many professors and many merchants, when laws are in order and trade prospers, when social conditions are ripe – when, that is, you have all the prerequisites for a thousand warships – only then can there be a thousand warships.[26]

—Yukichi Fukuzawa

The Imperial Navy and Technology

While there were shortcomings in Japan naval industry during the war, and those qualitative shortcomings in relation to submarines will be discussed, it is important to also highlight that the IJN passed a significant legacy to the private sector that formed the basis of Japan's post-war ship building industry. The pre-war years and war time imperatives pushed Japanese industry to respond. Washington and London Naval treaties would put weight restrictions on naval ships stimulating efforts to reduce weight during ship construction and lift quality.[27] Later resource shortages and a ruthless submarine warfare campaign by the U.S. compelled Japan to improve its mass production capability and reduce the costs of ship production – for example Japan's own 'liberty ships' or *senjihyōjyunsen*, required industry to improve the standardisation of its tools and spares and to put in place stronger project and efficiency management controls.[28]

An important project which most demonstrated the culmination of Japan's technical capacity of the time was the *Yamato* battleship seen then as the project of the century. The *Yamato* is well known for its size, but there were other important aspects to its development. The *Yamato* incorporated technology and processes that while in the early stages of development would later be advanced post-war. This included welding, block construction, and cost and efficiency management methods introduced by Nishijima Ryōuji.[29] The relative effectiveness of Nishijima's methods is demonstrated by a comparison between the *Yamato* (built in Kure by the IJN under Nishijima's supervision) and the second ship of its class the Musashi (built in Nagasaki by Mitsubishi). The *Yamato* would be completed two months faster than the Musashi and at lower cost: *Yamato*'s hull required half the amount of personnel hours to build, and this despite *Yamato*'s construction commencing before the Musashi, carrying more risk.[30] Nishijima's cost control and schedule management methods included pioneering efficiency methods, such as the conversion of construction components into quantifiable metrics followed by the calculation of the labour hours required to complete the relevant work. For example the lengths of metal sheeting to be cut, the length of welds required, or the amount of rivets needed.[31] Many of Nishijima's methods would be adopted post-war.

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26 Cited in Samuels, *Rich Nation, Strong Army*, p. 43.

27 Maema, *Senkan Yamato Tanjō*, Vol. 1 [The Birth of Battleship *Yamato*, Vol. 1], Tokyo, Kōdansha, 1997, p. 109.

28 For example in the 1920s the cruisers *Nachi, Myōkō, Ashigara* and *Haguro* were built by different companies (IJN/Kure, Mitsubishi, Kawasaki) with different tools and materials being used. This led to greater cost, quality control issues and poor management of spare parts. See Maema, *Senkan Yamato Tanjō*, Vol. 1, pp. 105-108.

29 Maema, *Senkan Yamato Tanjō*, Vol. 1, p. 35.

30 See Ibid., p. 35; Maema, *Senkan Yamato Tanjō*, Vol. 2, pp. 80-81.

31 Maema, *Senkan Yamato Tanjō*, Vol. 1, pp. 349-350.

Although with many shortcomings, the IJN therefore represented the forefront of ship building and after the war would bequeath to private industry a significant capability in the form of personnel, infrastructure, technology and know-how that would form the basis of post-war development and expansion.[32]

Imperial Navy Infrastructure

It would not be difficult to believe that the atomic and allied air bombings (both Nagasaki and Hiroshima were the home of large ship yards) destroyed Japan's ship building and naval infrastructure, or that subsequent Occupation policy resulted in this infrastructure being eviscerated. Regarding the post-war ship building it has been noted that 'although Japan found itself behind in some areas of technology because of interruptions of the Occupation, shipbuilding was not a particular problem.'[33] This is because Japan's naval and ship building industry was not a priority target for allied attacks and largely survived. Subsequently, Occupation policy towards reparations reversed from being punishing to relatively accommodating as tensions between the U.S. and Soviet Union increased. This infrastructure was dual use and would later serve as the basis for regrowth. The U.S. Strategic Bombing Survey noted that 'merchant ships and naval ships were built in the same yards and required much the same type of construction facilities, and it would have been possible for the Japanese to divert facilities from merchant to naval or vice versa'.[34] Japanese literature also recognises that private ship yards played an important role in constructing naval ships for the IJN.[35]

The Japanese ship building industry technically survived, albeit in dire straits, in that the facilities, knowledge and personnel remained. The IJN had naval construction yards at Yokosuka, Kure, Sasebo and Maizuru. The Yokosuka Naval Yard suffered minor war damage.[36] The U.S. would requisition the yard as its naval headquarters and also use it for ship repair, with berths and armory sold to private industry.[37] Kure Naval Yard, the IJN's largest and where the *I-201* submarine was built, would have its operational capacity reduced by approximately 30%.[38] Large parts of ship and engine construction facilities would transfer to Harima Ship Building (to later form part of Ishikawajima-Harima Heavy Industries (IHI)) and the U.S. company National Bulk Carriers, with the rest sold to private industry.[39] Over three thousand seven hundred employees would carry on

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32 This does not mean the system was perfect. The U.S. also pointed out 'inadequate mass-production techniques' and 'poor production administration' amongst other areas. See *U.S. Strategic Bombing Survey: Japanese Naval Construction*, Washington, D.C., U.S. Government Printing Office, 1946, p. 2.

33 James Auer, *The Postwar Rearmament of Japanese Maritime Forces, 1945-71*, New York, Praeger Publishers, 1973, p. 230.

34 *U.S. Strategic Bombing Survey: Japanese Naval Construction*, p. 13.

35 *Showa Zōsenshi*, Vol. 1, p. 752.

36 *U.S. Strategic Bombing Survey: Japanese Naval Ship Building*, Washington, D.C., U.S. Government Printing Office, 1946, p. 13.

37 *Showa Zōsenshi*, Vol. 1, p. 742.

38 The U.S. report states that 'half the floor space in the dockyard and practically all the rest of the naval station was destroyed… Japanese estimate capacity was reduced by two thirds'. Although one wonders how accurate this assessment is given Kure's postwar use by National Bulk Carriers, its continual employment of thousands of personnel and the size and sophistication of the Kure yard and that much machinery remained, see reference fifty. *U.S. Strategic Bombing Survey: Naval Ship Building*, pp. 13-14.

39 *Showa Zōsenshi*, Vol. 1, p. 742.

work, removing sunken IJN warships and repairing commercial ships.[40] Sasebo would suffer only minor damage, with 'effect on production slight'[41], and most facilities would become Sasebo Heavy Industries.[42] Under a 1946 order from the Supreme Commander for the Allied Powers, employees would repair commercial ships and destroy warships. Maizuru suffered 'little damage and no effect on production' in allied attacks, and became Iino Construction/Maizuru Ship Building (later part of Hitachi Shipbuilding Corporation). The facilities and employees here would repair ships.[43]

Fifteen of the twenty three commercial yards were bombed and a quarter of the floor space of commercial shipyards was destroyed, a significant but not absolute number.[44] Most of the damage to commercial shipyards was a result of nearby air raids, the primary target being fleet units in nearby harbours and air stations located at the yards.[45] Space precludes a full description of the damage, but some key yards are worthy of further description. Mitsubishi's facilities in Nagasaki were significantly damaged – some totally destroyed.[46] Mitsubishi's facilities at Kure were far from the epicenter of the atomic blast and although 30% of the buildings suffered some damage, almost all machinery survived fully intact.[47] Both Mitsubishi and Kawasaki's facilities at Kobe, where submarine construction took place and where the future *Oyashio* would be built, were heavily damaged. Post war Kawasaki Senshusha (which produced submarines) would switch to the development of fishing vessels and repair of merchant ships.[48]

Table II: Kobe Floor Space Destroyed by Allied Air Attacks

Shipyard	Floor space before attack (1,000 sq ft)	Average Employment 1944	Floor Space destroyed by air attack (1,000 sq ft)
Kawasaki Kobe	2,539	24,048	907
Mitsubishi Kobe	2,384	23,506	469

Source: *U.S. Strategic Bombing Survey: Merchant Ship Building*, p. 38.

In addition to the above facilities remaining broadly in place, U.S. policy towards reparations shifted as tensions with the Soviet Union grew. In December 1945 the Pauley Report to the President indicated that the U.S. would seek punishing reparations from Japan's naval and ship building industry. This included half of all machinery; all of Japan's land, naval and air arsenals and bearing factories, all facilities in some twenty ship yards, all capacity for steel production beyond 2.5 million tons and half of Japan's thermal power stations.[49] The Japanese view was that

40 Takeaki Teratani, *Zōsengyō no Fukkō to Hatten* [The Revival and Development of the Ship Building Industry], Tokyo, Nihon Keizai Hyōronsha, 1993, p. 88.
41 *U.S. Strategic Bombing Survey: Japanese Naval Ship Building*, p. 13.
42 *Showa Zōsenshi*, Vol. 1, p. 743.
43 Teratani, *Zōsengyō no Fukkō to Hatten*, p. 88.
44 *U.S. Strategic Bombing Survey: Japanese Naval Ship Building*, pp. 13-14.
45 *U.S. Strategic Bombing Survey: Japanese Merchant Ship Building*, Washington, D.C., U.S. Government Printing Office, 1946, p. 38.
46 *Showa Zōsenshi*, Vol. 1, p. 47.
47 Ibid.
48 Ibid., pp. 47-48.
49 Teratani, *Zōsengyō no Fukkō to Hatten*, pp. 70-88 for an in depth discussion of reparations.

this would send the real income of each person back to 1930 levels.[50] However as relations with the Soviet Union deteriorated into the Cold War, the key word associated with Japan changed from 'demilitarisation' to 'Asia's factory' and Japan was increasingly seen as an important bulwark to communism. Implementation of reparations would stall due to differences between the U.S. and the Soviet Union, and the subsequent Strike Reports would call for an easing of reparations for fear of damaging Japan's economy – even the former Naval yards would be spared as they were under private ownership, under operation and employing workers; that is they were providing stability. In 1949 the termination to any further reparations as per the Pauley Report was announced, removing the cloud from Japan's ship building industry and leaving it relatively unscathed barring some equipment and machinery transfers overseas.[51]

Imperial Navy Submarine Technology

Shortly after the war, the U.S. deployed a team to Japan to assess Japan's naval technology in the form of the U.S. Naval Technical Mission to Japan (USNTJ). These reports were of extraordinary breadth and detail, covering all aspects of Japanese naval technology including electronics, medical, ordnance, ships, chemistry and physics. The reports of interest here are those related to Japan's submarines, particularly welding, propulsion and in relation to the *I-201* as these areas will later be contrasted with the *Oyashio*. It should be noted however that while Japan's submarine technology and designs were not world's best, authors have assessed Japanese submarines through to the end of war as 'modern and effective weapons' and 'modern by the standards of the day, and some, particularly late in the Pacific War, were quite innovative'.[52]

USNTJ assessed Japan's welding material and workmanship as relatively low with inferior rivet construction remaining the principal method. Welders had little to no training, with Navy yard welder trainees being given only a two month training course.[53] With little education and training it is unsurprising that USNTJ concluded that 'the standards in both material and workmanship are decidedly lower that those encountered in the U.S. Navy practice'.[54] The quality control system was also generally low. For example although the Japanese carried out x-ray inspection of submarine hull welds, the U.S. believed the standards of acceptance were not high as 'even surface imperfection would have been sufficient to disqualify fifty percent of the welds observed by U.S. standards.'[55] Estimates are that five to ten percent of submarine pressure hull welds were examined.[56] The primary focus of Japan's welding efforts 'was not to innovate or seek out and apply the inherit advantages of welding' (weight reduction and strength), but rather 'speed up production to meet war time demands'.[57] In addition to lack of workmanship, the equipment used was dated and inadequate. Electrode specifications were not met, and a diversified line of electrodes for different uses was not

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50 Ibid., p. 73.

51 Teratani, *Zōsengyō no Fukkō to Hatten*, pp. 70-88.

52 Boyd and Yoshida, *The Japan Submarine Force and World War II*, pp. 34-35.

53 U.S. Naval Technical Mission to Japan, 'Japanese Welding Standards', November 1945, p. 1.

54 Ibid., p. 1.

55 Ibid., p. 11. The report continued 'No pre-heating or post-heating was undertaken. Very little consideration was given to thermal stresses. No wide range of alloy electrodes was developed and no provision was made for electrodes to be used in various positions'.

56 U.S. Naval Technical Mission to Japan, 'Welding in Japanese Naval Construction', January 1946, p. 47.

57 Ibid., p. 1.

developed.[58] The use of automatic and semi-automatic welding was in its infant stages.

In the field of propulsion USNTJ was also unimpressed. Diesel engines were mostly of European design a decade prior to the war. With Japan having almost no access to western technology, the old designs and lack of domestic innovations, Japan possessed no high speed, high output engines comparable to U.S. models. Battery technology was also viewed relatively poorly, with the USNTJ assessing that 'Japanese battery practice resembles American practice of 25 years ago, when it was more of an art than a science' and that the *I-20I* class batteries were 'two-cell glorified automobile types'[59] the technical capacity of which when compared to the U.S. was six to one in favour of the U.S., that is 600 cycles versus approximately 80 cycles of the *I-201*.[60]

The U.S. reports are consistent with the memoirs of those involved in the broader shipping industry both during and post-World War II. Yoshiki Masao, a professor of shipping construction at Tokyo Imperial University, was involved in research and development including in the fields of electric welding, and served as the President of the Shipbuilders' Association of Japan between 1961-1963. Yoshiki recalled that 'Japan's shipbuilding industry before World War II was not highly developed. Even research within the Tokyo Imperial University was weak. Those that graduated from Tokyo Imperial University had little interest in conducting further research, seeking employment in the shipyards instead.' Yoshiki continued:

> *After World War II the Allied powers sent a number of technical study teams to Japan as part of an effort to seek reparations. These study teams investigated Japan's shipping industry, both facilities and machinery. They concluded that the machinery used in Japan's ship building industry was thirty to forty years old.*[61]

The Development of Japan's Ship Building Industry

Japan's ship building industry would be transformed post-war over three periods: immediate post-war -1949, 1949-1954 and 1955-1967. The immediate post-war to 1949 period was dire. Only the most basic ships (coastal and small fishing vessels) were permitted for construction so that Japan could deal with various post-war challenges such as food shortages.[62] For example until the Fifth Ship Building Plan (1949), restrictions included that merchant ships were to be less than 7,000 tons, oil tankers less than 12,000 tons, and ship speeds under fifteen knots.[63] Other restrictions included a ban against the use of heavy oil, which hindered the development of diesel engines. The third period extended from 1955 to 1967 during which the Japanese shipping industry transformed from a domestic to international focus, this period is beyond the scope of this thesis. The key period of interest here is 1949-1955 in the lead up to the construction of the *Oyashio* where two broad events took place. Firstly, as described earlier, the punishing threat of U.S. war reparations on the ship

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58 U.S. Naval Technical Mission to Japan, 'Japanese Welding Standards', p. 11.

59 U.S. Naval Technical Mission to Japan, 'Lead Acid Storage Batteries Used by the Japanese Navy', December 1945, p. 1.

60 Ibid.

61 Teratani, *Zōsengyō no Fukkō to Hatten*, p. 139.

62 The Society of Naval Architects of Japan ed., *Showa Zōsenshi*, Vol. 2: *Sengo* [The History of Showa-period Japanese Ship Building, Vol. 2: Post-war], Keibundō, Tokyo, 1981, p. 101 (hereinafter, cited as *Showa Zōsenshi*, Vol. 2).

63 Teratani, *Zōsengyō no Fukkō to Hatten*, p. 116.

building industry was removed providing the industry with certainty – this requires no further elaboration. The second event was the large amount of capital investment that took place with the objective of shifting industry from rivet construction to welding, replacing obsolete machinery, adopting the block system of construction, and in developing diesel engines.

The major change over the pre-war period would be the shift from rivet to weld construction and the accompanying large scale investment that was required in machinery (Table III). With this shift, investment into automatic welding machines, gas cutting and other related equipment was required. With the adoption of the block system of construction, a large amount of investment into cranes and the changing of ship yard layouts was also needed.[64] In addition to research and investment into welding, progress would also be made in the use of high tensile steel, the basis of which was laid during the war as described earlier. Although the IJN had used a type of high tensile steel known as Ducol in a number of its submarines, welding the material failed due to its hardness properties and the lack of development of Japan's welding electrodes as assessed earlier by USNTJ. As discussed earlier Japan would later receive assistance from Germany, which included the *I-511* which had an all welded pressure hull using ST-52.[65] ST-52 would become the basis of Japan's post-war research into high tensile steel and the result was HT-52. Concurrently, research was conducted into weld electrodes for use with HT-52.[66] The result of these and other related efforts would be that the *Oyashio*'s pressure hull would be all welded with high precision and made from HT-52 (later renamed to SM-52W/NS-31), to be discussed later.[67]

Table III: Investment into Japan's Ship Building Industry, 1950-1955 (million yen)

	1950	1951	1952	1953	1954	1955
Welding	185.7	567.8	1034.7	594.0	280.5	1306.0
Machinery	566.5	881.9	657.8	1588.2	1197.0	1396.4

Source: Adapted from Teratani, *Zōsengyō no Fukkō to Hatten*, p. 181. Teratani originally cites Eiichi Kaneko, *Gendai Nihon Sangyō Hattatsushi*, Part 9: *Zosen* [Modern Japanese Industrial History, Part 9: Ship Building], Tokyo, Modern Japanese Industrial History Research Society, 1964, p. 489.

Diesel engines represented another area of focus and development. Through the use of lighter oils diesel engines became cheaper to operate. The use of superchargers and the increase of cylinder sizes led to the attainment of greater power. The use of enhanced welding skill would lead to the reduction of the amount of steel required, which in turn led to lighter engines. Efforts were also made to make diesel engines quieter through the use of rubber to reduce the effect of engine vibrations for 'special purposes' – a likely reference to submarine usage.[68] The culmination of technological progress led to significant demand followed by investment and competition by Japanese firms into diesel engine manufacturing. Between 1950-1953 Japanese companies also

64 Ibid., p. 181.

65 See also Hiromi Koshima, 'Taiatsusenkoku no Kōzō to Zaishitsu [Pressure Hull Structure and Material]', trans. Tohru Kizu, *100 Trivia of Submarines, Sekai no Kansen* [Ships of the World], No. 766, September 2012, p. 27.

66 Japan Welders Society conducted research into assessing prototype electrodes in areas such as crack resistance, workability and fabrication. See *Showa Zōsenshi*, Vol. 2, pp. 24-25.

67 *Showa Zōsenshi*, Vol. 2, pp. 24-25, 40.

68 *Showa Zōsenshi*, Vol. 2, p. 121.

sought foreign diesel technology, returning to key relationships first established during the pre-war years. In 1953 Mitsubishi and Kawasaki would reestablish cooperative relationships with German company MAN, first entered into 1929 and 1928 respectively and MAN diesel engines would be later used in the *Oyashio* (discussed later).[69]

It was not only through investment but also research that contributed to post-war progress and here Japan did not wait. Even under these restrictions research was undertaken in the bureaucracy, industry and academia that would enhance Japan's ship building capacity. Former IJN officers and others active in the pre-war period also played an active role in this effort. Yoshiki Masao also viewed the technological state of Japan's ship building industry at the end of WWII as 'regrettable'.[70] To lift Japan's ship building standards Yoshiki believed it was important that Japan change how research was perceived and how information was shared: the pre-war incredulity towards research and the pervasive levels of secrecy would need to change. Yoshiki promoted this approach during his tenure as Chairman of the prestigious Shipbuilders' Association of Japan. In 1946 Yoshiki successfully established research committees within the Shipbuilding Association including in the areas of electronic welding and steel ship construction.[71] Yoshiki headed the committee on steel ship construction and appointed Fukuda Tadashi, a former Vice Admiral in the Imperial Japanese Navy, as the head of the welding committee. This decision was recognition that the IJN had relatively greater experience in welding. Pre-war, Fukuda was the leading exponent of the use of welding for naval construction and in his new position he would advocate that Japanese fishing vessels be constructed by welding.

Yoshiki emphasised during discussions that pre-WWII Japan was technologically behind other nations and persuaded committee members to return to their companies and bring their shipping data, secrets and all, which would be shared. This marked divergence from the pre-war situation, which was highly stove piped with companies focusing on protecting company secrets. Yoshiki also participated in welding committee meetings and recounts that the main lesson learned included the importance of precision. This recognition would have a knock-on effect across a range of areas related to the welding of joints – for example the edge planer was made redundant leading to research in the use gas cutting. Research was also conducted into the use of specialised weld electrodes. Another key factor was the care and thorough approach in introducing new methods and technologies. Japan imported welding technology and know-how from the U.S. initially included automatic welders, electrodes and the block method of ship construction. Before these methods were fully adopted they would undergo a thorough review process: 'while the methods and technology may have been used by the U.S., before we adopted them we conducted test after test until we confirmed with our own eyes that we could adopt the method with confidence'.[72]

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69 Institute of Politics and Economy ed., *Nihon no Zōsengyō* [Japan Ship Building Industry], Tokyo, Tōyō Keizai Shinpōsha, 1959, p. 88.

70 Teratani, *Zōsengyō no Fukkō to Hatten*, p. 139.

71 Teratani, *Zōsengyō no Fukkō to Hatten*, p. 137.

72 Ibid., pp. 150-151.

The Development of *Oyashio*

Reculer pour mieux sauter: take a step back in order to leap forward[73]

The importance Japan places on an indigenous ship building capability, including submarines, has been shown. It has also been demonstrated that Japan's ship building capacity survived into the difficult immediate postwar period. In addition, we saw that an extensive period of research, development and technological transformation took place, in effect serving to modernise Japan's ship building infrastructure and practices across a number of areas of relevance to submarine construction, including metallurgy, welding and diesel engines. Japan now possessed three important ingredients for the development of the *Oyashio*: pre-war experience in submarine design and construction and the personnel that were involved in that program; a modernised and indigenous ship building capacity; and the support of the United States. On the other side of the coin Japan had not constructed a submarine for a long-period of time and advances had taken place. In addition, the onset of the Cold War and provision of U.S. support was countered by a domestic climate that was sensitive towards rearmament creating a complex political environment for *Oyashio*'s construction.

Oyashio – Design Aspects

With the U.S.-Japan Security Treaty coming into effect in 1952, the establishment of the Japan Self Defense Forces looming and plans for rebuilding naval ships underway, discussions took place within the Maritime Security Forces (predecessor to the MSDF) about once again possessing a submarine capability.[74] It had been several years since Japan built a submarine and technological progress in the field had been made, particularly through the U.S. greater underwater propulsion power program (GUPPY) and the development of the *Albacore* and *Nautilus*. The U.S. developed *Albacore*, inspired by the German type XXI U-boat, was an important milestone in submarine history.[75] Throughout World War II submarines had been deployed primarily as surface ships, but this gradually changed as enhanced allied anti-submarine warfare capabilities (such as radar) led to increased German U-boat losses. These losses would see a shift in focus in the use of submarines to primarily undersea rather than on surface. This shift, in turn, required the design and associated capabilities that would enhance undersea performance of submarines by streamlining the hull amongst other measures. The tear drop hull of the *Albacore* submarine 'was designed with underwater speed as the prime requirement.'[76] The *Nautilus* would bring about the 'momentous step in nuclear propulsion'[77] and in 1958 both the tear drop hull and nuclear propulsion would be integrated into the *Skipjack*-class.

Kawasaki and Mitsubishi were aware of the early discussions taking place within the bureaucracy regarding the development of an indigenous submarine and commenced recruitment, drawing on IJN expertise. Kawasaki established a 'Special Warship Research Room' that consisted

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73 French saying taken from Samuels, *Rich Nation, Strong Army*, p. 57.

74 Yoshihiro Mizukami, 'Kaijō Jieitai Sensuikan Kenzōshi [The Construction History of JMSDF Submarines]', *Sekai no Kansen* [Ships of the World], No. 524, May 1997, p. 112.

75 See Roy Burcher and Louis Rydill, *Concepts in Submarine Design*, London, Cambridge University Press, 1995, pp. 19-20 for a discussion on key milestones in submarine evolution, which the author has drawn from.

76 USS Albacore, 'Forerunner of the Future' <http://www.ussalbacore.org/html/visitor_center.html> [last accessed May 2013].

77 Burcher and Rydill, *Concepts in Submarine Design*, p. 19.

of twenty three personnel, fifteen of which were recruited between 1954-1955.[78] Three of the six directors of the team were former IJN personnel (including former commander of the *I-58* submarine, Hashimoto Mochitsura, the captain who sank the USS Indianapolis in 1945), with two other directors having been involved in submarine construction in the pre-war period. After both Kawasaki and Mitsubishi gathered former personnel involved in submarine construction that had left at the end of the war, a joint Kawasaki-Mitsubishi Submarine Study Group was established in March 1954.[79] At this study group the latest foreign submarine developments were discussed, including the development of nuclear propulsion submarines. The Maritime Staff Office (MSO) would submit a formal request for the development of a submarine to the Technical Research and Development Institute (TRDI),[80] and in September that year an 'Undersea Weapons Study Group' was established within the MSO. These meetings were chaired by Yoshimatsu Tamori (involved with submarines in the IJN including the *kaiten* torpedo) and attended by representatives from the Internal Bureau, MSDF, Kawasaki and Mitsubishi.

The Undersea Weapons Study Group discussed the type of submarines that would be developed and sought three broad proposals in the form of a 'basic plan'.[81] For the basic plan, the Group engaged the Japan Ship Design Association as an expert intermediary. The Ship Design Association had some fifty members and its broad role included establishing basic ship performance requirements, gathering information left behind by the IJN and providing that information to various shipyards.[82] In effect it acted as a specialist conduit between bureaucracy and industry. The Chairmen of the Ship Design Association in the 1950s included former IJN Rear Admiral Kondo Ichiro and former IJN Captain Makino Shigeru (1954), both had previously worked in the IJN's Naval Technical Department. Particularly fortunate in relation to the *Oyashio*, many members included those with submariner backgrounds.[83] For example, members Oaki Ryōsaku and Maruishi Yamaichirō were both involved in pre-war submarine programs and were present during briefings given by Dr. Schmidt during his visit to Japan in 1943.[84]

Three proposals were put forward by the Ship Design Association 250 tons, 600 tons and 1000 tons. In April 1955 the 1,000 ton proposal was selected. The selected model, however, was not a tear-drop hull nor was it to adopt nuclear propulsion. Terada states that 'safety was number one' priority and so the proposal 'closest to submarines used by the IJN' was selected.[85] This meant

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78 Kawasaki Heavy Industries, *Kawasaki Jūkō ni okeru Sensuikan Kenzō no Enkaku to Sengo no Kenkyū* [The Beginnings of Submarine Construction in Kawasaki Heavy Industries and Post War Research], November 1955, p. 7.

79 Mizukami, 'Kaijō Jieitai Sensuikan Kenzōshi', p. 97.

80 Akira Terada, 'Kaijō Jieikan ni Miru Dezain no Hensen [Changes of Naval Designs in the JMSDF – Submarines]', *Sekai no Kansen* [Ships of the World], No. 312, September 1982, p. 96.

81 Akira Terada, '*Oyashio* Kenzō no Omoide [Memories of the First JMSDF's Domestic Built Submarine *Oyashio*]', *Sekai no Kansen* [Ships of the World], No. 524, May 1997, p. 78.

82 The function of the Ship Design Association ended in 1958 with the personnel joining the then Japan Defense Agency. See *Showa Zōsenshi*, Vol. 2, p. 577.

83 As former IJN Naval Yards passed to private industry former IJN personnel also followed. However those involved in the IJN submarine programs found the move more challenging, although the precise reasons why is unclear. Terada, '*Oyashio* Kenzō no Omoide', p. 96.

84 Oaki would write a series of articles in the 1950s regarding submarine hull design and hydrodynamics, including 'Ryōsaku Oaki, Kōsoku Sensuikan no Sekkei ni tsuite [High Speed Submarine Designs],' *Senpaku* [Ships], October 1957, pp. 979-987.

85 Terada, '*Oyashio* Kenzō no Omoide', p. 97.

that Japan would return to the fleet-type submarine, which while representing a relatively low risk and incremental approach, meant the development of obsolete technology to others. Diet member Masanobu strongly criticised the JDA for this, and suggested further research into modern designs rather than 'reverting back ten years as your starting point'.[86] Officials conceded that after extensive research the conclusion was that even the development of the non-tear drop hull submarine would be a challenge for the then existing level of Japanese technology.[87]

Regarding nuclear propulsion, although Japan would develop a nuclear power industry from the 1950s onwards it would avoid the adoption of nuclear propulsion in its submarine designs. Nuclear propulsion was likely discussed and discounted due to the significant political sensitivities Japan faced in relation to the establishment of the JSDF and Article IX of the Constitution. Any indication that nuclear energy would be used for military purposes in Japan, only ten years after the atomic bombings of Hiroshima and Nagasaki, would have likely led to the initiative being stalled at best or even terminated.

Oyashio – Normative Aspects

The broad design characteristics of *Oyashio* were addressed by adhering closely to existing pre-war experience. However managing the political sensitivities of *Oyashio*'s development would represent a significant departure from the pre-war way of doing business. Here it was not the JMSDF leading the way as would have the IJN but instead officials within the bureaucracy. Officials within the JDA recognised the sensitivities associated with Japan developing submarines. Japan had in place a constitution that forbade the possession of 'war potential' through Article IX of the constitution and Japan was establishing an armed force that was not a 'military' but a 'Self-Defense Force'. The development of a submarine would need to be squared with this rationale. Within the civilian side of the JDA (*naikyoku* or Internal Bureau) there was concern that developing a submarine capability carried a 'dangerous' perception.[88] Importantly, for there to be a consensus amongst industry, the bureaucracy and the MSDF agreed that the explanation for the development of the *Oyashio* would be that it would enable JMSDF destroyers to carry out anti-submarine training with the *Oyashio* being the target ship.[89] The sensitivity, or hypersensitivity, towards the *Oyashio* even extended to the Internal Bureau against using the Japanese kanji characters for submarine (潜水艦), instead adopting the euphemism of 'underwater target ship' (水中目標艦).[90] This in turn explains the various committee names addressed earlier, with the initial Kawasaki/Mitsubishi committee the exception. This perception was shared and understood, including amongst those that would join the JMSDF: in the early 1950s, a former MSF officer noted that there was fear in even 'saying something as foolish' as desiring to 'construct a submarine' outside a small limited group for fear of the backlash it may invite.[91]

The JDA would seek a budget of 2.7 billion yen in FY1956 for the development of *Oyashio*,

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86 House of Representatives Cabinet Committee, 4 April 1956.

87 Ibid.

88 Akira Terada, 'Teikoku Kaigun Sensuikan Gijutsu no Kaisō to Kaijō Jieitai *Oyashio* Tanjō no Keii, Part 2 [Imperial Navy Submarine Technology Memoirs and the Birth of the JMSDF *Oyashio*, Part 2], *Suikōshi* [Journal of Suikōkai], No. 412, September 1988, p. 30.

89 Ibid.

90 Ibid.

91 Tatsuo Tsukuda, 'Sensuikan Butai no Ayumi [Development of the JMSDF's Submarine Force]', *Sekai no Kansen* [Ships of the World], No. 420, April 1990, p. 74.

leading to debate in the Diet regarding the proposal.[92] Members questioned why a submarine capability was required, including the receipt of the *Kuroshio* from the United States. As crafted by the Internal Bureau, then Vice Minister Masuhara Keikichi stated that two submarines would be 'target ships for training'.[93] JDA Chief Sugihara Arata would assert the purpose was to conduct 'underwater radar training' and that submarines would be used as 'underwater targets' for 'maritime radar training' and 'maritime defence'.[94] When clarification was sought whether it would be used as an underwater target or as an offensive 'submarine weapon', Sugihara responded the former.[95] Some eight months later and in response to questioning by the Chairman of the Japan Socialist Party, then JDA Chief Funada Naka delivered a more convincing response, linking the capability to Japan's strategic geography, although the proposed use remained passive rather than 'offensive':

> *Japan is a nation surrounded by seas, with twenty percent of its food being imported, and in an emergency it would be important to protect our shipping. In a foreign attack on Japan, the severing of Japan's supply routes would be a concern and to that end we need to conduct training. As part of that training, we require an undersea target similar to a submarine.*[96]

Not all Diet members accepted the 'target ship' explanation for *Oyashio*. Diet member Tsuji Masanobu, who earlier critiqued the design characteristics of *Oyashio* as being obsolete, sarcastically asked JDA Equipment Bureau head Kubo whether what was being proposed was the use of 'billions of tax payers yen' to develop a 'training ship' and if so why the U.S. provided *Kuroshio* (discussed later) would not suffice. Kubo retorted that the technological level of *Kuroshio* was low, that one boat was not enough and that there was no prospect of receiving more (presumably at no cost) from the United States.[97] After persistent questioning by Masanobu and comparisons with the *Albacore*, Kubo would concede that while it was important Japan always consider the latest technology, in the first instance Japan would have to fill the ten-year blank left since the war.[98] While Masanobu would not be convinced of the value of the *Oyashio*, in August 1956 with the broad design parameters and budget in place, Kawasaki was revealed in newspapers as the company that would construct Japan's first indigenous submarine post-war.[99]

Oyashio – Foreign (United States) Technology

Japan would once again turn to a foreign country for submarine assistance, this time back to the United States. In addition to the change of U.S. policy towards Japan's rearmament (and the earlier abandonment of punishing war reparations), in the early 1950s the U.S. took the decision to assist Japan develop its armed forces, specifically: 'Assist Japan to develop military forces which will eventually be capable of assuming responsibility for defense of Japan against external aggression. As a first stage,

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92 House of Representatives Cabinet Committee, 4 April 1956.
93 House of Councilors, Foreign Affairs Committee, 25 May 1954.
94 House of Representatives Cabinet Committee, 14 July 1955.
95 Ibid.
96 House of Representatives Cabinet Committee, 24 February 1956.
97 Ibid.
98 House of Representatives Cabinet Committee, 4 April 1956.
99 Terada, '*Oyashio* Kenzō no Omoide', p. 97.

assist Japan to develop a balanced ten-division ground force and appropriate air and naval arms'.[100] The U.S. assistance to the *Oyashio* came in two forms: the provision of a *Gato*-class submarine in mid-1955, and technical advice, training assistance during the development of the *Oyashio*. The *Mingo* SS-261 (*Gato*-class) submarine was provided to Japan in following the coming into effect of the Mutual Security Assistance Treaty. Japan would rename the boat *Kuroshio*. The 81-strong crew of the *Kuroshio*, including former IJN personnel, would attend the U.S. submariner school for training.[101] The Japanese also thoroughly studied the *Mingo* technically and found that the simplicity of its rigging to be an advance to what was used in IJN submarines, adopting aspects of it in the *Oyashio*.[102] For example the *Mingo* used one pump for its seawater pump system whereas the IJN submarines had five.[103] Other differences included air ventilation, the use of valves and escape related mechanisms. Hull welding was also superior to Japanese practice during the war (covered later).

In late 1956 a delegation consisting of MSDF, Mitsubishi and Kawasaki officials would visit the U.S. including Electric Boat Company, Portsmouth and May Island Naval Yards.[104] Key lessons learned from the visit included changing the arrangement of the number of batteries from an odd number to an even number for degaussing; improvements to inner hull joinery and elimination of stress concentration on the inner hull plate (greater hull strength); improvement of inadequate separation between propeller and hull (likely in relation to reducing cavitation).[105] The strengthening of the hull was an area of surprise as the Japanese had confidence in research conducted by Kawasaki. However the U.S. had used HY-80 high tensile steel in the development of its nuclear submarines and had carried out many experiments, leading to a deeper diving ability. For example the U.S. advised the Japanese that the T-shape weld for the internal frame would provide greater stability, which Japan adopted increasing the diving depth of the *Oyashio* (although the degree to which is unclear). The U.S. involvement would continue well into the program. In April 1957 two specialists would provide technical assistance for the fitment of the *Oyashio*'s snorkel, including assistance with land-based testing. In September 1958 a U.S. specialist would survey the large scale wooden mockup of *Oyashio* created by Kawasaki, and make equipment layout recommendations so that the noise signature would be reduced. The same specialist would return in 1960 to observe sea trials.[106]

As Patalano has outlined the U.S. provided important support to Japan for the development of the *Oyashio*.[107] However that support should not be under or overstated. Certainly the provision

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[100] United States Objectives and Courses of Action With Respect to Japan, National Security Council 125/2, August 7 1952. The U.S. also provided a submarine rescue ship to standby during sea trials.

[101] Alessio Patalano, 'Nichibei Gunji Kōryū to Sengo Nihon no Sensuikan Butai no Hatten (1955-1976) [Japan-United States Military Exchange and the Development of Japan's Postwar Submarine Force]', trans. Takashi Genda, *Senryaku Kenkyū* [The Journal of Strategic Studies], No. 7, December 2009, p. 97.

[102] Terada, 'Teikoku Kaigun Sensuikan Gijutsu no Kaisō to Kaijō Jieitai *Oyashio* Tanjō no Keii, Part 2', p. 31.

[103] Terada, *Kaijō Jieikan ni Miru Dezain no Hensen*, p. 96.

[104] The delegation head of the visit was Tamori Yoshimatsu, accompanied by representatives from Kawasaki, Mitsubishi and the MSDF.

[105] See also Patalano, 'Nichibei Gunji Kōryū to Sengo Nihon no Sensuikan Butai no Hatten (1955-1976)', p. 98.

[106] Terada, '*Oyashio* Kenzō no Omoide', p. 100.

[107] Akira Terada, 'Sensuikan *Oyashio* no Kenzō narabini Kōshi ni tsuite [The Construction and Trial of *Oyashio*]', *Fune no Kagaku* [Ship Science], Vol. 13, No. 9, September 1960, p. 72. Other areas where U.S. components were used include radar, radio buoy, loran receiver, snorkel safety mechanism, and water pump. Fiber Reinforced Plastic was also used for part of *Oyashio*'s conning tower, first adopted by the U.S. as part of the GUPPY program in response to electrolyte corrosion. See Kawasaki Heavy Industries, 'Sensuikan no *Oyashio* no Kōzōbutsu [*Oyashio*'s Structure]', *Kōgyōzairyō* [Construction Material], July 1967.

of the *Mingo*-class submarine and technical support was important. U.S. submarine technology during the war was more advanced than that of Japan across a number of areas, such as radar, and the *Mingo* enabled Japan to make many small improvements. However Japan already possessed a significant indigenous submarine capability (of fleet-type) and the practical effects of U.S. support, while valuable, was not critical to the development of the *Oyashio*, a fleet-type submarine. Certainly, when contrasted with the U.S. provision of nuclear propulsion design support to the United Kingdom around approximately the same period, the assistance provided to Japan could be viewed as valuable but limited, but also understandable given the different nature of the relationships at the time.

Oyashio – Technical Aspects

An important technological advance of the *Oyashio* over the *I-201* was arguably the significant progress in hull fabrication and welding.[108] With a safe diving capability of 150 metres, as opposed to the 90 metres of the *I-201*, advances in high tensile steel, welding and fabrication and quality control were required beyond what Japan adopted during World War II. Table IV compares the *Oyashio* with the *I-201* and the U.S. *Gato*-class. The *Oyashio* used a thicker steel inner pressure hull than the *I-201* and its hull was completely welded and x-rayed. All areas of the pressure hull over thirty millimetres thick would use tempered steel, while the remainder would consist of SM52W, an improved alloy based on ST-52 (discussed earlier).

This represented the first instance of SM52W high tensile steel being welded in Japan's ship building industry.[109] With significant investment into automatic welding equipment, the *Oyashio* was both machine and hand welded leading to high precision tolerances of 0.5 millimetres. In addition, as opposed to only approximately five percent of the *I-201* pressure hull welding having been x-rayed, the *Oyashio*'s pressure hull was entirely x-rayed.[110]

Table IV: Submarine Pressure Hulls: *I-201*, *Gato*-class, *Oyashio* (compiled by author)

	I-201	*Gato*-class	*Oyashio*
Hull thickness	18-22 mm [1]	17.5 mm [2]	20-30 mm (tempered steel used for thickness beyond 30 mm)
Hull material	Medium steel [3]	Mild steel	High tensile (SM52W/NS30) [4]
Fabrication	Hand welded, 5% X-rayed. [5]	Welded	Machine/hand welded, 100% X-rayed.

Notes: 1. U.S. Naval Technical Mission to Japan, 'Characteristics of Japanese Naval Vessels Article 6 – Submarines', January 1946, p. 8.
2. Mark W. Allen, *Leader of the Pack: The Fleet Submarine USS Batfish in World War II*, Kindle Version, 2011, p. 10.
3. U.S. Naval Technical Mission to Japan, 'Characteristics of Japanese Naval Vessels Article 1 –Submarines', pp. 20-21. See also footnote twenty four.
4. Koshima, 'Taiatsusenkoku no Kōzō to Zaishitsu', p. 27; Kawasaki Heavy Industries, 'Sensuikan no Yōsetsu ni tsuite', pp. 30-31.
5. U.S. Naval Technical Mission to Japan, 'Characteristics of Japanese Naval Vessels Article 6 –Submarines', p. 8.

108 Kawasaki Heavy Industries, 'Sensuikan no Yōsetsu ni tsuite [Submarine Welding]', *Yōsetsu Gijutsu* [Welding Technology], January 1962, p. 30. See also Koshima, 'Taiatsusenkoku no Kōzō to Zaishitsu', pp. 26-27.

109 Kazuo Umeno, 'Sensuikan *Oyashio* Sengo Saisho no Kokusan SS [*Oyashio*: Japan's First Post-War Domestically Produced Submarine]', *Sekai no Kansen* [Ships of the World], No. 617, October 2003, p. 62.

110 Kawasaki Heavy Industries, 'Sensuikan *Oyashio* ni tsuite [The Submarine *Oyashio*]', *Fune no Kagaku* [Ship Science], Vol. 13, No. 9, September 1960, p. 68.

A second area of important progress was propulsion, both in relation to diesel engines and batteries. Diesel submarine engines 'should furnish maximum amount of power with minimum weight and space requirement' and 'should operate with small fuel consumption per unit of horsepower'.[111] By this criteria, Japan ship building industry possessed diesel engines that were more capable than what was used in the *I-201* and what the U.S. used in the *Gato*-class. An initial examination of the table would suggest with similar underwater speeds (approximately twenty knots) of the *I-201* and *Oyashio* that the propulsion may not have significantly changed, or that the *I-201* propulsion was adopted in the *Oyashio*. However, this is not the case. The *I-201* used a direct drive system (propeller attached directly to the diesel engine), which limits the number of engines to one or two, which in turn limits the potential range of the submarine. Writing in 1955, Ito (former IJN officer responsible for research into diesel engines post-war) would advocate the importance of diesel electric drive. The *Oyashio* was the first domestically produced submarine to adopt the diesel electric-drive for the propeller shafts, where the diesels are linked to a generator.

Table V demonstrates the above progress made directly in relation to submarine diesel engines. By the mid-1950s, diesel engines that were suitable for submarine use were half the weight of that used in the *I-201*, operated at higher revolutions per minute, and at small stroke to bore ratios. Additionally, by the mid-1950s diesel engines in Japan had become lighter through enhanced welding techniques and more efficient use of material.[112] Diesel engines also gained increased power outputs. This combination of less weight and more power led to enhanced power to weight ratios. While we do not have access to the specifications of the Kawasaki/MAN V22/30 diesel engines used (including physical dimensions) in the *Oyashio*, it is likely that the engine was smaller, providing more space within the submarine. Secondly, the reduced stroke to bore size indicates that the *Oyashio* likely had greater fuel efficiency than the *I-201*, indicating that all other things equal the *Oyashio* possessed relatively greater range. On these specifications, Japan's diesel engine technology by the mid-1950s had surpassed U.S. technology of the 1940s as used in the *Gato*-class.

Table V: Comparison of Diesel Engines

	I-201	*Gato*-class	Japan mid-1950s
Type	Four cycle	Two cycle	Four cycle
Horsepower	1,500	1,600	1,500
RPM	675	750	900
Cylinder Diametre mm	300	222.25	220
Stroke mm	380	266.7	330
Cylinders	10	16	12
Torque	7.46	5.88	10.96
Average Piston Speed m/s	8.55	—	9.0
Weight (t)	14.5	14.5	7.1
Power to weight ratio (kg)	9.7	9.0	4.8

Source: Table compiled by author. Sources include Isao Ito, 'Sensuikanyō no Enjin [Submarine Engines]', *Senpaku* [Ships], March 1955; U.S. Navy, *The Fleet Type Submarine*, Navpers 16160 <http://maritime.org/doc/fleetsub/index.htm> [last accessed May 2013]; U.S. Navy, *Submarine Main Propulsion Diesels*, Navpers 16161 <http://maritime.org/doc/fleetsub/diesel/index.htm> [last accessed May 2013].

[111] See U.S. Navy, *Submarine Main Propulsion Diesels*, Navpers 16161 <http://www.maritime.org/fleetsub/diesel/index.htm> [last accessed May 2013], p. 3.

[112] Institute of Politics and Economy, *Nihon no Zōsengyō*, p. 91.

Other propulsion related progress included battery performance and the use of the snorkel. The yardstick by which the *Oyashio*'s battery would be measured against was the IJN's Mark 1 Type 33 battery, heavily criticised in U.S. technical reporting (as highlighted earlier) as being 'two-cell glorified automobile type'. The life of the Mark 1 Type 13 was estimated at 80 cycles (which the U.S. believed to be highly optimistic) whereas comparative U.S. batteries of the time had a life of 600 cycles. The *Oyashio*'s battery life - the Yuasa SCA-45 - was approximately 500 cycles.[113] The snorkel in the *I-201* was of rudimentary nature, being one of the earliest IJN submarines to have such a mechanism.[114] In addition, as most pre-war diesel engines were primarily two-cycle, the use of the snorkel was limited and unfit for underwater use given the low amount of exhaust pressure.[115] The *Oyashio*'s snorkel was linked to a four-cycle turbo-charged engine and was carefully tested with land based facilities and sea trials with the support of U.S. engineers.

Conclusion and Observations

Oyashio represented an important technological and political milestone in Japan's post-war history. It was an important technological achievement as new indigenous and foreign technologies, and new indigenous construction processes were successfully applied lifting the quality and capability of Japan's submarine industry beyond pre-war levels. It represented an important political milestone in that a submarine capability was reestablished during a time in which the very existence of the Japan Self Defense Forces was being questioned.

Japan, in developing the *Oyashio*, may have created one of the world's most advanced fleet-type submarine at the time. However the world had already seen the advent of the tear-drop hull and nuclear propulsion. Was it not obsolete? In the view of some, such as Masanobu at that time, *Oyashio* may have been viewed as an insignificant capability or even obsolete. Certainly if a short term view is adopted, that is if Japan ceased developing submarines with *Oyashio*, then it would have made little sense. However, from a long-term perspective *Oyashio* made sense. Japan had not constructed a submarine for over a decade, personnel remained but were scattered, some technologies and facilities remained but were either new or untested. *Oyashio* enabled Japan then to draw together, consolidate and reestablish a former industry, and then assimilate and apply new and old indigenous and foreign technologies. In doing so a new foundation was established from which future more capable submarines would evolve. For example the ST-52 high tensile steel and the accompanying requirements used in the *Oyashio* would evolve eventually to HT-60, HT-70 and HT-80, and beyond. The knowledge and experience associated with the development of *Oyashio* was diffused serving to raise the capability of the ship building industry as a whole, including through numerous publications (see biography under Kawasaki).

The political importance of *Oyashio*'s development should not be understated. Controversy over core national security issues, such as the U.S. alliance and even the types of platforms Japan was to possess meant that reestablishing a submarine capability was politically contentious. By

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113 Yasuo Abe, 'Technical Characteristics of JMSDF Submarines 2 – Machinery', trans. Tohru Kizu, *History of JMSDF Submarines, Sekai no Kansen* [Ships of the World], No. 665, October 2006, p. 125.

114 The snorkel allows the submarine to operate its diesel engines just below the surface, drawing in air to charge the batteries for submerged operation.

115 Kawasaki Heavy Industries, *Sensuikanyō Dhiizerukikan Senzen kara Oyashio made no Gijutsu Hatten ni tsuite* [The Development of Submarine Diesel Engines from Pre-war to *Oyashio*], written response to author, 2013.

carefully defining the role of the submarine fleet, and by avoiding costly or perhaps fatal issues such as the adoption of nuclear propulsion an important capability for protecting Japan's maritime interests was reborn. The author would not go so far as to claim that a submarine capability was at risk of being viewed in the same manner as long-range bombers or intercontinental ballistic missiles, which were defined in the 1970s as 'attack' or 'offensive' weapons and beyond what was then permissible under the interpretation of Japan's exclusively defence orientated policy. However not reestablishing a submarine capability early, along with the other components of the MSDF, could have led to greater difficulty in establishing such a capability in the future. While this may seem unlikely, it should be noted that debate was also taking place in the 1950s regarding Japan's possession of aircraft carriers, with attempts made by the Government to argue that the possession of 'small' aircraft carriers for training purposes would not infringe upon Article IX – in the end this was unsuccessful.

In addition to the significance of the *Oyashio*, a number of broad factors can be observed in its development. Firstly from a technical perspective it was largely an indigenous Japanese effort. There was to be sure technical and even more importantly political support from the United States. However even without U.S. technical support the Japanese would have successfully constructed the *Oyashio* as it was a fleet-type submarine of pre-war design which Japan retained the technical capacity for even in the difficult postwar years. Albeit limited, U.S. technical assistance was generous and important as it assisted the Japanese develop a higher level of capability more quickly than it could have otherwise done. Secondly Japan adopted an incremental and cautious approach to both design and technical aspects with in essence a type of 'evolved' *I-201* submarine design selected. The tear drop hull was avoided: Japan would not construct the tear drop hull submarine until the Uzushio in 1968, almost twenty years after the United States developed the Albacore. Some years later a JDA technical official on having been requested by the MSDF to develop a tear-drop hull submarine and responded illuminatingly:

> *The tear drop hull design is possible, but our technological level has not reached the required level so it is impossible as part of the Second Defence Build Up Plan, and I would like to leave it for the Third. We must not develop an unsafe submarine. If we decide a tear-drop hull is required, until the environment is such that it can be produced we should continue on as present.*[116]

This incremental approach was combined with a significant degree of risk management in the form of extensive modeling, including the development of a large wooden mock-up, the use of land based testing for engine/snorkel, and extensive research and development within and across industry, the bureaucracy, JMSDF and outreach to the U.S. for technical guidance and technology. Japan also had in place a large ship building industry that had remained intact through the war including facilities, and former IJN personnel with submarine experience, which had undergone technological transformation post-war. Without this broader industry it is difficult to see how *Oyashio* could have been developed: 192 subcontractors contributed to the development of the *Oyashio* – this was

[116] Masami Nakanomyō, 'Kaijō Jieitai Sensuikan Seibi no Ayumi [Buildup Program of JMSDF Submarines]', trans. Tohru Kizu, *History of JMSDF Submarines, Sekai no Kansen* [Ships of the World], No. 665, October 2006, p. 114.

certainly not an undertaking by one major company.[117]

The final ingredient was the passion of many of those involved in reestablishing a capability of national prestige. While demonstrating that has not been a focus of this thesis, and many if not all those directly involved in the *Oyashio* have now passed away, it is clear throughout the historical accounts that there was significant enthusiasm across the key actors who likely saw it as their duty (*gimu*) to not allow the efforts of their elders (*senpai*) to go to waste. An illustration of this sentiment is demonstrated in the multi-volume handwritten submarine history by Yoshimatsu Tamori after the war.

> *Japan's submarines perished with the Imperial Navy. But is it acceptable to throw away the submarine spirit, developed over forty years through blood, tears and sacrifice?*[118]

Yoshimatsu would lead a team within the Japan Defense Agency/JSDF that would contribute to the reestablishment of Japan's submarine capability. A capability that after over a century of gradual evolution is now almost entirely indigenous, completing a national objective that started in 1904 with Japan's purchase of the Holland-class submarine. The submarine spirit most certainly lives.

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117 Terada, 'Sensuikan *Oyashio* no Kenzō narabini Kōshi ni tsuite', p. 73.

118 Tamori Yoshimatsu, *Nihon Kaigun Sensuikan no Enkaku*, Book 1 Article 1 to Book 5 Article 2 [The Submarine History of the Imperial Navy, Book 1 Article 1 to Book 5 Article 2], National Institute for Defense Studies Military Archives, n.d.