Japan's Oil Puzzle

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The Question

In December 1941, Japan started the Pacific War with more than 40 million barrels of carefully accumulated oil and oil products.[1] Within four months, she had conquered an oil-producing region capable of producing more than 60 million barrels of oil a year and potentially able to refine all that it could produce.[2] In the first six months of the Pacific War, the Imperial Japanese Navy ranged far and wide throughout the Pacific and Indian Oceans, leaving wreck and ruin from Hawaii to Ceylon. Yet by early 1944 that navy lacked the refined oil needed to leave its bases and defend the Marianas from the invading Americans. So desperate had Japan become that she resorted to the expedient of using unrefined crude oil to fuel her ships.[3] Only by that means could she send a battle fleet to defend a key position in her defense perimeter. By any measure, this was a remarkable turn of fortune.

What went wrong for Japan? Were her oil reserves inadequate? Was her planning faulty? What had she failed to foresee? Had she failed to develop the oil resources in the regions she conquered? Had she not allocated the shipping resources necessary to move the oil to where it was needed? Had the Allies destroyed her ability to produce oil? To move it?

This fundamental question of how Japan failed to supply her battle fleet with oil has long intrigued me. There is no doubt that the failure did happen. Concerns about an oil famine surfaced long before the fleet was essentially immobilized in 1945. But I wanted to understand how and why it happened – what combination of Japanese failures and Allied successes caused the Japanese to be without the fundamental resource that they needed to fight a naval war.

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[1] United Stated Strategic Bombing Survey, *Oil in Japan's War: Report of the Oil and Chemical Division* (Washington, D.C., 1946), 16. Hereinafter, "Oil Report."
[2] Oil Report, 45.
[3] Samuel Elliot Morrison, *History of United States Naval Operations in World War II*, vol. viii (Boston: Little, Brown and Company, 1953), 214-6.

Oil Basics

All oil is not created equal. That point is vital to understanding Japan's oil issues. We commonly speak of "oil" as a shorthand for oil and its derivatives, but we must sharpen our understanding to dig deeper into the issues at hand. Oil as it is pumped out of the ground is "crude;" it normally passes through a refining process to be transformed into useful products.

From the perspective of World War II military technology, there were five types of refined oil products that were crucial to making war. First, airplanes needed high-octane aviation gasoline ("av gas"). Second, lower octane gasoline was needed to run cars, trucks, tanks and the like. This is "motor gas." Third, diesel fuel was needed to run diesel motors. This included the motors of submarines, some types of naval and merchant ships, and some land transportation. Fourth, fuel oil was needed to fire the boilers that made the steam than moved most warships. Without av gas and fuel oil, a navy would be just so much useless metal. Finally, lubricating oil was needed to keep all of the aircraft, motor vehicles and ships running smoothly.

It becomes somewhat meaningless to simply talk about "oil" in this context. Understanding requires an inquiry into the type of crude oil or oil product being discussed. And crude oil comes in types as well. Refiners were not able to convert crude oil into any type of refined product that they desired. The type of crude played a role in the sorts of final products that could be produced. As an example, Japan herself had limited amounts of indigenous crude oil. She might have wanted to turn that all into gasoline, but in fact none her crudes would yield more than 45% gasoline and some would yield none at all.[4]

Refining techniques could be tweaked to produce more of one kind of product and less of another from a given barrel of crude, but there were definite limits to the tweaking. Within those limits were products that were not useful militarily. In addition to the five products described above, the refining process typically yielded kerosene, gas oils and a variety of solids. Some of

[4] United Stated Strategic Bombing Survey, *Oil in Japan's War: Appendix to the Report of the Oil and Chemical Division* (Washington, D.C., 1946), 41. Hereinafter, "Oil Report Appendix." See also, J. Aoki and G. Nara, "The Petroleum Industry in Japan," in U.S. Naval Technical Mission to Japan, *Japanese Fuels and Lubricants – Article 10, Miscellaneous Oil Technology and Refining Installations* (San Francisco, California: 1946), 50-3.

these products could be rerun through the refining process to produce militarily useful products, but some waste was inevitable. A barrel of crude not could be converted into its weight in av gas, diesel and fuel oil. All this complicated the oil issue that Japan faced.

For simplicity, this study uses the following conventions. When it says "oil," it should be read to refer to oil and all the derivative products of oil. If it means unrefined oil products only, it will say "crude oil" or "crude." If it is referring to refined products, it will use the word "refined." It will refer to the five crucial oil products listed above as "military oil." That refers to the uses to which the oil could be put, but some military oil was also used by Japan's civilian sector. And, of course, if the study means a specific type of oil product, such as fuel oil, it will refer to it by name.

Weights and Measures

A variety of weights and measures have to be used in any discussion of Japan's oil issues. Some are units of weight and others are units of volume. All have their context, and all should be understood in context.

First are the measures used for oil. As Japan used the metric system, the Japanese oil planners measured oil in kiloliters.[5] This is a unit of volume equal to 1,000 liters. Its weight could vary significantly, ranging, for our purposes, from a kiloliter of fuel oil (the heaviest), to a kiloliter of av gas (the lightest). Having introduced the kiloliter, we will see little more of it.

That is because most of the sources discussing Japan's oil issues were written by Western authors and so commonly used either barrels or tons to measure oil. Barrels are a standard industry measure. A barrel of oil is equal to 42 U.S. gallons or 35 Imperial gallons. It is also a unit of volume rather than one of weight, so that a barrel's weight will vary depending on the

[5] Oil Report Appendix, 2. See also, Arthur J. Marder, *Old Friends, New Enemies: The Royal Navy and the Imperial Japanese Navy, Strategic Illusions 1936-1941* (Oxford: Clarendon Press, 1981), 167, and David C. Evans and Mark R. Peattie, *Kaigun: Strategy, Tactics, and Technology in the Imperial Japanese Navy, 1887-1941* (Annapolis, Maryland: Naval Institute Press, 1997), 567n66, 593n40.

type of oil it is measuring. I have used a factor of 6.29 barrels per kiloliter in converting kiloliters to barrels, although a more precise conversion would go out more decimal places. This study will use barrels exclusively when discussing oil by volume. It is worth remembering, however, that the original Japanese measure for these numbers used was more than six times larger than the measure used in this study. A number such as 252,000 barrels sounds precise, but it really just a conversion of 40,000 kiloliters, a number than has a much less precise feel to it. Most of the numbers on which this study draws were originally expressed in thousands of kiloliters and in some cases in units of 5,000 kiloliters – 31,500 barrels.

Where I quote numbers in thousands of barrels, I am generally quoting numbers given by a source in that form. Where I have computed numbers myself, I generally give them in hundreds of thousands of barrels. I feel that the latter form is a better reflection of the accuracy of most oil numbers.

Oil moved by ship, and merchant ships of the era were rated by another unit of volume called the gross ton, or GT. A gross ton was simply 100 cubic feet. Formulas were used to compute and state a ship's internal volume as a GT rating. This was an inexact measure of a ship's carrying capacity. It included internal volumes that were not used for cargo. More significantly, it took no account of a cargo's weight. Filling a tanker's holds with light av gas presented no issue, but fill the same volume with lead and the ship's voyage was likely to be a short one. As a result, the carrying capacity of a tanker in GT cannot be translated directly and easily into the number of barrels of oil that the tanker could carry.

In practice, tankers were generally able to carry oil cargos (expressed in tons of weight) of from one and one-third to two times the GT rating of the tanker. For this discussion, it is enough to know that the GT rating of a tanker is only a rough guide to its carrying capacity.

This brings us to units of weight. The relevant measure for this study is the long ton (which here will be referred to as a "ton") of 2,240 pounds. The long ton is relevant to the story because it is the unit by which a warship's fuel tanks were measured. It becomes useful in understanding fuel consumption. Metric tonnes of 2,204.6 pounds are also used by various sources as a measure for

oil, but I have converted stated in tonnes to barrels, using the conventions adopted by the sources' authors for the conversions.[6]

Where the weight of particular types of oil product are concerned, I have used conversion factors to translate barrels into tons. A ton of fuel oil was generally taken to be 6.8 barrels; a ton of av gas, 8.65 barrels. The volume of oil in a ton of crude varied, but 7.1 barrels per ton were taken as a rough conversion.[7] A destroyer with 500 tons of bunker capacity would therefore require 3,550 barrels of fuel oil to fill its tanks.

The Oil Report

Many of the numbers in this study come from the report on Japan's oil issues compiled for the post-war United States Strategic Bombing Survey. While the Survey dealt in detail with the effects of bombing on Japan's economy and war effort, it also became a general survey of Japan's wartime economy. The Survey recognized the primacy of oil shortages in cramping Japan's ability to wage war, even though strategic bombing itself played a relatively small role in causing those shortages. The oil study team actually generated of two final documents: the Oil Report itself, and an appendix to the report. The report tells the story of Japan's oil issues with numerous charts and graphs. The appendix generally parallels the report, but provides statistics in greater detail.

The team working on the report was able to spend two months in Japan and the East Indies interviewing people and reviewing documents, working to a deadline so that their report would be rolled up into the more general Strategic Bombing Survey report on the Pacific War.[8] Two months was not much time to get the information that they were after, particularly in the chaos of post-war Japan, but they succeeded in acquiring an impressive body of data nonetheless. The report itself reflects the fact that not all records could be found, and that some no longer existed.

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[6] Evans and Peattie, 567n66, 593n40. Mark P. Parillo, *The Japanese Merchant Marine in World War II* (Annapolis, Maryland: Naval Institute Press, 1993), xx.

[7] Morison, vol. iii, 63n. Morison gives the factors for conversion to metric tons, yet another measure of weight. A metric ton is equal to about 2,204 pounds. I have here translated Morison's factors into factors for long tons.

[8] Oil Report, preface.

There are some errors and inconsistencies within the report itself, probably due to the short time in which it was created, the destruction of records, and the mass of information that the report was trying to analyze and present. Undoubtedly, some of the recollections of the people the team interviewed were mistaken or even misleading. But despite these obstacles, the report team did an excellent job in pulling together and presenting much information in a short time.

The report and appendix were written by triumphant Americans, who do not hesitate to criticize any shortcomings in Japanese plans or processes and who are always alert to anything that could be seen as evidence of nefarious Japanese plan to wage an aggressive war in the Pacific. But many of the criticisms are merited, and the allegations of evil plans can be ignored (or not) at the reader's pleasure. Neither detracts from the fundamental validity of the analysis. There is no guarantee that all of the numbers in the Oil Report and its appendix are right, and we will see that some of them are surely wrong, but I know of no better source documents to help examine Japan's oil problems in the great Pacific War.

Oil Report References

Rather than repetitively footnote each number presented in the text from the Oil Report and its appendix, I instead present here a guide to the tables in the Oil Report appendix that yielded the numbers I quote. If I quote a number that is neither in the report appendix nor calculated by me, I footnote it. The references are to the appendix due to it presenting the numbers in the greatest detail. Unless otherwise noted, all of these tables provide numbers for every fiscal year from 1931 through 1945, and for every calendar quarter from the second quarter of 1941 through the third quarter of 1945. Japanese fiscal years ran from April 1 through March 31, so that the second calendar quarter of 1941 was the first quarter of the 1941 fiscal year. References in the tables to the "Inner Zone" refer to a region containing the Japanese Home Islands, Manchuria, Formosa, and Japanese-controlled south Sakhalin, while references to the "Southern Zone" are references to the oil-producing region of the East Indies. This study will use these terms in the same way.

- Page 12, Table 1. Production, Consumption, and Imports of Liquid Fuels and Lubricating Oil – Inner Zone. Shows refined products imported, refined products produced from crude oil and synthetic oil, substitute fuel production, consumption and total inventories at the beginning of each period.
- Page 15, Table 2. Crude Oil – Imports, Production, and Inventories – Inner Zone. Shows crude oil imports, indigenous crude production, and inventories at the beginning of each period.
- Page 19, Table 5. Imports of Crude and Refined Oils – Inner Zone. Shows imports of crude oil, av gas, motor gas, diesel fuel, fuel oil, and lubricating oil.
- Pages 20-2. Table 6. Production of Refined Oils – Inner Zone. Shows production and imports of military oil products. For production, shows the source.
- Pages 23-4. Table 7. Consumption of Liquid Fuels – Inner Zone. Shows consumption of military oil products, broken down into consumption by the Imperial Japanese Army, the Imperial Japanese Navy, and the civilian sector.
- Page 25. Table 8. Inventories of Liquid Fuels and Lubricants – Inner Zone. Shows IJA, IJN and civilian inventories of military oil products as of the start of each period. Some of the dates are incorrect, but the correct dates are apparent in context.
- Page 76. Table 49. Production of Crude Oil in the Netherlands East Indies. Shows annual production for fiscal years 1940 and 1942 through 1945, itemized for Sumatra, Borneo , and Java.
- Page 77. Table 50. Production and Refining of Crude Oil in the Southern Zone. Shows crude oil production, crude oil put to refineries, and refined products (including the military oil plus kerosene and solids) for fiscal years 1940 and 1942 through 1945. This table had a typo – the crude through-put for 1943 should be 28,398 thousand barrels, not 23,398 thousand barrels as shown.[9]
- Page 77, Table 51. Production and Disposition of Crude Oil in the Southern Zone. Shows crude production, total of crude and refined products received from the Southern Zone in the Inner Zone, and crude and refined products either consumed in the Southern Zone or lost. Includes fiscal years 1942 through 1945, and calendar quarters from the second quarter of 1942 through the second quarter of 1945.

[9] Oil Report, 49. The Oil Report has the correct number in its text.

- Page 77, Table 52. Crude Oil Processed and Liquid Fuels and Lubricants Produced at Balikpapan. Shows crude produced from the Tarakan and Sanga Sanga fields and processed at the IJN-run Balikpapan refinery on Borneo. Shows the amounts of military oil products produced, plus kerosene, for the 1940 and 1942 through 1945 fiscal years.
- Page 81, Table 53. Crude Oil Processed and Refined Oils Produced by the Pladjoe Refinery, Palembang, Sumatra. Shows crude input to this refinery and output of military oil products plus kerosene and solids for fiscal years 1940 and 1942 through 1945 and months from June 1942 through August 1945.
- Page 83, Table 54. Crude Oil Processed and Refined Oils Produced by the Soengaigerong Refinery, Palembang, Sumatra. Shows crude input to this refinery and output of military oil products plus kerosene and solids for fiscal years 1940 and 1942 through 1945 and months from November 1942 through July 1945.
- Page 85, Table 55. Crude Oil Processed and Refined Oils Produced by the Pangkalanbrandan Refinery, Pangkalansoesoe, Sumatra. Shows crude input to this refinery and output of military oil products plus kerosene for fiscal years 1940 and 1942 through 1945 and months from September 1942 through August 1945.
- Page 86, Table 56. Distribution of Japanese Tankers by Use. Shows the total gross tonnage and number of tankers employed for various purposes, monthly from December 1941 through August 1945.

While the tables in the Oil Report and its appendix normally speak in terms of Japanese fiscal years, this study takes a different approach. For years prior to 1942, it will use fiscal years. For the years 1942 through 1945, it will use calendar years unless otherwise noted.

A Problem of Numbers

Simply put, Japan's oil problem was how to get enough of the right kind of oil to the right place at the right time. She started the Pacific War with a substantial stockpile, but needed more to fight the war. She got that by invading the East Indies, but then faced the problem of how to distribute the oil she had. The oil flowed in three ways: from the Indies to the Japanese Home

Islands and the territories close to them, from the Home Islands to the end users, and from the Indies to end users.

The trick was to balance the flows. A mix of crude oil and refined products had to go to Japan – crude for Japan's refineries and refined products to meet her immediate needs and replenish her reserves. Refined products had to go from the Indies to operational bases and units, but not at the expense of the Home Islands. Refined products went from the Home Islands to bases and units easier to supply from Japan than from the Indies, but that put pressure on her reserves.

That is where numbers become important. To understand the choices facing Japan, one must understand how oil was being produced, transported, and consumed. Understanding that requires lots of numbers – refining capacity in Japan and the Indies, what was refined in each place, crude production in both places, rates of consumption of different oil products, exports and imports, inventories and the flow of inventories, itemized by type of product, numbers and sizes of tankers used to transport the oil, how those tankers were allocated, used and lost. Japan's oil problem floated on a sea of numbers.

Problems with Numbers

Finding solid numbers for Japan's oil situation is not easy. The Oil Report provides many numbers, but with limits and qualifications. Other sources provide numbers as well, but those come with their own limits and qualifications. Comparing sources is of some help here, as is applying some common sense tests and doing a close review of the numbers that exist. The Oil Report provides the greatest volume of data and the greatest opportunity to analyze the data provided, so it is there that I will focus.

Where they had doubts, the authors of the Oil Report express them. For example, they acknowledge that they found few detailed records for oil consumption in the Indies.[10] They state

[10] Oil Report, 50. Another source says that oil records at Singapore were destroyed at the end of the war, and notes that at least some of the figures reported for the Southern Zone were "rough estimates." Jerome B. Cohen, *Japan's*

that not much is known about the production and consumption of Burma's oil.[11] They can only give a qualified view of how much oil Japan captured outright, and what became of it.[12] They footnote their statistics on Southern Zone production and refining with the observation that "some residents" of the Indies felt that the Japanese numbers were exaggerated.[13] They say that the reserve numbers at the end of the war has become inflated due to a failure to subtract losses.[14] That said, in many other areas of the report – such as Inner Zone production and consumption – they express no doubts.[15]

The accuracy of the oil numbers were subject to countervailing forces. Japan almost literally lived and died by these numbers. The Imperial Japanese Army and the Imperial Japanese Navy had been acutely aware of Japan's oil problem for years before the start of the war, and so had years to devise accurate processes to measure reserves, additions to them, and drains on them. That argues for the Inner Zone numbers – including imports from the Southern Zone to the Inner Zone – being as accurate as possible. However, the armed services were also fierce competitors for national resources, not above hiding resources from each other and inflating their own requirements. They clearly felt no compunction to share oil information with the civilian government, and likely had little inclination to provide that information to each other. They had considerable independence in acquiring oil before the Pacific War, and that independence would have given them scope to fudge their numbers if they were so inclined. There is evidence that the IJN did just that, using emergency appropriation measures to divert money into the acquisition of hidden oil reserves.[16]

While cheating probably affected the reliability of the pre-war numbers, I think that as the war continued the Oil Report numbers became fairly free of these influences. Pre-war, when the army and navy were each purchasing oil from their own budgets, they were of course each

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Economy in War and Reconstruction (Minneapolis, Minnesota: University of Minnesota Press, 1949), 140. Cohen served in the group that wrote the Oil Report.

[11] Ibid.

[12] Oil Report, 45.

[13] Oil Report, 49.

[14] Oil Report Appendix, 20.

[15] The Inner Zone included the Home Islands, Manchuria, Formosa, and the southern half of Sakhalin Island, but not occupied China, Indochina or Pacific War conquests. Oil Report, 2-3.

[16] Evans and Peattie, 408.

pushing for as large a budget as each could get.[17] This would have led them to exaggerate their oil needs and minimize their oil resources. But once the war began, their main point of oil resource competition was narrowed down to av fuel. The IJA did not use much fuel oil – the lifeblood of the IJN – and the IJN conversely used little motor fuel – after av fuel, the main focus of the IJA. Refined crude would yield all three products. This reduced the pressure on each service to cry poor in hopes of stealing the other service's oil. As the war developed, the IJA and the IJN each had unchallenged control of their own oil resources. This meant that they did not have to posture with each other; they could deal in a straightforward way. The services did cooperate, however grudgingly, in oil shipping and oil use projections. The two services did form an Army-Navy Oil Committee to coordinate oil issues. I expect that this promoted candid dealings, particularly because they could come at the expense of the relatively less powerful civilian oil Mobilization Bureau.[18] And finally, the war itself would have had a powerful tendency to eat any undisclosed reserves, forcing the services to put their cards on the table.

Oil Beyond the Numbers

The possibility of some of the Oil Report numbers reflecting distortions by the services leads naturally to a consideration of whether the numbers in the report catch all the oil that they appear to catch. Many of the Oil Report data are expressly limited to Japan's "Inner Zone" – the Home Islands, Korea, Manchuria and the Japanese portion of Sakhalin Island. What does this mean for the analysis I am attempting?

Given the structure of the Oil Report's numbers, they might fail to capture some oil beyond the exceptions that the report expressly mentions. This could have happened in a number of ways. For example, the report probably would not record oil that was purchased by one of the services for delivery outside the Inner Zone. Or it could be that not all oil coming to or leaving the Inner Zone was recorded in the numbers relied on by the Oil report. For example, fuel oil imported and then immediately transshipped to a battleship's bunkers might never find its way into the accounting of imports, reserves, and consumption that formed the basis for the Oil Report's numbers. Also, the IJA and the IJN could have imported oil to the Inner Zone, but kept it off the

[17] Oil Report, 37.
[18] Oil Report, 35-5, 38.

books as an undeclared reserve. In fact, it is probable that the IJN did this. Finally, it may be that some of the Inner Zone numbers in the Oil Report are inaccurate, incomplete, or very broad estimates.

Japan certainly had oil storage facilities outside the Inner Zone. If oil was shipped directly to these facilities from beyond the Inner Zone, that oil would probably not appear in the Inner Zone records. For example, oil delivered directly to occupied China or to naval bases outside the Inner Zone and held there would probably not have been counted as Inner Zone reserves. I have found some evidence of deliveries directly to south China and Hainan, but it is hard to quantify the effect of this. At the time, Japan was engaged in an active war with China, with an ongoing bombing campaign, making it hard to know how much oil was being stockpiled for the long term and how much was meeting immediate needs.[19] I have also found mention of av gas deliveries that are not reflected in the Inner Zone import numbers. Again, these appear to relate to the war against China, making it hard to know much of this, if any would have been stockpiled.[20]

As to oil in the Inner Zone for a short time, it is possible that this oil went unreported, but the Report's charts and tables read as if they are capturing (or at least attempting to capture) all inflows and outflows on a consistent basis. Certainly, unlike the case of oil issued directly from the Indies, the Oil Report makes no express exception for oil held in the Inner Zone for a short time. Some short-term oil may not have been captured in the numbers, but I doubt that it is significant for the analysis in this study.

And then there could be oil that came to the Inner Zone but was never declared as part of imports or reserves. This is the hardest situation to quantify, for the obvious reason that the whole point of the cheating would be to create a secret reserve. The Oil Report makes no mention of either service admitting (or accusing the other) of hiding oil, but that may not be surprising. The officers interviewed may well have been reluctant to make such accusations to their American

[19] Robert Goralski and Russell Freeburg, *Oil & War: How the Deadly Struggle for Fuel in WW II Meant Victory or Defeat* (New York: William Morrow, 1987), 96. (In the latter half of 1940, US av gas was to be delivered to south China ports and Hainan.) Edward S. Miller, *Bankrupting the Enemy: The U.S. Financial Siege of Japan before Pearl Harbor* (Annapolis, Maryland: Naval Institute Press, 2007), 173. (In the summer of 1941, about 900,000 barrels of av gas on US export licenses were for shipment directly to Manchuria or southern China.)
[20] Evans and Peattie, 407.

interviewers. That said, a source other than the Oil Report does say that the IJN hid oil purchases.[21]

One could check numbers for oil exported to Japan against the Oil Report's import numbers. If exports to Japan exceeded imports shown in the Oil Report, that would be an indication of secret hoarding. Unfortunately, I have not had much luck in unearthing reliable export data. There are two sets of exports numbers in Miller's *Bankrupting the Enemy*: one of US exports compiled by the US Department of Commerce and one of total exports compiled by the US Office of Naval Intelligence.[22] The Commerce numbers are for US exports only, ranging from 1935 through July 1941. If US oil exports to Japan exceeded imports reported in the Oil Report, that would of course lead to a conclusion that the Oil Report import numbers are probably missing substantial oil purchases, the more so because oil from other sources was reported to make up 20% of the oil that Japan imported.[23]

A quick review shows, however, that Commerce's export numbers are well under the import numbers reported in the Oil Report. The highest percentage of exported US oil to reported Inner Zone imports is in 1938, when US exports amounted to 93% of reported imports. The year 1939 comes second, with US exports equal to 90% of Inner Zone imports. In all the other years, the ratio is less than 80%. If US oil was a constant 80% of Japanese oil imports, 1938 and 1939 would be good evidence of significant oil deliveries being made outside of the Inner Zone or "off the books." But I cannot determine that the 80% ratio holds in all years. In fact, the overall percentage for the period 1935-1940, based on the Commerce Department numbers, is 75% for all oil, just over 80% for crude, and just under 70% for refined products. So the best than can be said is that the Commerce Department numbers are somewhat suggestive of imports not found in the Oil Report numbers for some pre-war years.[24]

[21] Evans and Peattie, 408.
[22] Miller, 161, 164.
[23] Oil Report, 11.
[24] In doing this comparison, I had to adjust the Oil Report numbers, which use Japanese fiscal years, to the Commerce Department numbers, which use calendar years. I did this assuming that oil purchases were constant for each quarter of a Japanese fiscal year. I used the same assumption for the ONI report.

At first glance, the Office of Naval Intelligence numbers seem to support the proposition that a lot of Japanese oil was never recorded as imports or as inventory. The ONI report's estimation of oil exports to Japan from all sources for 1936-1940 shows about 23 million more barrels exported than the Inner Zone import numbers show were imported. That is about 12% of all exports to Japan during the period, with the biggest gap in 1938.

Unfortunately, the ONI report also gets a number of things about Japan's oil situation demonstrably wrong. For instance, the report's total export number for 1936 is less than the Inner Zone import number for the year. More substantively, the ONI report reckons that Japan was importing oil at such a rate that its reserve at the end of 1940 stood at 74,495,000 barrels. This is a far higher number than any I could find in any other source. The ONI estimates of consumption are also in general markedly higher than those in the Oil Report. They are actually lower for 1936, but higher for all other years and almost 25% higher for 1938. Finally, I note that the ONI report has all US exports being 70% of the total oil exports to Japan. This is a lower number than I have seen in any historical study, including the Oil Report.

Again, I conclude that the ONI report numbers are some evidence of oil deliveries not reflected in Inner Zone numbers, but are not evidence that these deliveries were so large that they make the Oil Report numbers worthless. The ONI report was necessarily a series of estimates made with the data at hand; it could not be a detailed after-the-fact study.

One other important clue to the completeness of the Oil Report numbers comes from the IJN inventory at the start of the Pacific War. Evans and Peattie report numbers for the IJN stockpile (converted into barrels) as of December 1, 1941.[25] Here they are, compared to the Oil Report numbers for the IJN stockpile as of January 1, 1942.

Quantities in barrels of:	December 1, 1941 (Evans and Peattie)	January 1, 1941 (Oil Report)
Fuel oil	22,894,000	21,717,000
Av gas	2,980,000	2,551,000

[25] Evans and Peattie, 410, citing various post-war Japanese-language sources as authority.

Isooctane	170,000	Not reported
Motor gas	Not reported	88,000
Diesel fuel	Not reported	440,000
Aircraft lubricants	38,000	Not reported separately
Other lubricants	88,000	Not reported separately
All lubricants		126,000
Crude oil	9,041,000	Not reported separately
Products distributed to ships and bases	5,802,000	???

The numbers for fuel oil, av gas, and lubricants track nicely to the Oil Report inventory numbers, particularly as a month of war has gone by. The Oil Report does not track isooctane, and the crude holding is well within the total crude holdings shown in the report. The number for oil products already distributed, however, has no parallel in the Oil Report.

That is the most solid indication I have found that some oil was held off the books. There is no evidence that the oil in the hands of the ships and bases had previously been issued from inventoried stocks. Overall reported Inner Zone consumption declined in the first part of 1941 rather than increasing. If reported Inner Zone inventories were being used to top up ships and bases, I would expect to see a jump in reported consumption as the inventories declined. It is theoretically possible that there is no jump in consumption because the ships and bases had always been kept stocked to the maximum, but that seems inherently unlikely.

The good news here is that we can identify this additional 5,800,000 barrel cache of oil and take it into consideration. Given that the IJN accounts for the majority of the reserves, it is likely that this additional quantity represents most of the oil outside of the official Inner Zone inventory numbers at the start of the Pacific War. If the IJA had a hidden reserve, it would likely be significantly smaller, in proportion to the IJA's much lower rate of consumption. It is also very likely that any pre-war hoardings by the IJN were rapidly exhausted. Before the first year of the

war was over, the IJN was living such a hand to mouth existence with oil supplies that it is highly unlikely that it could have accumulated another significant unidentified reserve.[26]

I think that this additional 5,800,000 barrels also explain an apparent anomaly in the IJN's oil consumption numbers for the first year of the war. At the start of the war, all foreign oil sources of any significance were closed to Japan. Until she got the Indies oil flowing again, consumption had to be from her recorded reserves and from any other pools of oil held outside of the reserve numbers. But by the end of the 1942, the Indies had begun to produce substantial amounts of refined products, opening up a new source of supply. The evidence of the Oil Report is that the Indies oil was either exported to the Inner Zone, issued directly to operational units, or wasted. The Japanese interviewed by the report authors said that they never had an interest in storing significant amounts of oil in the Indies.[27]

That being the case, it is possible to estimate the IJN's oil usage by adding to its Inner Zone consumption numbers the amounts of refined products that were allocated to it from the Indies but never imported to the Inner Zone. Taking that approach, the IJN's oil consumption in the fourth quarter of 1942 would have been about 6,700,000 barrels. But its reported consumption for the first quarter of the year was only about 3,900,000 barrels. This makes no sense – the IJN was at least as active in the first quarter of 1942 as in the last. The difference can be explained by the IJN consuming oil early in the year that was not part of the Inner Zone stocks.

As I explain on further detail below, I also suspect that the inventory numbers in the Oil Report do not report all of the inventory of diesel fuel or lubricating oils. The bulk of these products were used by the civilian sector, and I expect that their inventory numbers would have therefore been harder to track accurately. As I describe below, the numbers seem to point in that direction. Given that these oil products had a relatively modest impact on Japan's overall oil picture, and on the oil problems of the IJN and the IJA, these issues do not much affect the overall analysis.

[26] Richard B. Frank, *Guadalcanal* (New York: Penguin Books, 1992), 370.
[27] Oil Report, 49-50, 57.

In all, it seems that the Inner Zone reserve probably did account for the majority of the oil held by the IJN and the IJA, that most if not all additional holdings by the IJN are identified above, that this pool was quickly depleted after the start of the Pacific War, that the IJA's relatively small demand for oil make it unlikely to have large stocks not identified in the Inner Zone numbers, and that the accounting of oil products used in the civilian sector was probably less exact than the accountings maintained by each service for its own purposes.

Actual versus Calculated Inventories

Another way to look for unreported reserves is to check consumption and production numbers against the reserves reported at different dates. The Oil Report provides data on Inner Zone inventories as of a particular date, plus data on Inner Zone consumption, production and imports. I used the consumption, production and import numbers from one period to predict the inventory for the start of the next period, and then compared the predicted number to the number reported. A discrepancy between the calculated and actual number would highlight an issue in the data, including the identification of additional reserves not previously reported being fed into the numbers. I made these calculations for fiscal years 1941 through 1944, for comparison to the reported inventory numbers at the start of fiscal year 1942 through 1945.[28]

It appears that the inventory numbers themselves were not calculated in this way, as they seldom agree exactly with the numbers derived from consumption, production, and imports. I would expect that discrepancy; all of the numbers have to incorporate a certain amount of imprecision. The fact that the inventory numbers were not just the result of the mathematical exercise I was undertaking makes the comparison process useful.

For fuel oil and av gas, the calculated numbers agree very well with actual inventory numbers. For the start of each fiscal year from 1942 through 1945, inventory numbers calculated from the prior year's consumption, production and import figures are consistently within 10% of the actual numbers. For motor gas, the numbers agree well until 1945, when the calculated number

[28] I also looked at the fiscal years 1931 through 1940, but there – with one exception – the numbers were in very close agreement. The exception was fiscal year 1935, where my calculated reserve for motor gas was 1,258,000 barrels higher than the actual reported inventory.

drops to 82% of the reported inventory number. For lubricating oil, the numbers agree closely for 1942 and 1945, but vary in 1943 and 1944. The variation suggests a timing issue, with the 1943 calculated number being above the actual number and the 1944 calculated number being below the actual inventory.

For diesel fuel and crude oil, a comparison of the actual and calculated inventory numbers shows much greater differences. For diesel, only the 1942 numbers show a good agreement. The calculated inventory number is significantly less than the actual reported inventory for all other years. For 1943, the calculated number shows a negative reserve – that is, that 1942 consumption less production and imports should have taken the reserve below zero. That cannot be right.

I suspect that this is more than a timing error. The variance has to be attributed to some combination of the consumption numbers being too high and the reserve, production and import numbers being too low. I find it unlikely that the reported production and import numbers would be too low given Japan's emphasis on producing as much refined product as possible. If anything, I would expect production numbers to be over-reported as refiners struggled to meet quotas. I would also expect imports to be tracked very carefully, given their importance.

Reserve and consumption numbers are a different matter. Diesel fuel was used primarily by the Japanese civilian sector. I think it very likely that this contributed to the inaccuracies in the numbers. When counting inventory, civilian stocks would be more likely to be held in many different locations, leading to problems in identification and counting. Hoarding would exacerbate this. Civilian reports of consumption could well have been less precise than the numbers produced by the IJA and the IJN, and may have had some built-in padding in anticipation of civilian allotments being reduced based on a percentage of past usage and in recognition of the civilian sectors lack of bargaining power when oil use allocations were set. All of this could add up to significant under-counting of reserves and over-counting of consumption.

Even with this discrepancy, the diesel oil numbers are still reasonably consistent. To give a sense of the magnitude of the issue, the cumulative difference between the actual reserve and the calculated reserve over the 1941-1944 fiscal year period is only six percent.

For crude oil, the discrepancy is slightly higher: eight percent. As with diesel, the actual reserve is higher than the calculated reserve, suggesting the same issues of under-reported initial reserves and over-reported consumption. Consumption in this case means sending the crude to refineries for processing. The amount of refined products produced is fairly consistent with the amount of crude reported as going to the refineries, suggesting that the consumption number is reasonably accurate. As with diesel oil, I think it inherently unlikely that production or import numbers were being under-reported. On balance, I suspect that the initial reserve number failed to take into account all of the crude present in the Inner Zone, and that the additional crude was found and tabulated as the oil shortage intensified. This could (and I think probably did) include crude held by the IJN in undisclosed reserves. I cannot determine this with certainty, because the Oil Report does not break out crude holdings by IJN, IJA, and the civilian sector. But if, as seems likely, the IJN was hoarding unreported quantities of refined products, it was probably holding undisclosed quantities of crude as well.

The Southern Zone

As between Oil Report numbers for the Inner Zone and Oil Report numbers for the Southern Zone, the report itself flags the Southern Zone numbers as less certain. The Indies numbers may be less certain than the Inner Zone numbers, but events show that they had a reasonable basis in reality. The Inner Zone numbers reflect significant imports from the Indies. Also, the facts show that the Imperial Japanese Navy based many of its units in the Indies to be close to fuel sources there, and supplied forward bases directly from its Indies oil resources.[29] And the Japanese made important decisions – such as sending their oil workers to the Indies at the price of neglecting their own oil industry – in the clear belief that the Indies would yield substantial oil.[30] All this supports the idea that Japan was largely successful in exploiting the Indies' oil

[29] Oil Report, 50.
[30] Oil Report, 57-9.

wealth. Finally, if there was overstating, I would expect it to be found more in refining results than in crude pumped. The evidence shows that the Japanese made a relatively straightforward job of getting the Indies oil wells producing again. They struggled more to get the refineries back into operation.[31] The Southern Zone numbers may be less certain than the Inner Zone numbers, but they do make sense in context.

Checking the Numbers against the Numbers

Another way to assess the numbers in the Oil Report is to test their own internal consistency. I hit upon two ways of doing this: by checking the individual Southern Zone refinery production numbers against reported aggregate production for the Southern Zone, and by checking Southern Zone production numbers against Inner Zone import numbers. By and large, these tests confirm that the numbers are internally consistent.

Southern Zone Refinery Numbers

For one test of internal consistency, I compared the total Southern Zone refinery production numbers in Table 50 for the individual production numbers reported for the four main Southern Zone refineries in Tables 52 through 55. Most but not all of the aggregate refining numbers for the Southern Zone correspond closely with the numbers reported separately for each of the four major refineries in the Zone. The Report says that a fifth refinery, at Lutong in northern Borneo, was out of production for most of the war. It identifies a sixth refinery at Tjepoe in Java as being about as damaged as the Balikpanan refinery. It mentions no refinery at Tarakan, although other sources do.[32]

The major discrepancies between the aggregated numbers for the individual reports and the total refined production report are for fuel oil production in fiscal year 1943 and 1944. For 1943, the

[31] Oil Report, 45-50.
[32] Morison, vol. viii, 214. Nihon Kaigun, *Tabular Records of Movement (TROMs)*, http://www.combinedfleet.com/kaigun.htm (May 2014), for Japanese tankers *Kokoyu Maru* and *Jambi Maru*. Hereinafter TROMs. The TROMs on this site are an invaluable resource for researching the activities of individual Japanese ships.

total numbers show 473,000 more barrels than the aggregated numbers of the four refineries. For 1944, they show 545,000 more barrels than the aggregated numbers. The discrepancies are useful indications that the Oil Report authors did not simply total the numbers for the four major refineries to come to the total Southern Zone refinery numbers. Where they were aware of other production in the Southern Zone, they took it into account.[33]

I expect that the explanation for the discrepancy is straightforward. It is simply that at least one other refinery, apart from the four for which individual production numbers are provided, was also producing. This may be the Tjepoe refinery coming on line, or the Tarakan refinery in production, or some combination of the two. While the Oil Report does not mention the Tarakan refinery, Morison notes that when the IJN banned Borneo crude from use as bunker fuel ships were instructed to load fuel oil refined at the Balikpapan, Tarakan or Palembang refineries.[34] The TROMs also make reference to crude being taken to Tarakan for refining and refined oil products being loaded at Tarakan.

Inner Zone Diesel Fuel Imports

I also compared Southern Zone production numbers to import numbers for the Inner Zone. Once the war began Japan had no significant source of oil imports other than the Indies. Inner Zone import numbers greater than Southern Zone production numbers would indicate an inconsistency in the numbers.

I did discover one inconsistency from this exercise. The Inner Zone import numbers for diesel fuel exceed diesel fuel production numbers in the Southern Zone in fiscal years 1942 and 1943, by 98,000 barrels in 1942 and by 501,000 barrels in 1943. I suspect that the additional diesel fuel came from a refinery in the Southern Zone apart from the four for which individual production numbers are provided. Again, this could be Tjepoe or Tarakan. In the case of diesel fuel production, however, the report authors failed to pick up the additional production in their Southern Zone production numbers. On slight evidence, I suspect that the refinery in question

[33] As I noted above, there is also an obvious type on Table 50 – a "3" in place of an "8".
[34] Morison, vol. viii, 214.

was Tarakan. The U.S. Navy review of IJN fuel technology identifies Tarakan as the IJN's principal source of crude refined into diesel fuel.[35]

Estimates and Approximations

I made one last check of the Oil Report numbers by looking for obvious rounding. I converted many of the oil report numbers into kiloliters to see whether the converted numbers wound up being in 5,000 kiloliter (or greater) increments. A lot of zeroes and fives at the end of the converted numbers would suggest a fair amount of estimating and approximating in the background. Almost all of the Oil Report numbers were taken from numbers expressed in multiples of kiloliters and then rounded to the nearest thousand barrels. I wanted to see if higher level rounding was also taking place, because this would suggest areas of greater uncertainty.

The results were interesting in their lack of uniformity. That is, there was good evidence of higher level estimating in some cases, but little evidence of it in other cases. For inventory numbers, there was good evidence of diesel fuel stockpiles being estimated at a high level in the pre-war years, some evidence of crude oil stocks being high level estimates in 1943, and no evidence of higher-level estimates for other inventory numbers. A hard look at the diesel numbers has already given me reason to think that they are incomplete as to reserves and possibly wrong as to consumption.

For Inner Zone imports, it looks as if fuel oil imports were estimated in the pre-war years and that av gas imports were estimated in 5,000 kiloliter (31,500 barrel) increments throughout almost all of the period. Inner Zone consumption numbers also look largely like high level estimates, with the odd exception of lubricating oil. For the IJN particularly, almost all the other consumption numbers are rounded to 5,000 kiloliters.[36] Crude input and refined product output at the IJN's Balikpapan refinery also appear to be higher level estimates in many but not all

[35] U.S. Naval Technical Mission to Japan, *Japanese Fuels and Lubricants – Article 1, Fuel and Lubricant Technology* (San Francisco, California: 1946), 8.

[36] The pre-war IJN consumption numbers do agree generally with the only other source that I found which speaks to them. Evans and Peattie, 407. Evans and Peattie provide a breakdown of IJN oil consumption for a year in the late 1930s that totals about 5,040,000 barrels. The Oil Report IJN consumption numbers for 1937-39 averages 5,200,000 barrels annually.

cases. There is no pattern to the differences, either by year or by type of product, but the number of zeroes and fives in the number point to some greater than usual estimation. This is bolstered by the other four East Indies refineries reporting input and output monthly while the report for the Balikpapan refinery is by fiscal year only.

Other numbers in the Oil Report appear to be estimates to the nearest thousand kiloliters. Monthly input and output numbers for the Indies refineries appear to be reported to this tolerance. Monthly production in the Inner Zone occasionally hints at higher level estimation, but is actually built up from production numbers from individual refineries and so likely to have been rounded to the nearest thousand kiloliters.

Foundation and Facade

The Oil Report gives the most comprehensive set of data on the Japanese oil situation that I have found. My review has pointed up limitations to the report, some made clear in the report itself, some emerging from a closer look at the report's numbers, and some coming from a comparison of the report to other sources. I characterize all of these limits as flaws in the facade of the report, but not in its underlying foundations. They can largely be taken into account and dealt with when examining the overall story. None are so great, either separately or in combination, that they destroy the usefulness of the Oil Report.

Getting Numbers from the Numbers

Now that I have concluded that the numbers in the Oil Report are reasonably accurate, I have to consider how to use those numbers in this study. Inventory, production, and import numbers are relative straightforward. I intend to use them largely as they are stated in the Oil Report.

Deriving consumption numbers is somewhat more complicated. The Oil Report only gives detailed consumption numbers for the Inner Zone. It gives some general guidance on oil used in the Southern Zone, but nothing like the detail provided for the Inner Zone. Getting over-all

consumption numbers from the report for either the Imperial Japanese Navy or Japan as a whole requires that some assumptions be made about both the Inner Zone numbers and the distribution of oil products in the Southern Zone.

The first question is to what extent the Oil Report consumption numbers really did capture all use of Inner Zone oil reserves. I believe that the report's numbers are substantially complete for consumption of declared reserves in the Inner Zone. It is quite clear that the numbers do not include oil issued in the Southern Zone directly to operational units. I think it very likely that the consumption numbers do not take into account the use of unreported reserves, but there are other ways to estimate that.

I think it reasonable to assume that Inner Zone consumption includes oil issued from the Inner Zone regardless of where that oil was consumed. For example, if an aircraft carrier left the Inland Sea bound for Truk with her bunkers full of fuel oil and her gasoline tankage full of av gas, I believe that all the fuel oil and av gas that she carried would be recorded as Inner Zone consumption. And if a tanker was sent to refuel the carrier at Truk, I again think that the oil that the tanker carried would be charged to consumption for the Inner Zone. Any more detailed system of recording consumption would be too complex to work. Moreover, it would carry the accounting beyond the point of the exercise, which was to record distributions from the reserve, track current use of the reserve, and project future needs. Finally, the pre-war consumption numbers track the one other estimate of consumption that I was able to find, suggesting that the consumption numbers were broadly based on charges against Inner Zone oil supplies.

I next want to establish a consistent basic view of oil production and consumption in the Indies. While reasonable minds could vary on this point, I have tried to adopt a single consistent approach to all numbers to be compared from period to period. It is not the end of the process of estimating consumption, but it provides a useful baseline. My approach to the Indies numbers is based on several elements.

- I accept that the import numbers to the Inner Zone accurately reflect oil moving from the Southern Zone to the Inner Zone.

- I assume that oil from the IJN oil resources in the Indies (of which more later) was used in the Indies or shipped directly from the Southern Zone to operating units at bases such as Truk and Rabaul. The Oil Report supports this assumption.
- I assume that the merchant marine took from the Indies refineries controlled by the Imperial Japanese Army fuel oil equal to the merchant marine's Inner Zone consumption. This based on the supposition that the Japanese would want to have as many ships as possible use Indies fuel oil rather than Inner Zone fuel oil, but that many merchant ships would be traveling to destinations other than the Indies.
- I calculate that the IJN took up to 40% of the oil refined by the IJA's Sumatran refineries, and took it in the form of fuel oil. This is drawn from an estimate found in the Oil Report.
- I assume that (apart from fuel oil) the IJA used locally or shipped directly to IJA units all the military oil products that it produced in the Indies but did not export to the Inner Zone. That would have been the Japanese intention.
- I assume that diesel fuel imported to the Inner Zone came from either the Tarakan or Tjepoe.
- I divide losses in transit proportionately between the IJA, the IJN, and crude oil, with the IJN and IJA shares based on their total usage in the period and the share of crude oil lost based on the total amount of crude oil shipped in the period .[37]

Any refined oil not accounted for above I regard as wasted. Some of the wasted oil may have been phantom production that never existed, but I lack the evidence to conclude that definitively. Whether wasted or phantom, it did Japan no good.[38]

My baseline for total consumption will in general be the sum of Inner Zone consumption for the period plus refined Indies products under IJN control, 40% of Sumatran refined production received by the IJN as fuel oil, merchant fuel oil and the rest of the Sumatran refined military oil

[37] Oil Report, 50. Oil Report Appendix, 24. See the Report for support of the 40% number and the Navy's Indies oil resources being sent directly to operational units. I admit that the merchant marine number is arbitrary, but there is no other data to use.

[38] Note that my calculation tends to minimize the possible waste of fuel oil. If the Navy had been taking some of its Sumatran allotment in av gas rather than fuel oil, overall consumption would go down and more fuel oil would potentially go to waste. The same would be true if merchant ships were being fuelled from IJN Indies resources as well as IJA resources.

products not exported, less losses and fuel oil not used by the IJN or the merchant marine. IJN consumption will be the sum of its Inner Zone consumption, its refined Indies products and the fuel oil it received from Sumatra, less losses. Where additional oil sources – such as captured stocks or unrefined crude –play a role in consumption, I will identify them.

Pre-war Problems

Japan knew that she had an oil problem, and she knew that the problem was becoming more acute over time. In 1935, her pre-war oil consumption peaked at 28,592,000 barrels of the military oil products. Against this, crude oil production in the Home Islands had reached its maximum of 2,990,000 barrels in 1916.[39] Possession of Manchuria, Formosa, and parts of China brought few additional oil resources to Japan, while her ongoing war with China greatly increased her oil needs. The government put increasing stringent restrictions on the civilian use of oil, only to see military demand drive annual consumption back up to 28,558,000 barrels in 1940.[40] In 1935, the IJA and the IJN had accounted for 18% of Japanese military oil product consumption. By 1940 that number had risen to 32%.

What was to be done? Not only was demand far outstripping sources of supply under Japanese control, but the oil available internationally could be reduced or even cut off entirely by economic or political factors. By the end of the 1930s, more than three-quarters of Japan's oil imports were coming from the United States, a country not favorably disposed to Japan's aggressions in China.[41] The Japanese government responded with a number of steps.

Most obviously, Japan had to import more oil than she consumed and so build a reserve. This she did this throughout the 1930s, trying to assemble a reserve comprised of the military oil products plus crude oil. She had varying degrees of success. Her reported fuel oil reserves peaked in 1937 and had declined 24% by October 1941, while her reserves of av gas actually

[39] Oil Report, 23.
[40] Oil Report, 30. See also, Miller, 162-3.
[41] Oil Report, 11. Miller, 164.

reached their high point in January 1942.[42] Inner Zone crude oil reserves reached their peak in 1941, and then declined quickly as Japan turned the accumulated crude into refined products.

Facilities had to be built to hold the oil reserve. Operating as they did with a high degree of separation and no small measure of mutual jealousy and suspicion, the IJA and the IJN were each quite willing to build their own storage facilities to hold the oil stocks reserved for each service. A 1934 law took up any remaining slack by requiring civilian importers and refineries to stock a six month reserve, prompting them to build storage tanks to hold the required reserve oil. Through these measures, Japan had by the end of 1941 an estimated 60,000,000 barrels of storage capacity.[43]

So Japan committed the resources necessary to build and store an oil reserve. What else had to be considered? In the pre-war period, up to half of all Japanese oil imports came on foreign ships.[44] Here was another vulnerability that Japan had to address. Even if she could buy oil not all foreign carriers might be willing or able to carry it. She responded to this issue by building up her tanker fleet, increasing its gross tonnage from 101,114 GT in 1930 to 345,849 GT in 1938 and 575,500 GT on the eve of war.[45] Many of the tankers built by the Japanese yards in the 1930s were fast ships of about 10,000 GT, meant for the run from California to the Home Islands. They would be very useful in the coming war both in importing oil from conquered territories and as oilers accompanying the ships of the Imperial Japanese Navy on combat operations.[46]

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[42] Some of the decline in fuel oil reserves may have been due to fuel oil being diverted into hidden reserves, but the amount of the decline suggests that it was not all due to such diversions. Fuel oil reserves declined by 7,258,000 barrels from April 1, 1935 to October 1, 1941.

[43] Oil Report, 16.

[44] United Stated Strategic Bombing Survey, *Japanese War Production Industries* (Washington, D.C., 1946), 3. This report says that in 1941 35% of all Japanese imports came in on foreign ships, but that "[t]he dependence on foreign tankers was particularly heavy, with about half of the oil carried into Japan prior to the war carried in foreign tankers."

[45] United Stated Strategic Bombing Survey, *The War Against Japanese Transportation, 1941-1945* (Washington, D.C., 1947), 26. Hereinafter, "Transportation Report." Oil Report Appendix, 92. Numbers in the Transportation Report are for ships over 1,000 GT. Numbers in the Oil Report are slightly higher, probably due to the inclusion of ships between 500 and 1,000 GT in the initial numbers.

[46] Many were requisitioned by the Navy. Hansgeorg Jentschura, Dieter Jung, and Peter Mickel, *Warships of the Imperial Japanese Navy, 1869-1945* (Annapolis, Maryland: Naval Institute Press, 1977), 257-9.

The next piece in this particular puzzle was a build-up of Japanese oil refining capacity. This made her much less reliant on obtaining refined products from foreign sources. Instead, she could import crude and then either refine it immediately or store it for future refining. Not only that, but increased refining capacity meant that if Japan were to conquer an oil rich area, she could use its crude without having to worry about rebuilding its refineries. Her refining capacity increased from 9,500,000 barrels annually in 1930 to almost 32,000,000 barrels per year in 1941, and then kept increasing until reaching a peak of almost 42,000,000 barrels per year in 1945, before the B-29s began targeting the oil industry.[47]

Japan's last possibility was to develop technologies that would allow her to get oil from more readily accessible raw materials, such as oil shale, coal tar, and coal. In this she was generally disappointed, so synthetic oil and oil substitutes will play no further part in this study.[48]

Planning for War

Making Projections

As the United States put Japan under increasing economic pressure to end her war in China, Japanese planners began to think more and more seriously about the consequences of a Pacific War. They thought in terms of a two year war, although their economic projections generally used a three year time horizon.[49] When they considered the issues, they confirmed that Japan could not fight on her oil reserves alone. She would require a lot of additional oil – oil that, in a war with the United States, could only be gotten from the East Indies.[50] And given that the Dutch and British had refused to sell her all of the Indies oil she wanted, she would have to go to war with the British and the Dutch to get it.[51]

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[47] Oil Report, 19: Table 6, 41.
[48] Oil Report, 41-4.
[49] Oil Report, 40.
[50] The three major oil-producing islands of the East Indies were Borneo, Sumatra, Java. The latter two were Dutch colonies; Borneo was split between a Dutch colony and a British protectorate.
[51] Miller, 158, 162. Oil Report, 30.

Japanese planners produced at least three projections of oil reserves in the months before the start of the Pacific War. Here they are in summary, with the numbers in barrels:[52]

Army-Navy Committee Study (June 1941)

Period	Estimated Reserve at Start of Period	Estimated Production and Imports	Estimated Consumption
September 1941-September 1942	61,045,000	5,035,000	37,760,000
September 1942-September 1943	28,320,000	12,901,000	34,613,000
September 1943-September 1944	6,608,000	23,600,000	34,613,000
September 1944	-4,405,000		

The higher consumption number for the first year of the war probably reflects a 3,150,000 barrel allocation for the "decisive battle," the massive naval battle that would decide the war. This study assumed that most of the first year addition would come from domestic production and synthetic oil, while the second and third year additions would have a large component of oil from the East Indies. Without the Indies oil, Japan would exhaust her reserves before the end of the second year. Even with it, she would run out in the third year of the war. That was a grim conclusion indeed.

Navy Planning Bureau Review (August 1941)

Period	Estimated Reserve at Start of Period	Estimated Production and Imports	Estimated Consumption
September 1941-September 1942	59,157,000	5,035,000	33,984,000
September 1942-September 1943	30,208,000	21,020,000	33,984,000
September 1943-September 1944	17,244,000	41,976,000	33,984,000
September 1944	25,236,000		

[52] H. P. Willmott, *Empires In the Balance: Japanese and Allied Pacific Strategies to April 1942* (Annapolis, Maryland: Naval Institute Press, 1982), 69-70. Marder, 167-8, 246n.

The IJN planners revised the estimates by assuming much higher levels of imports from the East Indies and by slightly lowering their estimates of consumption. They estimated naval consumption as 17,600,000 barrels for the first year of the war and 15,700,000 barrels for the following two years. The planners assumed 2,800,000 barrels of domestic production annually and production from synthetic oil rising to 4,500,000 barrels after three years. If only this domestic production were added to the reserve, the reserve after two years of war would stand at just under 1,300,000 barrels. At first blush, this sounds like the planners just got in under the wire with a two year war, but in fact they did not. Not included in the consumption numbers was a 3,150,000 barrel set-aside for the "decisive battle" and a 6,300,000 barrel allotment for civilian use. With these additional demands on oil resources, the reserve was again exhausted within two years unless the East Indies oil were added.

Japanese Planning Agency Review (December 1941)

Period	Estimated Reserve at Start of Period	Estimated Production and Imports	Estimated Consumption
December 1941-December 1942	52,863,000	5,349,000	32,725,000
December 1942-December 1943	25,485,000	16,362,000	31,466,000
December 1943-December 1944	10,383,000	33,354,000	29,893,000
December 1944	13,844,000		

The numbers changed, but the conclusions remained the same. The country would be out of oil before the end of the second year of war, unless Japan could get significant oil supplies from the Netherland East Indies. In addition, the consumption numbers are now becoming patently unrealistic.

Cabinet Planning Board "Budget" (start of war)[53]

Period	Estimated Reserve at Start	Estimated Production	Estimated Imports	Estimated Consumption

[53] Oil Report, 38-40.

	of Period			
First year	51,100,000	3,200,000	1,900,000	35,900,000
Second year	20,300,000	3,800,000	12,600,000	34,600,000
Third year	2,100,000	5,300,000	28,500,000	35,900,000
Fourth year	0			

This final set of numbers is interesting, as it appears to be more an oil budget than just a set of projections. That is strongly suggested by the reserve falling to precisely zero after three years of war. If Japan wanted to retain the ability to fight for three years, it would have to budget for these numbers. This was the grimmest set of numbers since the original Army-Navy Committee study, and the set perhaps closest to reality. By down-playing domestic production and revising consumption figures upward, it even more strongly stated the need for the Indies oil.

Of the first year estimated consumption total of 35,900,000 barrels, the IJN was projected to account for 17,600,000: 15,120,000 barrels of fuel oil, 1,550,000 barrels of av gas, and 930,000 barrels of other refined products. The IJA's share was 5,700,000 barrels and the civilians got 12,600,000 barrels. In the second and third years the civilian share stayed constant, the IJN's share dropped to 15,700,000 barrels – perhaps because it was to fight the "decisive battle" in the first year – and then rose again, and the IJA's share increased to 6,300,000 and then 7,600,000 barrels – perhaps to fight the China war to a victorious conclusion. [54]

Moving the Oil

There was a hidden but important issue lurking in these projections. As we have seen, all of the projections expected that large quantities of oil would be imported to the Home Islands. The planners were apparently assuming that the East Indies refineries would be knocked out and that most or all of the Indies crude oil would have to come to Japan for refining. [55] But whether the Indies oil came as crude or as refined products, great quantities would have to come to the Inner Zone – the strategic, logistical, and administrative center of Japan's military machine. Did Japan have enough tankers to move that oil?

[54] Oil Report, 38, Evans and Peattie, 410.
[55] Oil Report, 41.

The United States Office of Naval Intelligence attempted in March 1941 to estimate the Japanese ability to ship oil. Its study credited the Japanese with 520,199 gross tons of oil carriers, including 80,000 GT of IJN oilers and 100,755 tons of whale oil carriers. Excluding the whaling ships and fleet oilers left Japan with an estimated 23 fast tankers with a total tonnage of 224,095 GT and another 16 slow tankers totaling 115,349 GT. ONI credited those 39 tankers with the ability to import 30,270,000 barrels of California oil annually.[56] That amounts to each GT importing about 90 barrels of oil each year. Given that the run to the Indies was considerably shorter than the run to California, and the number of barrels to be imported in the year of highest imports – 28,500,000 barrels – was lower than the ONI's projection, was this the end of the matter?

Perhaps not quite the end. Experience in the real world suggests that the ONI's numbers were a bit high. Take *Kyokuto Maru* as an example of real world performance. She was one of the fast modern 10,000 GT tankers that Japan built in the 1930s. She managed 32 trips importing oil in three and a half years before the war. With a gross tonnage of slightly more than 10,000 GT and a carrying capacity of 93,000 barrels, her annual yield was about 85 barrels per GT.[57] *Kyokuto Maru* was a large fast ship. Other smaller slower tankers would have been less efficient than she was.

This is confirmed by a look at Japan's overall oil importing efforts before the war. Japan had 345,849 GT of total tanker tonnage in 1938, when she imported 34,000,000 barrels of oil.[58] But up to half that oil was imported in foreign ships, so let us give the Japanese tanker fleet credit for importing between 17,000,000 and 20,400,000 barrels of oil in that fiscal year. Put another way, under this assumption each GT of tanker tonnage in 1938 imported between 50 and 60 barrels of oil annually. This reinforces the fact that the real world takes its toll on these sorts of projections. Ships encountered delays in loading and discharging oil, broke down, hit bad weather, and required overhauls.

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[56] Miller, 165.

[57] TROMs. *Kyokuto Maru's* TROM does give her foreign ports of call for her 32 trips. Given that the US was the main source of Japan's oil imports, most of her trips were likely to California. But she could have hauled oil from the Indies or Russian Sakhalin also.

[58] Oil Report, 12: Table 1. Table 1 only counts crude oil and the military oil refined products. The number above assume that an additional 10% of other refined oil products were also imported. Transportation Report, 28.

So let us assume that the Japanese were able to move the Indies oil at the annual rate of 60 barrels per GT of tanker. Looking at the last set of projections, which set imports at 28,500,000 for the third year of the war, Japan would need 570,000 GT of tankers to move the crude.

Japan began the war with 575,464 GT of tankers of any worthwhile size.[59] The IJA and IJN were reserving 188,040 GT of that total for use in supporting their bases and operations, leaving 387,460 GT for other uses. Of that smaller pool, about 20,000 GT were required for use around the Home Islands, leaving 367,000 GT were available for importing the East Indies oil at the war's outset. Those tankers were capable, in theory at least, of delivering 22,000,000 barrels of oil annually against projected imports of 12,600,000 barrels in the second year of the war. So far, so good. But Japan would need another 108,000 GT of tankers working the Indies route to meet the maximum import number of 28,500,000 barrels, plus whatever was needed to replace war losses and bolster support for the IJA and IJN as they operated on the periphery of the expanded Empire. The Japanese saw this basic issue coming in due course, striving to meet it by converting cargo ships to tankers and giving priority to tanker construction at the end of 1942.[60] There was no apparent problem looming here, as long as losses were contained, the tankers were operating at something approaching their peace-time efficiency, and construction targets were set and met to expand Japan's tanker fleet in the second war year.

The make-up of the tanker fleet bears some further examination. With tankers, bigger is better. Larger tankers could handle their cargos more efficiently. They were also generally faster, more modern ships. The United States Strategic Bombing Survey report on transportation showed Japan beginning the war 94 tankers of more than 500 GT in size. Of these, the report counted 32 between 6,000 and 10,000 GT in size and another 19 over 10,000 GT. These 51 ships accounted for more than five-sixths of total tanker tonnage; they were going to be the workhorses of Japan's oil war. The 19 largest ships alone accounted for more than 40% of total tanker tonnage,

[59] Transportation Report, 32.
[60] United Stated Strategic Bombing Survey, *Japanese Merchant Shipbuilding Report* (Washington, D.C., 1947), 1, 16. Hereinafter, "Merchant Shipbuilding Report." TROMs for ships converted to tankers.

and probably more than half of Japan's ability to move oil once speed and efficiency are considered.[61]

Fourteen of the largest ships were modern fast tankers, built starting in the mid-1930s to bring oil from the US and the Indies. They were much in demand as auxiliaries to support the combat operations of the IJN, with the navy requisitioning all but two before the start of the war. Upon requisition, these ships were generally modified so that they could refuel warships at sea. The IJN-requisitioned ships would not spend all of their time in direct support of the fleet. They would also be used to move oil from the Indies to the Home Islands. But the IJN's combat operations would divert a substantial portion of the high quality ships in the pool, and expose the ships accompanying the fleet to heightened risks.

Another five of the biggest tankers were actually huge whale oil factory ships readily converted to carrying oil. The IJN also requisitioned four of these ships before the war began, using them to move oil in bulk to the IJN's forward bases. Again, a significant asset would be partly diverted from moving oil to the Home Islands, and exposed to greater risks in the bargain. These big ships presented the juiciest possible targets for USN submarines; none would survive the war.[62]

The fates of these 19 ships would be a bellwether for Japan's oil fortunes. Japan's merchant marine on the eve of war had 1,609 ships of more than 500 GT in size, but these 19 – less than 2% of the total – were going to be crucial to Japan's ability to fight the war. It was a remarkably concentrated area of vulnerability, if the Allies could find a way to strike at it.

The Start of the War and 1942: Over the Brink

[61] Transportation Report, 32. The Oil Report gives the total number of tankers as 111, with essentially the same total tonnage. Because the Transportation Report gives a breakdown by GT, I have followed its numbers here. I have confirmed the number of large tankers by cross-checking against the loss reports of the Joint Army-Navy Assessment Committee ("JANAC"). Joint Army-Navy Assessment Committee, *Japanese Naval and Merchant Shipping Losses During World War II by All Causes* (Washington DC: U.S. Government Printing Office, 1947), hereinafter JANAC.
[62] TROMs.

Reserves

What was Japan's oil situation at the start of the Pacific War? Reported inventory numbers for January 1, 1942 show that she had 28,204,000 barrels of military oil products. Together with 14,492,000 barrels of crude oil, Japan's total stocks in these categories stood at about 42,500,000 barrels, plus perhaps another 5,600,000 barrels of other oil products, such as kerosene, not essential to military operations.[63] Thus, at the start of the war Japan had less oil in reported reserves than any of the three year oil projections assumed.

Looking at the refined products reserves in detail, the fuel oil reserve was the largest by a fair margin, at 21,716,000 barrels. Almost the entire reserve was controlled by the IJN. At the projected wartime usage rate for the IJN plus civilian usage rate equal to the rate for fiscal 1940, this reserve would last just 16 months. I believe that the IJN likely had unreported additional reserves, although I also believe that these were quickly used up. If these amounted to 6,000,000 barrels in total, and 80% was fuel oil, that would extend the reserve for another three months. While civilian usage could be pared somewhat, fuel oil would have to keep flowing to the merchant marine.

The next highest reserve product was av gas, with 4,254,000 barrels lying in storage split about 60% IJN reserves and 40% IJA reserves. At the usage rates for October through December 1941, this reserve would only last for about 16 months.[64]

Motor gas reserves amounted to 1,037,000 barrels, with 60% of the reserve in the hands of the IJA and most of the rest in civilian reserves. At the usage rates for July-September 1941, the reserve would last only three and one-half months. But more than half of the peace-time usage

[63] Oil Report, 12-16. Figures for October 1 are only slightly higher than those for January 1, 1942. The major difference is a decrease of about 600,000 tons in the fuel oil reserve and of about 80,000 tons in the diesel oil reserve. These decreases almost certainly reflect Navy operations immediately before and in the first month of war. The reported IJN fuel oil reserve was a wasting asset from the start of the 1937 fiscal year. Net withdrawals in fiscal year 1940 were 3,466,000 barrels, just 157,000 barrels less than fiscal year 1941, which included four months of war. In contrast, reported reserves of av gas and motor gas actually increased from October 1, 1941 to January 1, 1942.

[64] Reported rates of consumption for the fourth quarter of 1941 also support the notion that the IJN was consuming an unreported fuel oil reserve. Reported fuel oil consumption from Inner Zone reserves increased by less than 25% between the third and fourth quarters of 1941, but av gas consumption more than doubled.

was civilian, and could be ruthlessly suppressed. Further, the numbers from the civilian reserves were likely understated, giving an additional cushion. For diesel, the reserve stood at 619,000 barrels – only enough for a bit more than a month. As with motor gas, the bulk of the consumption was civilian and so of little concern to the IJA and IJN. In addition, this was the only refined product for which the majority of the reserves were in civilian hands. If civilian reserves were understated, as seems likely, that would give an additional margin for this product.[65]

The last refined product to consider is lubricating oil, with a reserve of 533,000 barrels of oil and an expected reserve life at peacetime use rates of two months. For this product more than 90% of the use was civilian but 80% of the reported reserves were held by the IJA and IJN. The IJN's reported reserve was adequate to meet its peacetime needs for 15 months. I think that this is another example of the civilian sector being left to shift for itself, but with more reserves than reported. The evidence also points to additional civilian reserves that were not captured in the Japanese reserve figures.

The proportions of the military oil products are not coincidental. They reflect the planners' views of how Japan would fight the Pacific War. So we see that the bulk of the refined reserve is fuel oil, needed to power most of the ships of the Imperial Japanese Navy and much of the Japanese merchant marine besides. The IJN directly controlled all but 44,000 barrels of this pool. Next comes av gas, critical fighting the air battles in the Pacific skies as well as supporting the IJA in its land campaigns. Then comes motor gas, the relatively modest allotment reflecting the IJA's relative lack of mechanization. With oil supplies so constrained, the IJA had long been disinclined to developing its mechanized forces. Diesel fuel is next, the size of the reserve allotment reflecting the relative modest demand for it by the IJA and the IJN. But it was still critical as a fuel for a number of merchant ships as well as IJN submarines and some IJN escort vessels. Finally come lubricating oils, critical but not required in large quantities by the armed services.

[65] Oil Report, 62, 67-8.

The contrast to German reserves in August 1939 underscored the importance of the mix. The Germans were about to fight a war predominantly on land, with a heavy reliance on air power. While av gas was only 15% of the reported Japanese reserve of refined products, it was 22% of the German reserve. Respective proportions of motor gas were 4% and 16%. Most striking was the difference for fuel oil: 77% of the Japanese refined reserve even before considering undisclosed stocks, while naval fuel oil and naval diesel fuel combined account for less than 36% of the German reserve.[66]

Consumption: 1942

Getting good numbers for Japan's oil consumption in the Pacific War is not easy.[67] I have found a few different sets of numbers in various secondary sources, in addition to the numbers in the Oil Report. The Oil Report numbers are admittedly incomplete, measuring only consumption in the Inner Zone. One of the problems immediately evident is that the numbers measure different things for different periods. Here is a summary of consumption numbers for 1942. I have converted numbers originally expressed in units other than barrels to barrels.

Consumption Numbers by Source: 1942 (barrels)

Source	Period	IJN "Heavy Oil"	IJN Av Gas	IJN Total	Total
Evans and Peattie[68]	"First Year"			30,055,000	51,975,000
Parillo[69]	12/8/41-3/31/42	3,732,000	622,000		
Parillo	4/1/42-3/31/43	22,392,000	2,799,000		
USSBS (Inner Zone)	1/1/42-12/31/42	10,944,000	1,666,000	14,242,000	25,549,000
Cabinet	1942			17,600,000	35,900,000

[66] Chiefs of Staff Committee, Technical Subcommittee on Axis Oil, *Oil as a Factor in the German War Effort* (London: Offices of the Cabinet and the Minister of Defence, 1946) ,8. This source give reserves in tons, which I have not attempted to convert into barrels.
[67] For this discussion and generally, "consumed" means "issued to operational units," not actually burned. The Japanese could not have been tracking when each individual ship, airplane, truck and tank was consuming the fuel in its tanks. They would have instead tracked oil as it was issued from reserve stocks to operational units or bases.
[68] Evans and Peattie, 412. Willmott presents essentially the same numbers, but with less detail.
[69] Parillo, 45.

Planning Board[70]					

Other estimates fall roughly into line with these numbers. Oft-quoted is Vice Admiral Nagano's comment, made in late October 1941, that "we are expending 400 tons of petroleum" every hour.[71] Unfortunately, this is a reference to peacetime consumption and so not very helpful. Post-war, Lt. General Hoshina commented that the IJN underestimated its fuel consumption by fully 50%, which, if his reference was to the IJN estimate of 17,600,000 barrels in the first year, would point to a consumption of 26,400,000 barrels.[72] According to Evans and Peattie, an estimate of annual IJN consumption in a Pacific war done in the late 1930s generated a number of about 25,400,000 barrels, interesting because it is markedly higher than any of the numbers used in the immediate pre-war period.[73]

What emerges from these numbers, beyond blurred vision and a headache? First, while different units of measure – tons, kiloliters, and barrels – can be converted back and forth, it is harder to deal with the issues of timing. One set of the numbers is based on fiscal years, one on "war years," one on a combination of periods. The Oil Report presents numbers from the war period by calendar quarter. Inconsistencies between what is being measured also hinder straight comparisons. Evans and Peattie speak in terms of total IJN consumption and total consumption for Japan, but Parillo's numbers deal with only two refined oil products as used by the IJN: "heavy oil" (by which I presume he means fuel oil but not diesel fuel) and av gas.

Still, useful information can be extracted. First, every secondary source that I have found comments that oil consumption in general, and the IJN's consumption in particular, was higher than projected. Marder, for example, chides the Japanese for basing their consumption numbers

[70] Oil Report, 38-9.
[71] Eri Hotta, *Japan 1941: Countdown to Infamy* (New York: Alfred A. Knopf, 2013), 220. In context, the "we" in Nagano's statement probably refers to Japan as a whole. At 7 barrels to the metric ton, this would equate to an annual consumption of about 24,500,000 barrels. Another source quotes Nagano as saying that the IJN was consuming 2,900 barrels of oil an hour, and implies that Japan was consuming oil at a reduced rate of 75,000 barrels a day in late 1941. Both numbers cannot be right. I suspect that the first is a mistranslation of the Nagano statement quoted in Hotta. The second yields an annual consumption number of 27,375,000 barrels, a little less than total reported consumption in fiscal year 1940. Goralski and Freeburg, 102.
[72] Parillo, 28.
[73] Evans and Peattie, 406.

on peacetime rates of use.[74] Given the Cabinet projection of 35,900,000 barrels in the first year, it is not surprising to see a figure for total use in the first year of more than 50,000,000 barrels, and IJN use numbers ranging from 22,500,000 barrels to more than 30,000,000 against a Cabinet projection of 17,600,000 barrels.[75]

What is interesting is that this additional consumption did not come from oil reported in the Inner Zone. To reach these consumption numbers, somewhere between 15,000,000 and 25,000,000 barrels of oil had to have been consumed from sources other than Inner Zone inventories. Production in the Indies cannot account for the entire difference. In calendar year 1942, that amounted to 5,800,000 barrels not imported to the Inner Zone. Captured oil consumed during the year might account for another 4,000,000 barrels.[76] But that still leaves a gap of at least 5,000,000 barrels; one that would be at least partly filled by holdings not reported in the Inner Zone inventories. The 5,900,000 barrels cited by Evans and Peattie as oil distributed to ships and bases outside of reported reserves looks very plausible in this context.

Similar math applies to IJN usage. Taking Parillo's numbers, the IJN used 26,100,000 barrels of fuel oil from the start of the war through March 1943. The Oil Report credits the IJN with consuming a bit less than 15,000,000 barrels of Inner Zone fuel oil during this time (allowing for the use of a million barrels in December). A bit more than 4,000,000 barrels of fuel oil were refined in the Indies and available for consumption there during this period. The Oil Report credits Japan with captures of up to 4,000,000 barrels of oil in their initial offensives.[77] Say that half of this was used as fuel oil – 2,000,000 barrels. The difference – more than 5,000,000 barrels – must have come from oil not in the original inventory numbers. If the total IJN consumption number cited by Evans and Peattie is correct, at least 9,500,000 barrels of oil would have been consumed outside of the Oil Report's numbers. While the precise size varies, the

[74] Marder, 167. I think this is a bit unfair. The IJN consumed 6,808,000 barrels of oil in the Inner Zone in fiscal year 1940, while on a semi-war footing. Even allowing for an equal amount of consumption outside the Inner Zone, the projected wartime usage rate was 30% higher than the highest pre-war usage.
[75] The lower number comes from Parillo's figures, with fiscal year use divided equally into calendar quarters and the total of the first four quarters plus December 1941 multiplied by 1.1 to account for other oil products used by the IJN.
[76] Oil Report, 45.
[77] Ibid.

numbers strongly point to unreported IJN reserves of at least 6,000,000 barrels of refined products.

What are the right consumption numbers? I expect that we will never know for sure. But this is what I propose after a review of all the numbers I have seen.

Refined Products Consumed in Calendar Year 1942 (barrels)

	IJN	IJA	Civilian	Total
Total	26,500,000	8,000,000	8,000,000	42,500,000
Inner Zone	14,500,000	4,000,000	7,000,000	25,500,000
Southern Zone	4,000,000	1,500,000	500,000	6,000,000
Other	6,000,000	500,000	500,000	7,000,000
Captures	2,000,000	2,000,000	0	4,000,000

This takes the Inner Zone consumption numbers as a given. It adds refined products available for consumption from the Southern Zone, captures (which it assumes were in the form of refined products and which it splits equally between the IJA and the IJN), and an additional 7,000,000 barrels of consumption from reserves either outside the Inner Zone or otherwise not included in the Inner Zone inventory and consumption numbers. The actual numbers may have been a million barrels or so lower or two million barrels or so higher, but I struggle to accept numbers as high as those quoted by Evans and Peattie. The gap would then become so large that it strains credulity that the Oil Report would not have called attention to it.[78]

The IJN consumed 14,500,000 barrels of reported Inner Zone reserves in 1942. Most – about 11,000,000 barrels – was fuel oil, but the IJN also consumed almost half if the Inner Zone av gas burned in the year. Most of the remainder was diesel fuel: a bit more than 1,000,000 barrels of

[78] Most of the Japanese officers quoted in the Oil Report are from the IJN. They accused the IJA of being unresponsive to the IJN's needs, but there are no reports of them accusing the IJA of hoarding oil. Oil Report, 38. Oil Report Appendix, 10. Now engaging in pure speculation, I wonder if the IJN officers knew that the IJN was the greatest hoarder, and did not want to open the issue to examination. But if the unreported reserves were more than, say, 20% of the reported reserves, I would expect that the Oil Report investigators would have noticed them. They did note, for example, that non-military products constituted an additional 20% of oil not reported as part of the reserves.

it. The IJN used a total of 6,800,000 barrels of refined products in fiscal year 1940, the last year of peace. The greatly increased wartime consumption demonstrates the greatly increased demands of a full scale naval war, even before considering added consumption of Southern Zone oil products.

Balikpapan produced about 2,100,000 barrels of the military oil products in 1942, of which about 35% was av gas and another 35% fuel oil. I assume that all of that went to the IJN, given that the IJN controlled the oil fields and refineries there. Under my assumptions, the IJN got another 1,750,000 barrels of fuel oil from the IJA refineries in Sumatra, with the rest going to the merchant marine or being imported to the Inner Zone. Finally, the IJN got another approximately 300,000 barrels of fuel oil from either the Tarakan or the Tjepoe refineries.

Another possible addition to the IJN's consumption was unrefined crude not sent to the Inner Zone. This could be no more than 2,700,000 barrels. The IJN did use crude as bunker fuel for some time, but discontinued the practice due to the sulfur in the crude damaging boilers and the volatile elements in the crude posing a fire and explosion hazard. I was not able to determine when the practice began or ended. The reference to the practice suggests that only the IJN's Borneo crude had been used in that way, which would reduce the amount of crude available as a fuel oil substitute.[79]

One way to do a reality check on IJN consumption is to compare it to the oil consumption of other forces at other times. These numbers are surprising hard to find, but Samuel Elliot Morison does give an example for the United States Navy in the Palau and Leyte operations. He states that in the period from September 2, 1944 to October 31, 1944, USN service forces provided 4,500,000 barrels of fuel oil and 173,000 barrels of av gas to Third Fleet. For the period September 2, 1944 to January 23, 1945, deliveries totaled 8,250,000 barrels of fuel oil and 339,000 barrels of av gas.[80] At that time, Third Fleet was roughly equal in size to the first line

[79] Morison, vol. viii, 214-6. Borneo crude was once again allowed as bunker fuel beginning in May of 1944, as a means of giving the Navy enough fuel to fight the Battle of the Philippine Sea from a base in the southern Philippines.
[80] Morison, vol. xii, 76.

Japanese fleet at the start of the war.[81] Assuming, as seems reasonable, that deliveries to Third Fleet were roughly the same as consumption during the period, theoretical annualized consumption for Third Fleet would be between 22,000,000 barrels and 28,500,000 barrels. Third Fleet was actively engaged in combat operations during this time period, with long periods of sustained activity in combat areas involving all ships in the fleet. The Imperial Japanese Navy was larger and had generally less fuel-efficient power plants, but also operating under more stringent fuel constraints and at a somewhat less intense tempo, so the 26.5 million barrel number given above again seems reasonable.[82]

Another rough reality check is to compare IJN consumption to the theoretical consumption of the ships in the fleet. This piles assumption on assumption, but hopefully the inaccuracies cancel each other out. I seize on three numbers to attempt this. Evans and Peattie say that the IJN used about 1,150,000 tons of fuel in the Midway, Marianas and Leyte battles.[83] Parillo says that the Marianas consumed 200,000 tons and Leyte 150,000 tons.[84] Parillo's numbers are roughly comparable to my calculations of bunker capacity of the ships involved in these two operations plus the cargo capacity of the tankers that accompanied them. Subtracting Parillo's numbers from the 1.150,000 total would leave 800,000 tons for Midway: a one month period of maximum effort. Assuming that the IJN operated on average at 40% of its maximum tempo would yield an annual consumption of 26 million barrels, while a tempo of 50% of maximum would exceed the high number cited by Evans and Peattie.[85] Again, I think that this points to the 26.5 million barrel number being reasonable.

With a fair sense of overall IJN consumption, it is illuminating to look at that consumption in the first and last quarters of 1942. As I have said, Indies production was not a factor in the first

[81] Relative numbers were: Third Fleet, 9 fleet carriers, 8 light carriers, 6 battleships, 17 large cruisers, 2 small cruisers, and 62 destroyers; Imperial Japanese Navy: 6 fleet carriers (with a net loss of 2 during the year), 3 light carriers, 10 battleships (with 2 more joining during the year), 18 large cruisers, 20 small cruisers, 67 fleet destroyers. The Japanese fleet also included 61 old destroyers, 16 torpedo boats and escort vessels, and a variety of auxiliaries, small craft, and submarines. Morison, vol. xii, 424-8.
[82] A review records of movement for *Tone* and *Zuikaku* for the period December 1941 through December 1942 shows that they were active about 60% of the time. These were two of the most active ships in the IJN during the first year of the war. Looking at *Nagato's* record for the first half of 1942, I estimate that it was steaming less than 30% of the time. TROMs.
[83] Evans and Peattie, 410.
[84] Parillo, 42.
[85] Ibid.

quarter of 1942, and Japan had no other source of significant imports. And consumption from captured stocks likely took place in the second and third quarters, not the first or fourth. While consumption undoubtedly varied somewhat throughout the year, there is little reason to think that IJN consumption in the first quarter was any less than consumption in the fourth.

Focusing on fuel oil, we see that the IJN reported consumption from Inner Zone stocks of about 3,000,000 barrels in the first quarter of 1942. Using the proportions based the IJN's declared usage of Inner Zone reserves, the IJN used about 20,000,000 barrels in total or about 5,000,000 barrels a quarter. As we have seen, there is good evidence that the IJN drew on unreported reserves at the start of the war, and it would need to in order to raise its reported Inner Zone consumption figure to match the amount of oil that it actually consumed. However, by the fourth quarter of 1942 the Indies refineries have begun producing. The IJN's Inner Zone fuel use for the period is about 2,800,000 barrels; about 2,000,000 was available to it in the Southern Zone. Now the fuel oil in the Oil Report numbers comes close to matching the IJN's likely consumption. I no longer have to impute the existence of a large separate reserve. In fact, the evidence strongly suggests that by the end of 1942 that undisclosed reserve was mostly exhausted.

Assuming generally that refined products were drawn from the captured stocks and unreported inventories in the same proportion as reported for Inner Zone consumption, Japan used about 22,000,000 barrels of fuel oil and 5,900,000 barrels of av gas in 1942. These numbers would exhaust Japan's remaining reserves of fuel oil and av gas in August of 1943. Her reported crude oil reserve would only yield a bit more than 2,000,000 additional barrels of av gas and a bit less than 7,000,000 more barrels of fuel oil, extending both reserves to December 1943.[86]

The planners had been very wrong about consumption, but they had been clearly been right about one thing: Japan needed the oil from the East Indies to fight a three year war, and even fighting a two year war looked worrying unless she could get the oil flowing. Fortunately for Japan, her quest for the oil of the Indies looked to have succeeded beyond all expectation.

[86] Yield is based on the yield that Japan achieved in 1942, when she refined an amount of crude slightly greater than her pre-war reserve.

Exploiting the East Indies Oil

The East Indies had rich oil reserves and a well-developed oil industry, but to take advantage of it, Japan had to invade them, secure them, get the wells working again, get the refineries on line, get the crude to Japanese or Indies refineries, and get any Indies-refined products to where they were needed.[87] These imperatives shaped Japan's planning and drove her actions for the first few months of the war.

Japan had all of the Indies secured by the end of March 1942. As soon as she could, she sent thousands of specialists to the Indies oil fields and refineries in a concerted attempt to get the oil flowing again. Sending the specialists out of the country denuded Japan's own oil industry, but the prize was worth the cost.[88] In fact, by February 1942 Japan was actually downgrading the priority of her domestic oil industry in anticipation of oil from the Indies.[89]

Administration of the oil-producing regions was divided between the IJA and the IJN, with the IJA controlling 85% of the region's production and the IJN confined to a few oil fields and refinery resources in eastern Borneo. This allocation was clearly not based on the relative needs of the two services. It came about because the IJA had occupied the western and southern oil regions and the IJN the eastern region. The fact that the IJA had oil that the IJN needed led to some intense bargaining between the two. According to the IJN officers participating in the process, only the IJN's control of tankers kept the IJA from ignoring the IJN's requests.[90]

The Indies wells had produced 65,100,000 barrels of crude oil in 1940; Japan was able to get the wells working again in fairly short order, reporting that she lifted 25,927,000 barrels in fiscal year 1942. Restarting the refineries proved a tougher task. Of the five major refineries in the

[87] In addition to the East Indies, Japan also secured significant oil resources through the occupation of Burma. However, these resources were apparently appropriated by the Japanese Army for local use. They do not appear in the Oil Report or its appendix. Oil Report, 50.
[88] Oil Report, 57-9.
[89] Oil Report, 57. Another source gives the date as February, 1943. Jerome B. Cohen, *Japan's Economy in War and Reconstruction* (Minneapolis, Minnesota: University of Minnesota Press, 1949), 142.
[90] Oil Report, 38.

Southern Zone, the largest Sumatran refinery was captured virtually intact and put into operation within three months, two (including the IJN's refinery at Balikpapan) were operating by September 1942, although at reduced capacities, one began limited production in January 1943, and one was so thoroughly demolished that it was restored only in the waning months of the Japanese occupation.[91] Despite the problems, the four major Indies refineries reported production of 14,468,000 barrels of the military oil refined products in fiscal year 1942, refining almost 60% of the crude produced locally and converting about 94% of that crude into products needed by the war machine. Even better, the Japanese were able to tweak the mix of products to meet their wartime priorities. Before the war, 7% of the output of the Indies refineries had been av gas and 28% had been fuel oil. In the first fiscal year of production under Japanese control, reported av gas output was raised to 20% of the total and fuel oil to 47%.

Japan had planned to move most of the Indies crude to the Home Islands for refining. Now that she had some unexpected capacity in the Indies refineries, the need to import crude diminished. But Japan still had to move oil to the Inner Zone. Not all the oil could be refined in the Indies, as refinery capacity lagged crude production. And she needed to maintain her reserve and support military operations that used Inner Zone locations as sources of supply. The Home Islands were the strategic center of the Empire; Japanese plans called for many of the IJN's units to be stationed there, and the Inner Zone was the logistics base, training area, and aircraft production center for the rapidly expanding IJA and IJN air forces. It was a magnet for oil.

What did Japan do with the bounty of the Southern Zone? It appears that the IJN was content to supply as many of its units as possible directly from the Indies. The IJN refinery at Balikpapan was in operation in fairly short order, processing crude from the IJN's Borneo fields, and crude from those fields gave a good yield of the products the IJN most needed: av gas and fuel oil.[92] Being in the easternmost oil territories occupied, the oil was reasonably close to the active war zones in the southwest Pacific. I suspect that very little of the Borneo oil made its way back to the Inner Zone. In fact, the Oil Report's evidence is that the IJN required additional production

[91] Oil Report Appendix, 76.
[92] Oil Report, 50.

from the IJA's Sumatran resources to meet its ongoing needs.[93] This is reflected in the relatively small amount of fuel oil shipped from the Indies to the Inner Zone: only 345,000 barrels imported from 6,963,000 barrels produced by the Indies in fiscal year 1942.[94] It is likely that some diesel fuel went to the Inner Zone as well, but in relatively modest quantities.[95] The effect of the IJN drawing oil from the Indies can be seen in the fuel oil it drew from Inner Zone reserves, peaking in the third quarter of 1942 (at 2,893,000 barrels) and then declining in every quarter thereafter.[96] Well and good, but as we will see the Inner Zone fuel oil reserve was still a wasting asset.

Balikpapan produced about 4,575,000 barrels of the military oil products in fiscal year 1942, of which about 30% was av gas and another 30% fuel oil. I assume that all of Balikpapan's products went to the IJN for consumption in the Southern Zone, given that the IJN controlled the oil fields and refineries there.[97] The IJN got another approximately 466,000 barrels of fuel oil from either the Tarakan or the Tjepoe refineries for use in the Southern Zone.

The IJA's Indies refineries produced 9,241,000 barrels of the military oil products in fiscal year 1942, including 1,615,000 barrels of av gas and 5,083,000 of fuel oil. The IJA retained 892,000 barrels of av gas and 990,000 barrels of motor gas in the Southern Zone, while I assume that the IJN received 3,790,000 barrels of fuel oil and the merchant marine received 1,238,000 barrels of fuel oil – almost all produced – from the IJA's Southern Zone refineries.

Inner Zone imports of av gas in the period – 723,000 barrels – were less than half the refined amount, and about a quarter of Inner Zone production. Total refined imports in the period were 2,378,000 barrels, about a quarter of the IJA's refined production of military oil products. In the same period, the Inner Zone imported 8,146,000 barrels of crude oil.

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[93] Oil Report, 50.
[94] Oil Report Appendix, 19, 77. I use the fiscal year here (which ran from March to March) to give the production, refining, and import system more time to start working.
[95] These exports are not recorded (or at least not all recorded) in the Southern Zone production figures, but are shown in the Inner Zone import numbers.
[96] Oil Report Appendix, 24.
[97] While this assumption may be slightly overbroad, a review of the TROMs of the big *Itsukushima Maru* class tankers shows many trips starting at Balikpapan and ending at IJN bases in the central and southern Pacific.

On the face of it, the mix of imports is puzzling, as one would think that Japan would use its finite tanker resources to import as much high demand product – such av gas – to the Home Islands as it possibly could. With crude imports, a certain amount would wind up as lower demand product, such as motor gasoline, or as non-military products, or simply be lost in the refining process.

Five things explain this. First, Japan was taking a certain amount of crude directly from Northern Borneo, where the refinery had been thoroughly demolished. Given that the other recommissioned Indies refineries had more crude than they could handle, it made sense to send this crude directly to the Home Islands. This accounts for some of the crude, but not all of it, as I estimate north Borneo production as only about 3,920,000 barrels during fiscal year 1942.

Second, an element of bureaucratic initial may have crept in here. The Japanese planners had planned on bring crude, not refined products, back from the Indies, so crude got shipped. Perhaps, but I do not see this as a major factor.

Third, we may be seeing some inefficiencies in the shipping process. Tankers may have called to be filled with av fuel, but if none was available they were sent away filled with crude. This very likely to be a factor, but unlikely to be a major one. The Southern Zone refineries did have their fits and starts, but they were not out of operation for long time periods once they began production.

Fourth, some of the refined product got left behind for issuance direct to operational units. This is significant because it plays directly into consumption issues. To get a clear picture of Japan's oil situation, consumption both within and without the Inner Zone has to be considered. Refined product left behind, especially high value product such as av gas, is an important clue to overall consumption levels. Japan would try very hard not to waste it. If it could not be added to the Inner Zone reserve, it would be consumed. For the last calendar quarter of 1942, total consumption (calculated on the basis described above, which assumes use of most of the

unexported refined product) would have been 9,900,000 barrels.[98] If most of the un-exported oil was being used, consumption was spiraling well beyond pre-war expectations. And that is without adding in the possible use of unrefined crude as bunker fuel, as discussed below, or captured stocks. I think that this is the most significant factor in accounting for the refined products produced in the Southern Zone.

The final factor to consider is waste. As I have said, I doubt that av gas was wasted if by any means it be saved or used. But fuel oil is a different matter. Much of the Indies fuel oil was being produced in IJA-controlled refineries. The IJA did not need fuel oil; its priorities were av gas and motor gas. Unless the IJA was willing to set aside storage facilities to hold the unshipped fuel oil – and the Oil Report authors were told that the Japanese did not want to store excess production in the Indies – the unshipped product would simply be burned or pumped back into the ground.[99] In making a choice between shipping crude or fuel oil to the Inner Zone, the IJA would always pick crude. Crude could be refined into some av gas and motor gas. Fuel oil could not. The IJN could carry away any fuel oil that was available, using its own resources, but any left behind was burned or dumped. [100]

Why was oil not stored in the Indies for future consumption or refining? It would be logical to suppose that oil was stored there, but that apparently did not happen. The shortages to come and the evidence of the Oil Report strongly suggest that this was not the case.[101] Japan's reluctance to accumulate oil reserves in the Indies is puzzling, but the Oil Report says that Japan controlled output to only produce as much oil as tankers were available to carry it. The Oil Report appendix adds that "Japan did not wish to build up reserve stocks of oil to serve as bombing targets."[102] That is an odd rationale. Both the Oil Report and the Oil Report appendix attribute the burning or dumping of refined products to the effects of the Allied blockade, but the

[98] Annualized, the last quarter number would exceed the gloomiest consumption number in any of the pre-war oil projections.
[99] Oil Report, 49-50, 57.
[100] Under my assumptions, about 225,000 barrels of Indies fuel oil were wasted in October-December 1942. The waste number fluctuates in 1942. It even shows a surplus in the third quarter, in which more oil is consumed than produced, likely due either to captured fuel oil being fed into the system or to an overestimation on my part of fuel use by the merchant marine. But the deficits increase in 1943 and 1944.
[101] Oil Report, 49-50, 57.
[102] Oil Report Appendix, 83.

production versus export numbers strongly suggest that these practices started well before the blockade began to bite. It may be that the wells and refineries had limited storage facilities designed to hold only working stock, but the ex-British naval base at Singapore, built to accommodate a sizeable fleet, must have had significant oil storage.

The absence of reserves in the Indies also points to another potential waste issue: waste of crude oil. About 2,700,000 more barrels of crude were reportedly lifted in the East Indies in 1942 than were refined or exported. Some of it might have been used in unrefined form as bunker fuel, but it was probably otherwise wasted. Crude produced exceeded crude refined or exported by even greater margins in 1943 and 1944, suggesting that much of that crude was wasted also.

Domestic Production: 1942

Japan's home refineries were busy in 1942, producing 16,482,000 barrels of the military oil products. The bulk of these products came from crude oil, and the bulk of the crude came from Southern Zone imports and the Inner Zone stockpile. Reflecting the refining activity in the Inner Zone in 1942, crude oil declined from being a little more than a third of the Inner Zone reserve to being a little more than a quarter. In absolute terms, crude in the reserve declined from 14,492,000 barrels to 7,677,000 barrels, even with the Indies imports and domestic production. Japan's refineries were operating at half or less of their maximum capacity during the year. Sending experienced workers to the Southern Zone may have reduced these refineries' actual capacities below their maximums, but probably didn't halve them. In fact, Japan continued to build out the capacity of their refineries in 1942, ready to take in crude oil not being refined in the Indies.[103] But additional crude did not arrive.

Moving the Oil: 1942

We have seen that Japan's plans called for much of the Indies oil to be moved to the Inner Zone, either as crude to be refined or as finished products to replenish the central reserve. In calendar

[103] Oil Report, 65.

year 1942, Japan devoted an average of 41 tankers to Indies imports. The average GT committed was 342,805, and from July 1942 on accounted for more than half of all tanker tonnage afloat. The average GT rating of each tanker was almost 8,300 GT, indicating that Japan was assigning her larger, faster tankers for this duty.

With an average return of 60 barrels per GT of tanker, Japan could have expected to import more than 20,500,000 barrels of oil from the Indies had it been available. In fact, her yield was much closer to 33 barrels per GT committed. She imported 1,557,000 barrels of refined products and another 6,087,000 barrels of crude. She left 2,700,000 barrels of crude in the Southern Zone, some of which may have been used as fuel oil but much of which was likely wasted. Looking at the number and average GT of tankers used in the fourth quarter, after the import system had some time to get up and running, barrels equivalent to between 55 and 60 tanker loads of oil were delivered to the Inner Zone while an average of 52 tankers was employed on the import run. With oil going to waste in the Indies, this was not an impressive performance. But at least tanker losses were negligible, and Japan was able to add 107,082 GT of new, converted and captured tanker tonnage to her pre-war total.[104]

While Japan's tanker losses in 1942 were low, with none of her largest 19 tankers being lost, the Japanese had made plans throughout the year to increase tonnage. She had lost more than a million GT of shipping since the start of the war, but this was within the range predicted at the start of the war.[105] USN subs had not yet racked up an impressive score of sunk tankers, but the IJN would have been aware that a number of attacks that should have been successful had been thwarted by torpedo problems.[106] Despite the low losses of tankers and the generally acceptable level of merchant ship losses overall, plans for tankers to be built in fiscal year 1943 increased steadily, starting at 43,740 GT in December 1941, but evolving through six different plans until it reached the figure of 235,810 GT in March 1943 – just before the start of the 1943 fiscal

[104] Transportation Report, 118.
[105] Cohen, 254.
[106] Transportation Report, 117-8. Perhaps the best example of torpedo failures was *USS Tinosa's* July 1943 attack on *Tonan Maru No. 3*, in which *Tinosa* fired at least seven dud torpedoes at the damaged and stopped tanker. From this and many prior incidents, the Japanese must have been aware that the toll in sinkings would increase significantly if the USN every managed to fix its torpedo problems. Clay Blair, Jr., *Silent Victory: The U.S. Submarine War against Japan* (Philadelphia: Lippincott, 1975), vol. i, 408-9.

year.[107] Only one of the 19 big tankers had been lost by that date (plus two oilers), counterbalanced by the capture of five big tankers in the first year of the war and the conversion in early 1943 of more than 100,000 gross tons of freighters and transports for use as tankers. It is unclear precisely what drove the increase in numbers, but it was almost certainly was a combination of anticipated losses, a desire to move more oil from the Southern Zone, and a need to bolster support for units at far-flung bases.[108] Many of the conversions were of ships already requisitioned by the IJN as transports, reflecting a change in emphasis from invasions and troop reinforcements to moving oil to the fleet and the Home Islands.

Budget Comparison: 1942

A comparison of the Cabinet Planning Board budget to the results obtained helps to summarize the oil picture in 1942:

	Reserve at Start of Period	Production	Imports	Consumption – Inner Zone	Consumption – Other	Reserve at End of Period
Budget	51,100,000	3,200,000	1,900,000	35,900,000	0	20,300,000
Actual[109]	42,500,000	4,500,000	8,500,000	25,500,000	17,000,000	30,000,000

The reserve computed for the actual results agrees closely with the January 1, 1943 inventory taken by the Army-Naval Oil Committee: 28,048,000 barrels. Much of the difference can be attributed to the fact that most of the crude in the initial reserve had been refined by the end of 1942, with the inevitable loss of oil in the refining process to non-military oil or in the process itself.

[107] Merchant Shipbuilding Report, 44.
[108] Transportation Report, 118. Jentschura, 250. In this study, "tankers" refers to oil carrying ships built for the merchant marine and "oilers" to oil carrying ships built for the Navy. Functionally, a number of the tankers requisitioned by the Navy for fleet support operated as oilers. For gross tonnage losses, I have relied primarily on the loss numbers provided in the Transportation Report rather than the comprehensive review of Japanese shipping losses undertaken by the Joint Army-Navy Assessment Committee ("JANAC"). While the JANAC numbers are almost certainly more accurate, they usually do not identify as tankers ships that Japan converted from general cargo carriers to tankers. Nor do they usually count as losses ships that were damaged but not repaired. My comparison of the Transportation Report numbers to the JANAC numbers indicates that they are not very different where tanker sinkings are concerned. For numbers of ships sunk and the particulars of each ship, I have relied on JANAC.
[109] "Consumption – Other" reflects calculated Southern Zone consumption plus 6,000,000 barrels of captured oil and "off the books" reserves.

This analysis shows Japan with more than two-thirds of her Inner Zone reserve intact, against a budget-prediction that the reserve would be more than half depleted. The same analysis done for av gas appears even more promising, with the reserve at more than five-sixths of its January1942 levels. For fuel oil, the results are only a bit more worrying, with reserves at about two-thirds of their January 1942 levels. As noted, the level of crude had declined, from about one-third of the January 1942 reserve to about one-quarter of the reserve in January 1943. Year to year, the amount of crude in the reserve had dropped by almost half as Japan's refineries processed the crude into refined products. Consumption was considerably higher than predicted, but unreported reserves and an unanticipated early bounty from the Indies seemed to have more than made up for that. By putting both the wells and the refineries of the Southern Zone back into operation quickly, Japan had been able to shift consumption away from the Inner Zone reserve and provide imports to keep the reserve from declining too drastically. As the wells and refineries got back into production, Japan's prime minister pronounced the oil problem solved.[110] But the southern cornucopia was masking problems, and these problems would start to emerge in 1943.

On the Downward Slope: 1943

Moving the Oil: 1943

Japanese tankers suffered few losses in 1942, but 1943 saw the escalating Allied war on the Japanese merchant marine start to pay dividends. Japan lost only 9,553 GT of merchant tanker tonnage in calendar year 1942, plus another 10,000 gross tons of fleet oilers. That would accelerate dramatically in 1943, with losses mounting to 174,552 GT of merchant tankers and another 20,000 GT of fleet oilers. [111] Tanker losses as a percentage of all ships lost increased as well, from a mere 1% in 1942 to 10% in 1943.[112] Tanker losses were still proportionately lower

[110] Oil Report Appendix, 12. Cohen dates the announcement to February 1943. Cohen, 142.
[111] Transportation Report, 118. Jentschura, 250. I have estimated the gross tonnage of the oilers based on the displacement numbers provided in Jentschura.
[112] Transportation Report, 117-8.

than losses to other merchant types, but the trend was not comforting. Many of Japan's losses in the first year of the war came from transports and cargo ships committed to active combat zone, such as Guadalcanal. In 1943, the weight of the Allied attack was shifting deeper into the Empire. Japan ended the year with more tanker tonnage afloat than at its start, but the late-year trend was alarming. Of the 19 big tankers that she had at the start of the war, five were lost in 1943.[113] New tanker production was coming into service, but those tankers were also taking losses.

I would expect the IJN to be particularly alarmed. It depended on tanker tonnage to supply its forward bases and accompany its fleets into combat. These needs grew as Japan's Pacific defense perimeter had grown, both because of the increased distances and because the IJN's relatively undeveloped forward bases required it to use tankers as floating storage tanks. The dangers to this tonnage are reflected in the IJN having lost more than half of its pre-war fleet oilers in the first two years of the war. In January 1942, the IJN had 28 merchant tankers and fleet oilers supporting it directly, totaling 186,200 GT.[114] By January 1944, the number had shrunk to 19 and gross tonnage to 126,800.[115]

The number and tonnage of tankers supporting naval bases had grown, from 12 tankers in January 1942 to 36 by January 1944, but these were a different breed entirely: small ships not quite averaging 1,600 GT each.[116] Despite the tripling of numbers, gross tonnage went up by less than 22,000. These ships would not have been able to service the fleet in combat operations, while their small size would have impaired their effectiveness even for base supply. Put against the backdrop of the IJN's expanded commitments, ranging in 1943 from the Aleutians to the Solomons, this was not a healthy trend. The IJN undoubtedly wanted more tankers, not fewer, but oil exports to the Inner Zone were being given priority and the tanker pinch was on.

[113] JANAC.
[114] Jentschura, 250.
[115] Jentschura, 250-1.
[116] Combined gross tonnage for tankers and oilers dedicated to supply of naval bases and the fleet was 220,000 in January 1942 and 179,200 in January 1944. The average GT of tankers engaged in base supply had dropped from just over 2,800 GT to just under 1,600 GT, giving the definite impression of a barrel's bottom being scraped.

That pinch showed itself in another striking way. On the surface, oil exports from the Southern Zone were booming, almost doubling from 7,644,000 barrels in 1942 to 14,556,000 barrels in 1943. And the number of tankers engaged in exporting was generally rising as well, from 57 at the beginning of the period to 91 at the end. But a closer inspection reveals that all was not well.

At the start of the year, the 57 tankers working the Indies-Inner Zone route had a respectable average GT of 8,000, an indication that newer, faster, more efficient ships were still predominating. The average gross tonnage of the 91 tankers at the end of the year had declined to 6,800 GT. Japan was trying to move more oil, but with less capable ships. A look at the efficiency with which the oil was being carried underlines the issue. The second quarter of the year had seen the highest efficiency, with almost 8.5 barrels imported for every GT. By the October –December quarter, efficiency had fallen to a bit less than 6 barrels per GT, and the average annual import rate decreased from 33 barrels imported for every GT on the route in 1942 to 26 in 1943. Barrels imported in the fourth quarter were 20% off their second quarter peak, despite more ships and greater GT committed to the Indies-Inner Zone route.

Why was this? It was apparently not a lack of oil in the Indies. Both production and refining were reported to be strong in calendar year 1943, with crude production rising throughout the year and refinery output rising in the first half and plateauing in the second. More and more crude oil was being left behind in the Indies: in the second quarter about 30% of available crude stayed in the Indies; by the fourth quarter about 55% of the available crude was being left behind.[117] Refined products produced in the Indies could be sent directly to the units using them, but there was no reason to leave unrefined crude there if it could be helped. The Home Island refineries had plenty of excess refinery capacity to process the crude.[118] It is quite likely that this crude went to waste – more than 5,000,000 barrels of it in 1943. Clearly, Japan was running up against the limit of what she could move from the Indies to her Inner Zone.

Worse still, Allied efforts to block the oil route began to bite. The number of USN submarines in the Pacific had been rising, and would more than double between February 1943 and May of

[117] The percentage of refined products remaining in the Indies remained almost constant between the two quarters, at about 84%, supporting the idea most of those products were being issued directly from the Indies.
[118] Oil Report, 43.

1944.[119] United States Navy subs had been hampered by faulty torpedoes; by September 1943 these bugs had finally been sorted out.[120] It was no coincidence that in the last two months of 1943 USN subs accounted for almost 40% of all tanker tonnage put out of action during the year. Tanker losses for the year totaled 173,552 GT, with another 30,125 GT of fleet oilers sunk or put permanently out of action. [121]

A look at submarine sinkings in the last quarter for 1943 highlights the reasons for concern. The post-war Joint Army-Navy Assessment Committee credits USN submarines with 10 tankers and an oiler sunk in that period. In addition, USN subs damaged 3 more oilers so severely that they never operated again, and the Japanese had the misfortune to lose a large tanker to a typhoon. Of the 14 successful sub attacks, 11 took place either in the East Indies or on the tanker route to Japan. Clearly, the USN was taking the war directly to Japan's oil lifeline. Three of the tankers sunk by subs had GTs of more than 10,000, indicating that the subs were striking at the larger ships. Ten percent of Japan's tanker gross tonnage wound up on the bottom in this single quarter. For the IJN's supporting tankers, the results were even worse: of the 25 tankers and oilers supporting the fleet in October 1943, only 18 remained afloat by January 1, 1944.[122] Thanks to construction efforts in the year, new tanker tonnage barely kept up with losses, but the IJN received very few new tankers or oilers to support its warships.

Increasing effective submarine attacks affected Japanese tanker movements in ways beyond the direct effects of sinking tankers and their cargos. Convoy systems had to be devised, escorts found, and evasive routing implemented, all in an attempt to mitigate the growing submarine menace. Longer routes and reinforced escort forces burned more fuel. Allied mining efforts, focused on the Indies oil ports, imposed delays, caused losses, and required extensive minesweeping efforts. [123] All this had the effect of decreasing the effectiveness of the tanker fleet. Ships swung at anchor waiting for convoys to form or for mines to be swept. Voyage times lengthened as the convoys moved at the speed of the slowest ship while trying to evade the

[119] Morison, vol. vi, 66.
[120] Morison, vol. viii, 16.
[121] Transportation Report, 118. Jentschura, 249-50.
[122] Jentschura, 249-53. JANAC. I have counted losses close to oil sources and on oil convoy routes as losses to the tankers allocated to moving oil to the Inner Zone. Some of those tankers may in fact have been allocated to the IJN for fleet or base support, which would make the IJN's situation at the start of 1944 that much more dire.
[123] Oil Report, 52-7.

subs and stay within range of land-based anti-submarine aircraft. As Japan gave priority to moving Indies oil to the Inner Zone, more and more tankers were allocated to that task, taking tanker resources from the fleet. All of this played a major role in choking off Japan's ability to get oil to where she wanted it.[124]

Worse, the Japanese countermeasures to the American submarine offensive, while logical, were largely ineffective. A major but hidden benefit of convoying is that it reduces the likelihood of submarines sighting ships. If ten ships travelled the same route independently, chances of a sub in the vicinity sighting at least some of the ships is relatively high. If the ships travel together in one concentrated group, the chances of the group being sighted goes down significantly.[125] But that benefit evaporates if the enemy knows the convoy's route and location. And evaporate it did, as the Americans managed to read the Japanese codes.[126] Once a convoy is intercepted, its second advantage comes into play – better defense through the concentration of anti-submarine forces protecting the convoy. This advantage was lost to the Japanese due to the IJN's poor anti-submarine warfare capabilities. Escort vessels were stretched thin, doctrine was undeveloped, training was poor, and equipment was sub-standard. In these circumstances, convoys were increasingly likely to become deathtraps rather than lifesavers.

In addition to taking more, if ineffectual, steps to safeguard tanker traffic, Japan also made plans to step up her production of tankers. The last production plan made in fiscal year 1942 called for 235,810 GT of tankers in fiscal 1943 and another 291,600 GT in fiscal 1944.[127] By December 1943, well into the current fiscal year, the numbers had been revised upward to 348,700 GT in fiscal 1943 and 478,680 GT in fiscal 1944. Japanese shipyards exceeded the 1943 goal, producing 94 new tankers and conversions of existing ships in the fiscal year with GT totaling

[124] Parillo, 98, 136-7, 143.
[125] W. J. R. Gardner, *Decoding History: The Battle of the Atlantic and Ultra* (Annapolis, Maryland: Naval Institute Press, 1999), 70-2.
[126] Parillo, 88-90. Chokepoints in the routing of the Japanese oil convoys would have played a similar role, but I judge that code breaking had the greatest effect.
[127] Merchant Shipbuilding Report, 44.

388,666 GT.[128] The numbers were impressive, but the average GT of the ships produced – just 4,135 GT – shows that the yards were turning out less capable vessels.[129]

To end this section where it began, the year saw Japanese tanker resources becoming increasingly overstretched. She was devoting a greater and greater portion of her tanker fleet to increasing oil imports, but was seeing losses mount and the amount of oil shipped per GT drop. So focused were the Japanese on the export issue that support to the fleet was dropping significantly, by 30% between the beginning and the end of the year. This cut into the IJN's operational flexibility, as fuel concerns began in intrude on strategic considerations when IJN leaders decided where to base ships.

Production and Imports: 1943

Imports to the Inner Zone totaled 14,556,000 barrels: 3,975,000 barrels of refined products and 10,581,000 barrels of crude. Av gas made up about one-third of refined imports, with diesel fuel in second place and fuel oil third at about 20% of the total. The Inner Zone produced 17,154,000 barrels of refined products, dropping crude reserves by 15,201,000 barrels in the process. While the Inner Zone imported 1,346,000 barrels of av gas in 1943, it refined more than one and one-half times that amount. The balance of the Inner Zone refined products came from synthetics, substitutes and perhaps the few remaining caches of crude oil not declared as part of the official inventory numbers. The Southern Zone produced about 25,000,000 barrels of the military oil products, considerably outstripping refinery output in the Inner Zone.[130] Fuel oil was almost 60% of the total produced, with av gas accounting for a bit more than 20%. I estimate that a bit more than 1,500,000 barrels of fuel oil produced in IJA refineries were wasted. The Indies pumped more than 46,000,000 barrels of crude and used no more than 30,000,000 barrels in its refining processes, leaving at least 16,000,000 barrels available for import. It seems that about

[128] Transportation Report, 118.
[129] For comparison, in December 1941 average tanker GT was 6,122 GT. Transportation Report, 32. I think of this as the house painting problem. If one painter can paint my house in 40 hours, five painters can probably paint it in eight hours. But 40 painters could not paint it in an hour. So with tankers: as the ship size got smaller and more ships were needed to move the same amount of oil, efficiency dropped off.
[130] This number assumes that all diesel fuel imported to the Inner Zone was refined at Tarakan or Tjepoe, and so not shown on the Oil Report's tables of Southern Zone refined production.

5,500,000 of these barrels were neither refined nor imported. If half of the tankers and oilers lost in 1943 were lost while laden, total losses would amount to about 1,100,000 barrels. Some of the stranded crude mentioned above could have been sunk as part of this number, but the losses would also have been spread among refined products and products already imported but being shipped to operational units.[131] The rest of the crude was probably wasted, as Japan showed no interest in building up stocks in the Southern Zone.

Consumption: 1943

Humor me with another table showing the various oil consumption numbers that I have found for 1943. At least this table is shorter than the table for 1942.

Source	Period	IJN "Heavy Oil"	IJN Av Gas	IJN Total	Total
Evans and Peattie[132]	"Second Year"			26,964,000	41,706,000
Parillo[133]	4/1/43-3/31/44	21,770,000	4,354,000		
USSBS (Inner Zone)	1/1/43-12/31/43	10,126,000	2,359,000	14,274,000	28,002,000
Cabinet Planning Board[134]	1943			15,700,000	34,600,000

The numbers from the different sources for IJN consumption narrow more than in 1942. Based on the Oil Report numbers, I calculate about 47,000,000 barrels consumed in 1943 between the Inner Zone and Indies production. Evans and Peattie show about 42,000,000. For the IJN – the biggest user of oil products throughout the war – Evans and Peattie show consumption of almost 27,000,000 barrels, while the adjusted number for Parillo would be about 28,500,000 and the calculated Oil Report number is in the middle at about 27,500,000.

[131] Losses in transit were presumably not counted as imports, and the Japanese apparently did not account for losses to the reserve once the oil was imported. Oil Report Appendix, 20. I assume that tankers carry barrels equal to 10.5 times their GT rating.
[132] Evans and Peattie, 412.
[133] Parillo, 45.
[134] Oil Report, 38-9.

The divergence for total consumption is important for this study. As it extends for the full year, I do not think that it is a timing issue. The Oil Report itself provides no consumption numbers for oil sent to operational units directly from the East Indies. I instead calculated those numbers by looking at the totals of refined products produced in the Indies, and then subtracting products that were shipped to the Inner Zone and assumed losses from tanker sinkings. In doing that, I assumed that most of the product refined in the Indies not sent to the Inner Zone went to bases or units receiving their oil supplies directly from the Southern Zone.

This assumption seems to work reasonably well for the IJN in 1943, but less well for IJA and civilian consumption. This makes sense in context. The IJN would have had the easiest time supplying its units from the Indies. It had a fleet of tankers and oilers dedicated to it for most of the period, and through the scheduling of convoys and the provision of convoy escorts, effective control of the rest of the tanker fleet. It makes sense that the IJN would be in the best position to minimize waste by having ships available to move products when products were available. The IJA was a distinctly second class citizen in this regard, and the civilian sector was a distant third. Thus, more production earmarked for the IJA and the civilian sector was wasted, resulting in a bigger gap between Indies production and Indies consumption and so a bigger gap in the overall figures.

This gap may also have resulted from the over-reporting of production numbers in the Indies, but I suspect that this was a minor cause compared to actual waste, at least in 1943 when the Allies were doing little to disrupt Indies oil production. The Oil Report does provide solid evidence that some refined products were burned or dumped when there were no tankers available to transport them.[135]

The close agreement between the calculated numbers from the Oil Report and the consumption numbers from other sources also strongly suggests that unreported reserves were much less of a factor on consumption. This is particularly the case for the IJN. I suspect that there were still unreported civilian reserves being tapped, simply because finding and reporting all those reserves would be difficult. Here are my final calculated consumption numbers for 1943.

[135] Oil Report Appendix, 77.

Refined Products Consumed in Calendar Year 1943 (barrels)

	IJN	IJA	Civilian	Total
Total	27,250,000	7,250,000	10,500,000	45,000,000
Inner Zone	14,250,000	4,750,000	9,000,000	28,000,000
Southern Zone	13,000,000	2,500,000	1,000,000	16,500,000
Other			500,000	500,000

Consumption figures for 1943 were not encouraging. In 1942, total consumption amounted to 42,500,000 barrels of refined product, with some additional consumption of unrefined crude and oil from possible reserves outside of the Inner Zone. In 1943, total consumption climbed by (conservatively) 2,500,000 barrels while the IJN's consumption increased by 1,250,000 barrels. Japan was not easily going to find salvation from her oil problem in conservation.

The IJN again accounted for the bulk of the consumption, divided fairly evenly between the Indies and the Inner Zone. All that oil had to be moved, in many cases out to the periphery of the Empire's expanded defensive perimeter, straining the tanker force further and further. As production and refining outran the ability to move the oil, potential waste increased, amounting to at least 5,000,000 barrels of crude and 1,000,000 barrels of fuel oil, and perhaps up to another 2,000,000 barrels of refined products as well. Some of this waste may have been lost in sunken tankers, but most was not.

The civilian sector increase – 2,000,000 barrels – was probably a reflection of the merchant marine coming back into use after being relatively idle for part of 1942. The IJA came third, with consumption of 7,250,000 barrels plus whatever Burma may have yielded. While the IJA's total consumption had dropped, it still consumed almost half of the av gas used.

The Oil Budget and Reserves: 1943.

Comparing the oil picture at the end of 1943 to the second year budget-projections seemed to give some cause for hope:

	Reserve at Start of Period	Production	Imports	Consumption – Inner Zone	Consumption – Southern Zone	Reserve at End of Period
Budget	20,300,000	3,800,000	12,600,000	34,600,000	0	2,100,000
Actual	28,000,000	4,000,000	14,500,000	28,000,000	16,500,000	18,500,000

The actual reserve on January 1, 1944 was about 16,500,000 barrels, again reflecting the wastage attendant to converting crude into military oil. It would seem from this comparison that a mere 9,500,000 barrels of imports should be enough to sustain the Inner Zone through 1944. If refined production in the Southern Zone continued as it had in 1943, the Southern Zone could look after itself. The glaring problem, though, was that the war was unlikely to end in 1944, short of a Japanese surrender. And surrender was not in Japan's plans, at least not in December 1943.

Overall, the Inner Zone reserve had dropped to about 38% of its January 1942 levels by January 1944. Almost 80% of the reserve was now in the form of refined products, as the Home Islands have been refining all available crude to meet the demand for refined products. Perhaps not surprisingly, Japan was now living a much more hand to mouth existence as production and imports failed to keep up with consumption.

As Japan struggled to build up her air forces annual av gas consumption in the Inner Zone increased from 3,526,000 barrels in 1942 to 4,860,000 barrels in 1943, causing the av gas reserve to drop to 55% of its January 1942 level. This was a much steeper drop than in the first calendar year of the war, but less than the overall reserve drop. That the decrease was not more severe demonstrates Japan's dedicated effort to extract av fuel from the Indies and bring it back to the Inner Zone. Despite that effort, the av gas reserve would be depleted in six months unless more could be added to it.

In contrast to av gas, fuel oil reserves dropped in line with the decrease in the general reserve, to 38% of January 1942 levels. Importing fuel from the Indies was obviously not a priority, although Inner Zone production of fuel oil did increase. IJN use of Inner Zone fuel oil was also

lower in 1943 than in 1942 – probably a reflection of the IJN's increased reliance on getting oil directly from the Southern Zone – but increased civilian use more than made up the slack.

Hitting Bottom: Early 1944

In 1943, the Japanese tanker fleet was stretched to the breaking point. In early 1944, it broke. The first quarter brought crushing losses: 264,195 gross tons lost to submarines and to two devastating USN carrier attacks on the Japanese bases at Truk and in the Palaus. In total, the first quarter saw at least 29 tankers lost plus another 4 fleet oilers. Nine of the tankers were big 10,000 tonners best suited to the Indies import route and fleet support. Five were big pre-war tankers, with half of the pre-war 19 now sunk, while another four were new construction just completed in 1943. The 10,000 tonners alone accounted for more than a third of the tanker tonnage lost.[136]

The carrier raids were particularly disastrous for the Imperial Japanese Navy, as the losses they caused were taken by the oilers and tankers directly servicing the fleet. Tankers in support of the fleet dropped to eight and 47,830 GT in April, from 13 and 93,850 GT in January. Contrast this to the high point of tanker support for the fleet, when from February through April of 1942 the Imperial Japanese Navy had 20 tankers of 151,810 GT in direct support of the fleet. The fleet now commanded only a third of the tankers resources that it had two years before. IJN oilers were also ravaged by the airstrikes, three with a total gross tonnage of 15,125 being lost (and another one of 5,000 GT lost in an airstrike on Rabaul in the same quarter). The IJN fully paid the price for having its supply ships linger at forward bases as floating storage tanks, After the strikes, only one IJN oiler remained afloat. And while tankers and oilers in direct support of the fleet were being decimated, the IJN's tanker pool for base supply was shrinking as well, from 57,360 GT in January to 48,600 GT in April.[137]

[136] Jentschura, 252-3. TROMs. At least four converted cargo ships acting as tankers were also lost in the quarter.
[137] Transportation Report, 118. Jentschura, 250-1.

The tanker tonnage dedicated with moving oil to the Inner Zone dipped but then rebounded in the first quarter. While tanker tonnage directly supporting the fleet dropped to less than a third of its wartime high, it was then been built back up to 67,910 GT by May 1944. That increase was part of preparations for the IJN's next decisive battle.

Into the Philippine Sea

Planning and Resources

The Imperial Japanese Navy had long been obsessed with the idea of the "decisive battle," originally conceived as a Mahanian Gotterdammerung in which a concentrated Japanese fleet would wreak such havoc on the Americans that they would give up the fight and seek a negotiated peace. So did the Japanese bring the Russians to the conference table in 1905, so would the Pacific War end forty years later. It was with the decisive battle in mind that the IJN launched its ill-fated invasion of Midway Island in 1942. It was with the decisive battle in mind that the IJN planned for 1944.

While 1943 had seen the IJN attempt responses to various Allied operations, no major naval engagement resulted. Instead, the year saw steady and heavy attrition of the navy's light units and air strength. The hope for 1944 was that the IJN could rebuild its air units and then crush the next major Allied invasion when and where it occurred. The plan, dubbed A-GO, was to catch the US fleet between the twin fires of land-based and carrier-based air attacks while it was in the middle of supporting an assault landing. Once Japanese airpower had done its work, the fleet would close to sink the resulting shambles with guns and torpedoes.

The Japanese planners hoped to make an invasion of Biak or Palau the occasion for the decisive battle. A look at the map shows why. The fleet's main forward base was now at Tawi Tawi, in the southwestern Philippines between the Sulu and Celebes Seas. This put the fleet within 1,000 miles of Biak, off the north coast of western New Guinea, or of Palau, east of the southern Philippines. By spring of 1944, however, the IJN had to face the possibility that the next major

Allied thrust might be to the Marianas. An invasion of the Marianas would require the greatest possible response from the IJN, as an Allied presence there would bring the Home Islands within bomber range. The problem was that the Marianas lay twice as far from the IJN's southern bases as Biak or Palau.

Basing the fleet in the Home Islands would have placed it closer to the Marianas, but almost doubled the distance to Palau and Biak. That might have made more sense from a strategic perspective, given that the Marianas was the more critical defense point and that basing the fleet in home waters would give it better facilities for maintenance and training, but the oil situation ruled it out. As of April 1, 1944, the Inner Zone reserves of av gas and fuel oil stood at 2,337,000 and 6,896,000 barrels respectively. These reserves were to be preserved to the greatest extent possible. The fleet would have to find its oil in the Southern Zone. Without enough tankers to move that fuel, the fleet had to stay close to its fuel source.

That made sense, assuming that the Inner Zone reserves were worth preserving. Basing the fleet in the Home Islands would mean that tankers would have to make the almost 3,000 mile run from Singapore to keep the reserves topped up while more tankers would have to stand ready to accompany the fleet when it steamed off to fight the decisive battle. At least with the fleet in the south, the tankers dedicated to support it would close to the oil sources supplying it.

But why were the Inner Zone reserves worth preserving? Apparently, the decisive battle was not as decisive as all that. If losing it was tantamount to losing the war, then preserving the Inner Zone reserves would be meaningless. If winning it meant winning the war, then again any remaining reserves in the Inner Zone would make no difference. And if the reserves were as large as reported, it is not as if the "decisive battle" would have absorbed all of the reserve. The actual battle consumed about 1,300,000 barrels of oil, less than 15% of the total reported reserves.[138] Even if the consumption had doubled, as might have happened if the Japanese had been more successful and so stayed in the battle area for a longer time, more than two-thirds of the reserves would have remained.

[138] Parillo, 42.

There is more evidence that the IJN's 1944 decisive naval battle was not viewed as an absolute war decider. By 1944, the emphasis on war production had shifted away from carrier aviation (the cornerstone of the decisive battle) to land based aircraft. In 1941 through 1943, the top priority for naval construction was aircraft and aircraft carriers. In 1944, land-based aircraft took the top spot and carrier air was at best a distant third. [139] Using land based aircraft to wear down the enemy suggests more of a strategy based on attrition over time, in hopes that the escalating losses eventually drove the Americans to the peace table. This is reinforced by IJN Captain Fuchida Mitsuo's post-war comments to his American interrogator that the IJA did not believe that a battle in the Marianas would be decisive.[140] Further evidence comes from Admiral Toyoda, who said post-war that the greatest constraint on the Marianas plan was a lack of tankers.[141] Tankers existed, but not for A-GO. If A-GO was to be the crucial battle of the war, tankers and Inner Zone oil could have been found.

In short, A-GO did not command a decisive share of resources. Unlike the IJN's pre-war concept of the decisive battle, A-GO was not expected to affect the balance of naval forces in the Pacific profoundly. Attrition in the lead-in to the decisive battle had always played a role in Japanese thinking. But now the decisive battle became another element in what, for lack of better alternatives, had become a strategy of attrition. And if the decisive battle was not the war-ender of the IJN's pre-war conception, then it could not have an absolute command on Japan's available resources.

Once put in this context, preparations for A-GO begin to make more sense. The fleet units earmarked to participate were mainly based at Tawi Tawi with forward bases at Batjan and Davao, less than 600 miles to the east across the Celebes Sea. Tawi Tawi was a relatively unprotected anchorage without extensive shore facilities, but it was reasonably close to the IJN's wells and refineries in eastern Borneo, allowing tankers to supply the warships with relatively short runs. If the fleet were to head for the Marianas, it would steam northeast through the Sulu Sea, then through the central Philippines to debouch into the Philippine Sea.

[139] United Stated Strategic Bombing Survey, *Japanese Naval Shipbuilding* (Washington, D.C., 1946), 4.
[140] United Stated Strategic Bombing Survey, *Interrogations of Japanese Officials* (Washington, D.C., 1946), vol. 2, p. 431.
[141] *Ibid*., p. 316.

Tanker Support for a "Decisive" Battle

For A-GO tanker support, the IJN called on some old veterans and some new arrivals. Pre-war survivors included *Tatekawa Maru, Nichiei Maru, Kokoyu Maru,* and *Gen'yo Maru*. These were all fast 10,000 GT tankers, survivors of more than two years of war. Newcomers included *Seiyo Maru*, completed in January of 1944, and *Azusa Maru*, which only left her builders on March 15. A new fleet oiler – the *Hayasui* – also joined the roster. Other tankers played supporting roles. *Eiho Maru* ran fuel oil and av gas out to *Azusa Maru* in the central Philippines in late June, while *Eiyo Maru No. 2* made oil runs to the Batjan area. *Yuho* and *Manei Marus* were also active in the A-GO area of operations at times suggesting that they were supporting A-GO. These latter four were standard, war-built type 1TM tankers of 5,200 GT and 58,640 barrel capacity. Altogether, more than 90,000 GT of tankers and oilers had been found to support A-GO, enough to move more than 850,000 barrels of oil.[142]

That is not a negligible showing, but it is instructive to compare it to support for the previous decisive battle, fought in 1942. Then, the IJN mustered eighteen tankers and oilers in direct support of the forces attacking Midway and the Aleutians, with a combined lift of more than 1,500,000 barrels.[143] This compares to a lift of about 650,000 barrels for the ships directly supporting A-GO, plus another 200,000 barrels of tanker capacity in secondary supporting roles. The MI and AL operations saw almost a quarter of all Japanese tanker tonnage in direct support; the A-GO operation commanded only about one-thirteenth of total tanker tonnage. Making the disparity even greater, the MI-AL warships were almost all likely beginning with bunkers filled from Inner Zone reserves, while the A-GO tankers were responsible for hauling oil from Borneo to the fleet anchorages.

Also instructive are the relative force levels for A-GO versus MI-AL. MI-AL saw almost every IJN ship of destroyer size or larger engaged in the operation. The only notable exceptions were two fleet carriers, one of which was damaged and the other of which had a badly depleted air

[142] Morison, vol. viii, 416-7. TROMs.
[143] Jonathan Parshall and Anthony Tully, *Shattered Sword: The Untold Story of the Battle of Midway* (Washington, D.C.: Potomac Books, 2005), 450-61.

group. A-GO was to feature all of the IJN's fleet and light carriers, but none of the three escort carriers that the IJN then had available. Only five of the IJN's nine battleships sortied with the A-GO forces, and only seven of 29 cruisers.[144] For destroyers, 40 of the approximately 70 available took part. No doubt the IJN found other employment for the ships that did not participate in A-GO, but if A-GO were to be decisive one would think that more ships would have been in the order of battle. In contrast, the next "decisive battle" operation – SHO – featured all nine battleships and 14 cruisers.[145]

This lesser effort is reflected in the tankers that were withheld from A-GO. Active at the time of the operation were the big pre-war tankers *Kyokuto Maru, Itsukushima Maru, Teiyo Maru,* and *Kuroshio Maru*. *Azusa Maru* and *Seiyo Maru* were examples of the 10,000 GT standard tankers that began to emerge from Japanese shipyards in the latter half of 1943; at least four more of these had been completed and requisitioned by the IJN before the A-GO preliminaries had begun. Some of these tankers were carrying oil back to the Home Islands at the exact time that A-GO was underway; immediately after the battle, *Hayasui* was detailed to offload *Itsukushima Maru's* cargo after she had been torpedoed in the Sulu Sea while on her way north.[146] It is easily seen that other oil movements were not put on hold for A-GO.

Nor, as we have seen, were the Inner Zone reserves opened up to fuel A-GO. *Azusa Maru, Tatekawa Maru,* and *Nichiei Maru* all left the Home Islands to join A-GO, and they all left empty. They travelled down through the Philippines to Tawi Tawi before moving on to Borneo to load oil. *Hayasui* also came south from the Home Islands to Davao in the southern Philippines; she may have been empty also.[147]

How much oil did A-GO need? In the event, the operation lasted a bit more than nine days from the departure of the Japanese carriers from Tawi Tawi on June 13 to their arrival at Okinawa on the 22nd. Some ships responding to the American invasion of Biak steamed for a bit longer,

[144] Two of the battleships were actually hybrid battleship-carriers. One could argue that battleships made little difference to the success of A-GO, mitigating against committing all of them. But then why take any? They were not used in the carrier anti-aircraft screens, and cruisers could have played the role of a vanguard force. If A-GO was to culminate in a surface action, the battleships and cruisers could have played a crucial role.
[145] Naval Shipbuilding, 6.
[146] TROMs**.** *Kyokuto Maru* was apparently in dockyard hands at Singapore until June 18.
[147] TROMs.

having cleared Tawi Tawi on June 10 for Batjan before eventually being ordered to execute A-GO instead. They then came north to meet the main group in the Philippine Sea. In all that time, oil use was about 1,300,000 barrels. Allow eighteen days as the maximum length of the operation if the Japanese had miraculously been successful and pursued the beaten Americans as they fled from the Marianas. Projecting actual fuel use on to possible fuel use for a longer, more successful battle suggests that the planners may have wanted 2,500,000 barrels for the entire operation. Viewed in this light, A-GO was poor in oil resources. The warships themselves would have accommodated about 700,000 barrels and the tankers another 850,000 barrels, together about a million barrels short of possible maximum consumption and only a bit more than actual consumption in a battle that ended in a fairly early Japanese retreat.[148]

Another feature of A-GO shows that Japanese priorities more than absolute limits on oil or tankers hampered the planning for that operation. When the idea of launching A-GO in response to an invasion of the Marianas was first raised, an immediate objection was raised that the fleet would not have enough fuel oil for such an operation until the latter half of 1944. The problem was solved by allowing the fleet to put Tarakan crude oil in its bunkers. This was an expedient with definite costs: the sulfur in the crude corroded ships' boilers while the aromatic elements in the unrefined oil created volatile gases in the ships' bunkers. Using crude meant paying a price in long term maintenance and, quite possibly, catastrophic short term battle damage.[149]

The Need for Crude

But why was crude needed? The IJN's Balikpapan refinery reported producing on average more than 200,000 barrels of fuel oil per month for each of the 1943 and 1944 fiscal years. Actual fuel oil production in the first part of fiscal 1944 was likely higher, as activities at Balikpapan wound down at the end of 1944 as the Allies came closer and bombing intensified, but say that production averaged 200,000 barrels per month for the first half of calendar year 1944. Fuel oil

[148] *Kokoyu Maru* hauled crude oil to Saipan in April, perhaps in contemplation of the fleet drawing oil there. Other tankers may have done the same. If so, that was a faint hope: the oil would have had to survive the initial American strikes and then the fleet would have to had such a success that it could draw the fuel as the Americans reeled away in disarray. TROMs.
[149] Morison, vol. viii, 215-6.

production from the IJA-controlled Sumatran refineries varied over the first six months of calendar 1944, but averaged about 175,000 barrels per month. Total fuel oil production would then have been in the order of 1,100,000 barrels in the first quarter of calendar 1944 and another 1,100,000 barrels in the second quarter.

The apparent problem here was accumulating enough fuel oil for the battle. This was in turn a function of when the set-asides began and how much could be set aside in a month. This did not seem to be an issue of stopped production. The records show that some of the tankers allocated to A-GO loaded fuel oil rather than crude in preparation for the battle, so the refineries were clearly producing fuel oil during this period.[150] From the perspective of how much fuel oil could be set aside in a month, both ongoing consumption and exports reduced the amounts available. Exports of fuel oil averaged about 100,000 barrels a month during the first six months of 1944, while fuel oil would also have been consumed by the IJN units based in the Southern Zone and the merchantmen taking on fuel for journeys back to the Home Islands.

A sense of the problem can be extracted by comparing an A-GO operation to the Marianas with the operations that the IJN did have fuel oil for – battles at Biak or Palau. I think it is a safe conclusion based on the distances involved that the IJN would have wanted between 1,000,000 and 1,500,000 barrel of fuel oil for operations aimed at Biak or Palau, and about 1,000,000 barrels more for a battle in the Marianas. This additional million barrels created the problem. The IJN leadership felt in May that it could be accumulated in the second half of 1944, which suggests perhaps 200,000 barrels per month – almost the entire production from Balikpapan – going into the reserve. That was an aggressive assumption, even though Balikpapan's fuel oil production appeared to be rising through the first half of 1944. And even if it could be made to happen, it still would not permit the IJN to fight a Marianas battle in June if the program to gather the oil only began in May.

[150] TROMs. The records of individual ships as shown in the TROMs vary in their detail on this point. Some specify the type of oil loaded, some simply say that oil was loaded, and others simply state ports of call, requiring the reader to infer that oil was being loaded at oil ports. My conclusion here is based on cases in which the type of oil being loaded is specified.

Hence the decision to use crude oil. But where did the IJN find the crude? The logical answer would be from its oil wells in eastern Borneo, but there is no hard proof of that. In fiscal 1943, the amount of crude fed into the IJN's Balikpapan refinery closely matches the crude pumped from Tarakan and Sanga Sanga, the two oil fields identified as being under IJN control. If additional refining capacity is loaded into the mix, it looks as if the IJN refined all of the Borneo oil it pumped from March 1943 through March 1944. Nonetheless, the TROMs indicate that crude oil was in fact available, and that it was loaded onto tankers at Balikpapan.

Three possibilities occur to me. The first is that the IJN had access to crude oil sources other than Tarakan and Sanga Sanga. There is a hint of this in the Oil Report, which refers to crude from "Sanga Sanga & others."[151] Unfortunately, the report does not name these other sources. They could have contributed unrefined crude for the IJN to use. Yet another possible source could have been the northern Borneo fields, which usually sent their crude on to the Home Islands. Second, the IJN may simply have increased crude production at Tarakan and Sanga Sanga to provide the additional oil. Japanese policy generally was not to pump more oil than could be refined or sent to the Inner Zone; because little of the IJN's production was being sent to the Inner Zone, the IJN may have been pumping only as much oil as its Borneo refineries could process. Faced with a need for more crude, the IJN just increased production in the fields. While overall crude production in Borneo does not show an increase in production for fiscal year 1944, that may be because production tailed off later in the fiscal year as Balikpapan and Tarakan wound down refining operations. There is evidence in the Oil Report's numbers that refinery production dropped in relation to crude production in fiscal 1944.[152] Finally, it may be that the IJN was getting crude from the IJA's Sumatran oil fields. I think that this is the least likely of the explanations, as I can find no record of crude moving from Sumatra to Borneo and references using crude as bunker fuel imply that Borneo crude specifically was used for this purpose.

On balance, I credit increased production and production from Borneo fields beyond Tarakan and Sanka Sanka as the sources of the A-GO crude oil. I suspect that these sources could

[151] Oil Report Appendix, 77 (Table 52).
[152] Diesel fuel production and production of fuel oil both declined relative to Tarakan and Sanga Sanga crude production.

produce an extra million or so barrels of crude in fairly short order. In 1940, Borneo was credited with producing more than 1,500,000 barrels of crude in a month. Inputs to Balikpanan in fiscal 1944 averaged a bit more than 500,000 barrels a month. Running the Borneo fields at about two-thirds their prewar capacity would have produced an additional million barrels in little more than two months.

This all squares with view of the IJN command that only by using crude could enough oil be gathered for a Marianas A-GO operation. The key point here is that the need to use crude was not brought on by a lack of tankers. The tankers that came south to support A-GO came empty. They could have come with full loads of Inner Zone fuel oil. Once in the Southern Zone, the tankers had to carry oil to the A-GO fleet whether it was fuel oil or crude oil. Lack of tankers may have, and likely did, cramp A-GO planning, but it did not force the use of crude oil in ships' bunkers.

A-GO: a Tanker's Eye View

The A-GO operation unfolds with three of the big 10,000 GT tankers heading south from Japan in early May 1944 in a convoy with five other tankers. All the tankers were empty; the three destined for A-GO were the 10,000 tonners *Azusa Maru*, *Tatekawa Maru,* and *Nichiei Maru*, plus the smaller *Eiyo Maru*. The oiler *Hayasui* starts south with the convoy, but collides with an IJN submarine and probably returns to the Home Islands after the collision.

Kokoyo Maru, *Seiyo Maru*, and *Gen'yo Maru* were are also assigned to A-GO. They were already engaged in oil supply duties in the Southern Zone. *Kokoyo Maru* arrives at Tawi Tawi (the main fleet anchorage for A-GO) on May 13 with a load of crude oil from Balikpapan. *Gen'yo Maru* loads fuel oil at Balikpapan, arriving at Tawi Tawi on May 15. *Seiyo Maru* takes oil from Tarakan to Tawi Tawi, arriving on May 20.

The Inner Zone tankers cycle through Tawi Tawi on their way to Balikpapan. *Nichiei Maru* is back at the fleet anchorage on May 18, *Tatekawa Maru* on May 19, and *Azuma Maru* at an unknown date. All have presumably filled at Balikpapan before returning to Tawi Tawi, but I

have no record of what they loaded. They probably top up the bunkers of the gathered fleet, but again there is no direct evidence of this.

On May 23, *Seiyo Maru*, *Tatekawa Maru*, *Kokoyu Maru,* and *Nichiei Maru* head for Davao in the southern Philippines. This positions them to support the fleet if it moves towards the Marianas, Palau, or Biak. The tankers take their first loss when *USS Gunard* torpedoes and sinks *Tatekawa Maru* while the tankers are in transit. The other three tankers go on to Davao, where they are eventually joined by *Hayasui* coming from the Home Islands. While there they refuel various ships and then take on fuel oil from battleship *Fuso* on June 13, when A-GO has been launched with the Marianas as the destination.[153]

Before A-GO is triggered, the Allied invade Biak. This causes the IJN to launch the Kon operation: a plan to land reinforcements at Biak, destroy Allied invasion shipping and naval support forces there, and bombard the Allied troops ashore. On June 3, *Gen'yo Maru* and *Azuma Maru* are directed to a refueling rendezvous east of the Philippines, apparently to refuel the Kon forces after the operation. A smaller tanker, *Eiyo Maru No. 2*, also goes south to the Kon operational area from Tarakan on June 6.[154] Kon is effectively superseded by A-GO, however, and so on June 8 the two big tankers are directed west across the Philippines, to Guimaras in the northeast corner of the Sulu Sea. This will be the carrier forces' last stop before entering the Philippine Sea and seeking out the American forces off the Marianas.

On June 14, the carrier fleet refuels at Guimaras. It then heads east toward the Marianas, followed by the two tankers. On June 16, it meets with all the tankers, the forces diverted for the Kon operation, and the *Hayasui* in the Philippine Sea about 300 east of the Philippines. That day and the next the warships fuel, then steam on into a maelstrom of USN submarine attacks and airstrikes. The tankers are not spared; although they attempt to withdraw the advancing

[153] Taking *Fuso's* oil is odd. *Fuso* had already been at sea, so her bunkers were probably not full. The tankers would not have drained her, as she needed some mobility in case she was attacked. Full, her bunkers would have contained 5,100 tons of fuel oil – about 35,000 barrels. The IJN must have been very concerned about fuel if they were willing to tap *Fuso* for a mere 20,000 barrels.

[154] It is not clear if this tanker was supporting the Kon and A-GO operations. I have credited it to A-GO support in the tanker gross tonnage and lift numbers above.

Americans pound them with airstrikes on June 20. *Hayasui* is bombed without serious damage, but *Gen'yo Maru* and *Seiyo Maru* are crippled and subsequently scuttled.

After the close of the battle, the surviving tankers go on to their separate fates. *Hayasui* meets the damaged *Itsukushima Maru* in the Sulu Sea and helps to transfer her oil. *Hayasui* then returns to the Home Islands and is sunk by *USS Bluefish* on her next outing, in September 1944.

Nichiei Maru still had a role to play in the closing stages of the Marianas operation, for she goes to Bacalod in the Sulu Sea to refuel the attack force's destroyers for their return to Japan. She then goes to the Home Islands to refuel *Yamato* (also part of the A-GO attack group) and then offload the rest of her cargo. She must not have parted with much oil during the operation if she had so much left after it was over. She lasts until January 1945, when *USS Besugo* sinks her in the Gulf of Thailand.

Kokoyo Maru also plays a role in the closing stages of A-GO. She heads for Okinawa to fuel some of the attack group on their way to Japan. She then heads for Singapore via Manila. *USS Bonefish* sinks her in July, west of Jolo in the Sulu Sea.

Azusa Maru returns to Guimaras, where she meets *Eiho Maru* bringing a cargo of fuel oil and av gas ("special grade gasoline") out from Balikpapan. This was likely intended as a back-up supply for the A-GO attack force, but now *Azusa Maru* takes the oil to the Home Islands. She manages a safe return to the Indies, but is sunk by *USS Barb* in September when she tries to reach the Home Islands again.[155]

A-GO: Conclusions

A-GO was billed as another attempt at the "decisive battle," but the resources devoted to it suggest that it was not uniformly viewed as a be-all and end-all. Tankers that could have been

[155] *Yuho Maru* and *Manei Maru* steamed from the Borneo oil ports to Guimaras. *Manei Maru* arrived there on June 23 and *Yuho Maru* on June 24. It is quite likely that each was on a mission similar to *Eiho Maru's*, bringing out additional oil for the attack force. However, their TROMs do not say that they rendezvoused with any of the tankers returning from the Philippine Sea. I have counted them in the totals for GT and barrels of lift given above.

used to support the A-GO fleet continued to ply the Southern Zone-Inner Zone oil routes. Fuel oil in the Inner Zone could have been supplied to the A-GO fleet, but was not. When A-GO planning was extended to the Marianas, the fleet was forced to use crude oil as fuel. None of this sounds like the sort of commitment that one would expect for a battle that was meant to decide the war. All of it is consistent with the Japanese planners viewing the A-GO operation as a concentrated attempt at attrition, and not as something that could itself bring the Allies to the conference table for a negotiated end to the Pacific War.

In the Abyss: 1944 Concluded

Moving the Oil

A look at a few more numbers completes the picture for 1944. Tanker losses for 1944 totaled 824,468 GT. Numbers of tankers on the Indies-Inner Zone run skyrocketed in 1944, from 95 at the start to 210 at the end, but the average tanker GT plummeted, from 6,260 GT to just 3,315 GT. Total gross tonnage on the run actually increased, but tanker productivity collapsed. In the last quarter of 1944, each tanker gross ton was importing less than 2 barrels of oil to the Inner Zone – about 7 barrels per gross ton on an annualized basis. This is reflected in the quarterly import results. In the first quarter of 1944, 2,824,000 barrels were imported to the Inner Zone. In the fourth quarter, imports dropped to 1,222,000 barrels.

Japanese yards managed to build or convert 806,290 GT of tankers in 1944, but the tankers that were built had an average GT of just 3,302. Most were more suited to coastal trade than long-haul trade routes and fleet support. Even the larger ships were far less capable than their pre-war antecedents, with many stories of breakdowns at sea or in harbor.[156] Worse still, deferred maintenance on the entire merchant fleet was now coming home to roost, with increasing numbers of ships laid up for repairs.[157] While the building effort broke all records for Japanese tanker construction, Japan lost more tanker tonnage than she built. By the end of 1944, the

[156] Transportation Report, 56. Parillo, 166-7.
[157] Merchant Shipbuilding, 20-1.

merchant shipbuilding industry was running out of steel, and production fell off.[158] At that point, more tankers would have done little good anyway, as the Allied stranglehold on the Southern Zone was complete. The IJN ceased most efforts to move oil from Balikpapan in December 1944, although some refining continued into 1945.[159] Japan attempted a few oil convoys in early 1945, but with scant success. Imports in the first quarter of 1945 amounted to less than 800,000 barrels, mostly av gas. Given the level of tanker losses in the period, losses of oil probably exceeded the amount of oil delivered.[160] By May, Japan abandoned the Indies oil routes entirely.[161]

The IJN's tanker capacity never recovered from its losses in early 1944, although it did manage to find 10 tankers for the October Leyte battles with almost as much carrying capacity as the A-GO tankers.[162] These SHO engagements were the IJN's last spasm, as the warships had no hope of resupply and the widely separated forces, scattered by the need to base wherever there was some hope of finding fuel, struggled to coordinate.[163] By February 1945, the IJN had permanently docked all of its remaining large ships, with the sole exception of the *Yamato*.[164]

Production and Imports: 1944

The Southern Zone produced 26,637,000 barrels of military oil products in 1944, bettering its 1943 production.[165] Japan's problem was that it could not move this oil to where it was needed. Refining in the Southern Zone probably did not consume more than 33,000,000 barrels of crude, leaving more than 8,000,000 barrels of crude for export, but only 2,967,000 barrels of Southern Zone crude arrived in the Inner Zone in 1944. In a break with the prior two years, the Inner Zone

[158] Merchant Shipbuilding, 28, 31-2.
[159] Oil Report, 55.
[160] Transportation Report, 118.
[161] Transportation Report, 50.
[162] Morison, vol. xii, 430-1. TROMs. The ten were *Hakko Maru*, *Itsukushima Maru*, *Nichiei Maru*, *Ryoei Maru*, *Nippo Maru*, *Takane Maru*, *Jinei Maru* (all 10,000 GT ships), *Yuho Maru*, *Manei Maru*, and *Omurosan Maru*. Because the SHO forces were spread from Borneo to the Home Islands, the SHO tankers had to cover a wider geographic area than the A-GO tankers did. Three of the SHO tankers were sunk in the course of the operation.
[163] Oil Report, 84.
[164] Arthur Marder, Mark Jacobsen, and John Horsfield, *Old Friends, New Enemies: The Royal Navy and the Imperial Japanese Navy, the Pacific War 1942-1945* (Oxford: Clarendon Press, 1990), 380.
[165] This number assumes that all diesel fuel imported to the Inner Zone was refined at Tarakan or Tjepoe, and so not shown on the Oil Report's tables of Southern Zone refined production.

imported more refined product from the Indies than crude, receiving 4,071,000 barrels of refined products.

Av gas dominated the import picture, with 2,296,000 barrels of this high priority product imported as Japan struggled to get as much as possible back to the Home Islands before the American occupation of the Philippines closed off the Indies route once and for all. For the first time, imports of av gas exceeded av gas produced in the Inner Zone. They rose from about 10% of all Southern Zone imports in 1942 and 1943 to a third of all oil imports in 1944. The imports helped make up for a decrease in Inner Zone production. As the growth in av gas use slowed, annual imports and domestic refined av gas exceeded annual use for the first time.

Increased tanker losses must have put a direct dent in imports. Assuming that half of the sunk ships were laden, losses would have been more than 4,300,000 barrels. Not all of the losses would have been to oil being exported to the Inner Zone; tanker sinking would also have taken a toll on oil being issued to operational units.

As crude imports fell off, Inner Zone production of refined products declined to 11,160,000 barrels. Japan now began to emphasize domestic production of crude oil, synthetic oil, and oil substitutes, but it was clearly a case of too little too late. Japan refined only 3,863,000 barrels from these sources, a bit more than one-third the total of refined products. By the end of 1944, she had effectively refined all of the crude oil available in her reserve.

Consumption: 1944

One last table summarizing the different consumption figures:

Source	Period	IJN "Heavy Oil"	IJN Av Gas	IJN Total	Total
Evans and Peattie[166]	"Third Year"			20,034,000	29,484,000
Parillo[167]	4/1/44-	17,105,000	3,421,000		

[166] Evans and Peattie, 412.
[167] Parillo, 45.

	3/31/45				
USSBS (Inner Zone)	1/1/44-12/31/44	7,989,000	2,705,000	11,807,000	22,135,000
Cabinet Planning Board[168]	1944			17,600,000	35,900,000

For 1944, the calculated Oil Report numbers diverge from the other two sources. For total consumption, Evans and Peattie show about 29,500,000 barrels versus my calculated Oil Report number at 40,000,000. For the IJN alone, the numbers are Evans and Peattie at 20,000,000 barrels, Parillo (adjusted) at 24,000,000, and the calculated Oil Report numbers at a bit more than 24,500,000.

The widening gap in 1944 is logical. Shipping problems grew far worse in 1944, and the main IJN refinery became subject to Allied bombing attacks.[169] None of the 10,000 GT tankers called at Balikpapan after June of 1944, and by the end of the year even calls from smaller, more expendable ships tailed off.[170] More production was likely to be wasted due to a lack of shipping to move it.

As more Indies product was wasted, the gap between my calculated consumption numbers and actual consumption grows. That said, I believe that for 1944 either the IJN consumption numbers from Evans and Peattie and Parillo are too high or the total consumption numbers from Evans and Peattie are too low. Otherwise, the IJN takes a portion of overall consumption so high that it is difficult to square with the known consumption numbers for the Imperial Japanese Army and the civilian sector in the Inner Zone. According to the Oil Report consumption numbers for the Inner Zone alone, the IJA and the civilian sector together consumed more than 10,000,000 barrels of oil products. This is more than the difference between IJN consumption and total consumption in Evans's and Peattie's numbers.

[168] Oil Report, 38-9.
[169] United States Strategic Bombing Survey, *The Fifth Air Force in the War Against Japan* (Washington, D.C., 1947), 34.
[170] TROMs.

Allowing for more waste and losses in the Indies, I adjusted downward IJN and total consumption as calculated from the Oil Report but not so low as the numbers given by Parillo and Evans and Peattie.

Refined Products Consumed in Calendar Year 1944 (barrels)

	IJN	IJA	Civilian	Total
Total	22,000,000	7,000,000	5,000,000	34,000,000
Inner Zone	12,000,000	5,000,000	4,500,000	21,500,000
Southern Zone	10,000,000	2,000,000	500,000	12,500,000

Consumption figures for 1944 saw the oil shortage taking hold. If half the tankers and oilers lost in the year were laden, about 4,300,000 barrels were lost in transit. Using the assumptions set out in the beginning of this study, somewhere between 1,000,000 and 2,000,000 barrels of fuel oil produced by IJA-controlled Indies refineries went to waste. Precisely how much was lost depends on how much fuel oil was lost in tanker sinkings while on its way to the Inner Zone.

The IJN again accounted for most of the consumption of refined products. It also put as much as 1,800,000 barrels of crude directly into its bunkers. [171] The IJA finally displaced the civilian sector as the second highest consumer of military oil products, with more than half of its usage being av gas.

A side note here, but an important one, is that the IJN still managed to consume a large quantity of oil when at the same time it was struggling to find oil for major strategic operations such as A-GO (the response to the American invasion of the Marianas) and SHO (the final "decisive battle" against the US forces invading the Philippines). Not only does this point out the difficulties of getting oil to where it was most needed, it also underscores the drain on oil use made by the routine, quotidian operations of a still-large navy. As of March 1944, the IJN still had 9 battleships, 15 carriers, 29 cruisers, and 235 other warships in commission. Training, escorting, and false alarms were clearly still consuming a lot of oil.

[171] This number is based on the approximate amount of oil required from the Southern Zone for the A-GO and SHO operations. I suspect that usage was somewhat less.

Budget and Reserves: 1944

A comparison with the budget-projection numbers at the start of the war shows this:

	Reserve at Start of Period	Production	Imports	Consumption – Inner Zone	Consumption – Southern Zone	Reserve at End of Period
Budget	2,100,000	5,300,000	28,500,000	35,900,000		0
Actual	16,500,000	4,000,000	7,000,000	22,300,000	18,900,000	5,000,000

The key point here is imports. The Southern Zone produced enough oil to meet the import goal, but Japan lacked the ability to move it. The alternative was to keep the oil in the Southern Region, but Japan was losing even the ability to move it within the region to where it was needed. Japan's transportation problems became insoluble as the Allies came advanced toward the Inner and Southern Zones.

Av gas and fuel oil reserves also showed that Japan was in the end game. As of January 1, 1945, av gas reserves stood at just over 30% of their levels in January of 1942, and fuel oil reserves were just 14% of their levels at the start of the war.

Av gas usage in the Inner Zone had reached its peak in the second quarter of 1944. The picture was one of more and more aircraft, but less and less fuel for each aircraft and pilot Av fuel use for the full year climbed to 5,484,000 barrels. Av gas imports actually increased, to 2,296,000 barrels, as Japan stressed importing refined products over crude oil, but more than half of the IJA's Indies av gas production was still left behind or lost in transit. The usage rate for the fourth quarter of 1944 would have exhausted the year-end reserve in less than four months. Without Southern Zone crude to refine, the Inner Zone could supply less than 100,000 barrels per quarter. Training and testing were all sharply curtailed to cope with the shortage in hopes of preserving some of the stored fuel for the defense of the Inner Zone.[172]

[172] Oil Report, 85-7.

Crude stocks had dwindled to a mere 3% of their level at the start of 1942. With little crude to refine and imports dwindling down to a slow drip, there was little hope of getting any more.

Conclusion

Japan knew that she had an oil problem well before she started the Pacific War. Leaving aside the obvious issue of whether she should have gone to war at all, she responded sensibly to the oil issues she identified. She laid in as much of a reserve as she could before starting the war, although she found that she was eating into her fuel oil reserve even before the war began. She made careful plans to seize and use the East Indies oil as quickly possible. She built tankers, both to build up her reserve before the war and to bring the Indies oil back to the Inner Zone once she got it. She expanded her own refining capacity so that she could use the Indies oil without being dependent on the Indies refineries.

What went wrong? Japan had clearly underestimated the rate at which she would burn through oil once the war was underway. But balancing that was the fact that she had also underestimated both the amount of oil that she would get from the Indies and how quickly she would get that oil. In particular, Japan benefited from getting the Indies refineries back on line in short order. Without those refineries, she would have had to ship Indies crude to the Home Islands, refine it, and then distribute it to operational units. With them, she could essentially cut out the middle step and ship refined products directly from the Indies to the fighting fronts. This suited the Imperial Japanese Navy particularly well, as her central and southern Pacific bases were in some cases closer to her Borneo oil centers than they were to the Home Islands. Without the Indies refineries in operation, Japan's tanker problem would have surfaced much sooner as her tankers would have had much heavier demands placed on them. Her own refineries would also have struggled to meet demand, and she would have seen her reserves drop at a faster rate than they did.[173]

[173] Oil Report, 19. In 1941, Japan's refineries could refine about 32,000,000 barrels of crude annually. Her refining capacity peaked at about 42,000,000 barrels annually, but only late in the war. Her consumption in the first two years of the war was well in excess of her refining capacity.

The inability to move oil efficiently was the root cause of Japan's oil problem. Even with Indies refineries operating, her efficiency in moving oil was unimpressive at the start and deteriorated from there. Even before the Allied attack on her shipping was sinking appreciable numbers of tankers, she was leaving crude behind in the Indies that could have brought to the Home Islands for refining. And if she had cared to, she might have produced even more crude oil in the Indies than she reported. The evidence is that she got the wells going again in fairly short order, while struggling more with getting the refineries running.

Once the Allied attack on her shipping – and particularly the USN submarine campaign – began to bite, Japan's oil situation quickly fell apart. This was compounded by the Allied advance across the Pacific, which eventually threatened Japan's oil resources and tanker routes with sea- and land-based air attacks. Once the Americans were firmly established in the Philippines, Japan's oil pipeline to the Indies was effectively severed and her oil supplies could be measured in months. Japan tried to protect her oil routes against the Allied onslaught, but her efforts at protection only made matters worse. Her defenses against Allied submarines, air and mining were largely ineffective but did have the effect of slowing the movement of oil still further.

Japan's ideas about how her oil resources should be used changed over time. She was quite free with them in 1942, fuelling the IJN's expeditions into the Indian Ocean and the disastrous attempt to force the "decisive battle" at Midway. By early 1944, however, that attitude had apparently changed, and the IJN was forced to fight the next "decisive battle," in the Philippine Sea, on its Southern Zone resources, without making any appreciable demands on the Inner Zone reserves. But these reserves were tapped in October, for one last "decisive battle" – and decisive defeat – in the Philippines. In all, it looks like a cycle of expectation – defeating the Americans at Midway – moderation – using the IJN in combination with land-based air to impose unacceptably high losses on the Americans in the Marianas – and desperation – throwing in all the chips in the Philippines in the recognition that without a victory the war was lost anyway.

Despite Japan's tankers issues, it was not want of tankers that forced crude oil into the IJN's bunkers before the Marianas battle. It was a reluctance to release the fuel oil that Japan had available in her central reserves. And while tanker shortages did hobble the IJN as the war went

on, this too was a conscious choice to use the tankers to bolster the Inner Zone reserves rather than supply the fleet.

The story of Japan's oil issues in the Pacific War is fundamentally a story of tankers – at the start, of her failure to use them effectively, at the finish, of her complete inability to protect them. Japan had little chance of winning the Pacific War (and none at all without external events to help her), but her failure to use her oil resources to best advantage brought her defeat that much more quickly.

Appendices

Refined Products Consumed in Calendar Year 1942 (barrels)

	IJN	IJA	Civilian	Total
Total	26,500,000	8,000,000	8,000,000	42,500,000
Inner Zone	14,500,000	4,000,000	7,000,000	25,500,000
Southern Zone	4,000,000	1,500,000	500,000	6,000,000
Other	6,000,000	500,000	500,000	7,000,000
Captures	2,000,000	2,000,000	0	4,000,000

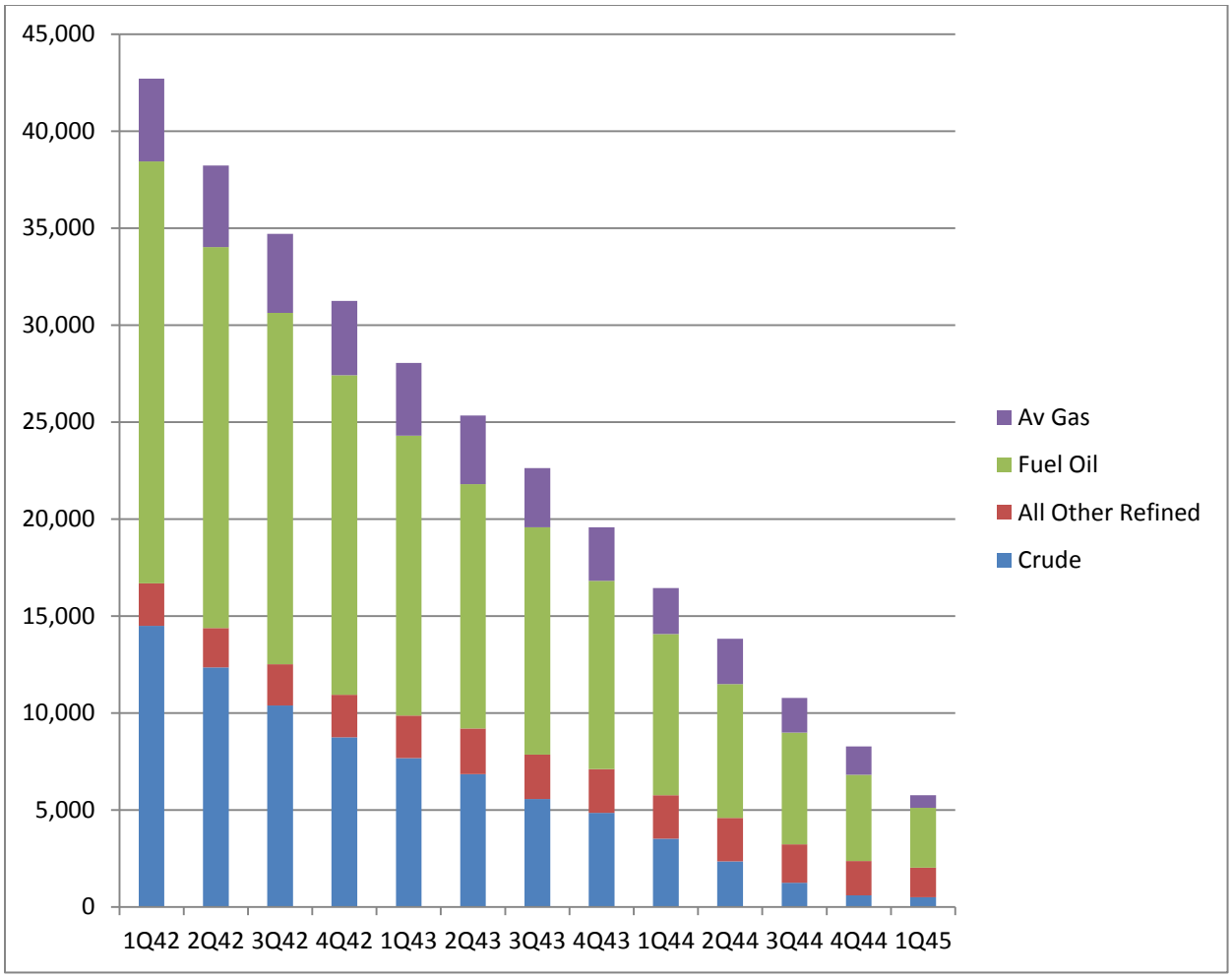
Refined Products Consumed in Calendar Year 1943 (barrels)

	IJN	IJA	Civilian	Total
Total	27,250,000	7,250,000	10,500,000	45,000,000
Inner Zone	14,250,000	4,750,000	9,000,000	28,000,000
Southern Zone	13,000,000	2,500,000	1,000,000	16,500,000
Other			500,000	500,000

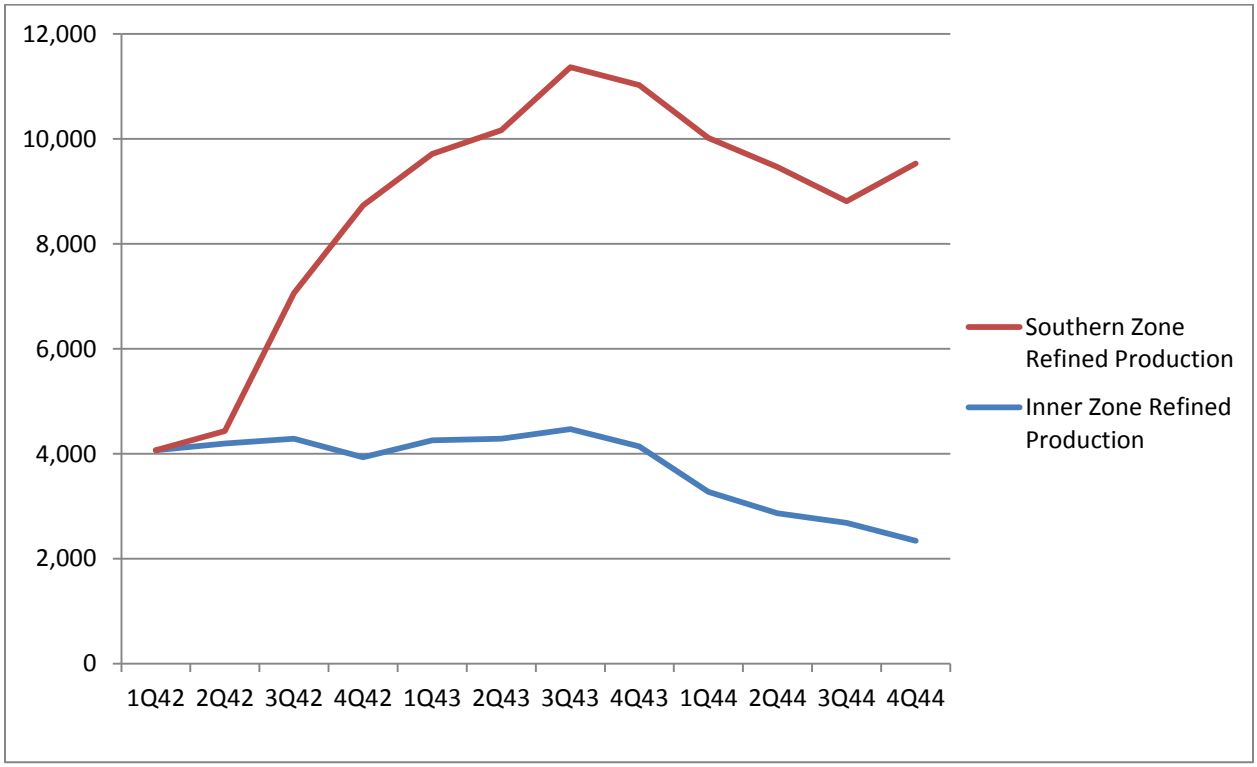
Refined Products Consumed in Calendar Year 1944 (barrels)

	IJN	IJA	Civilian	Total
Total	22,000,000	7,000,000	5,000,000	34,000,000
Inner Zone	12,000,000	5,000,000	4,500,000	21,500,000
Southern Zone	10,000,000	2,000,000	500,000	12,500,000

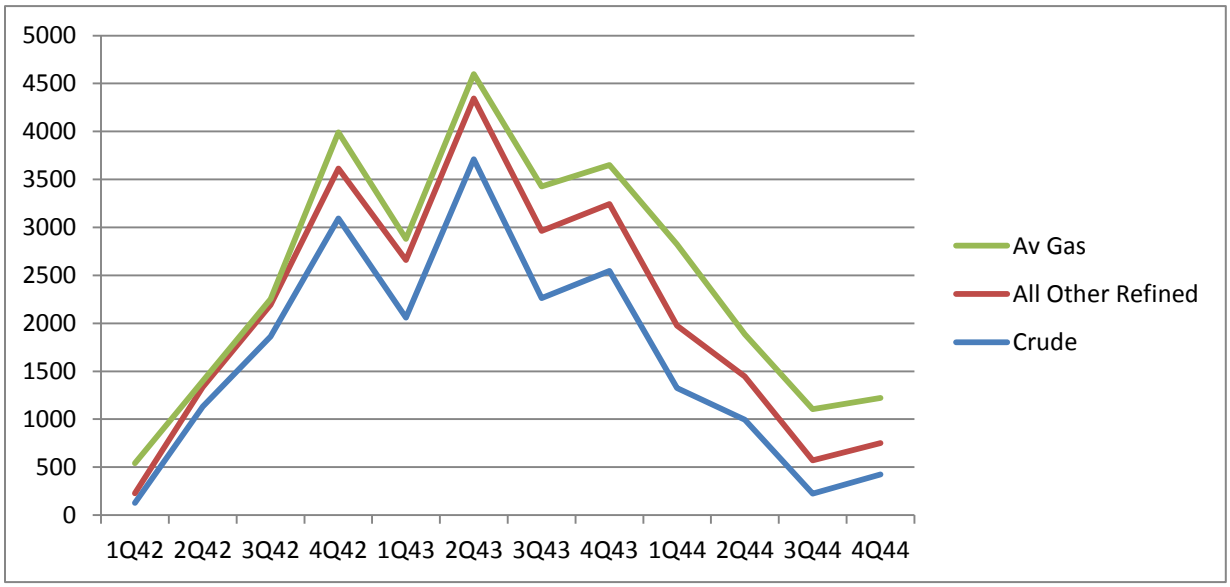
Aggregate Reserves at Start of Quarter (000s of barrels)



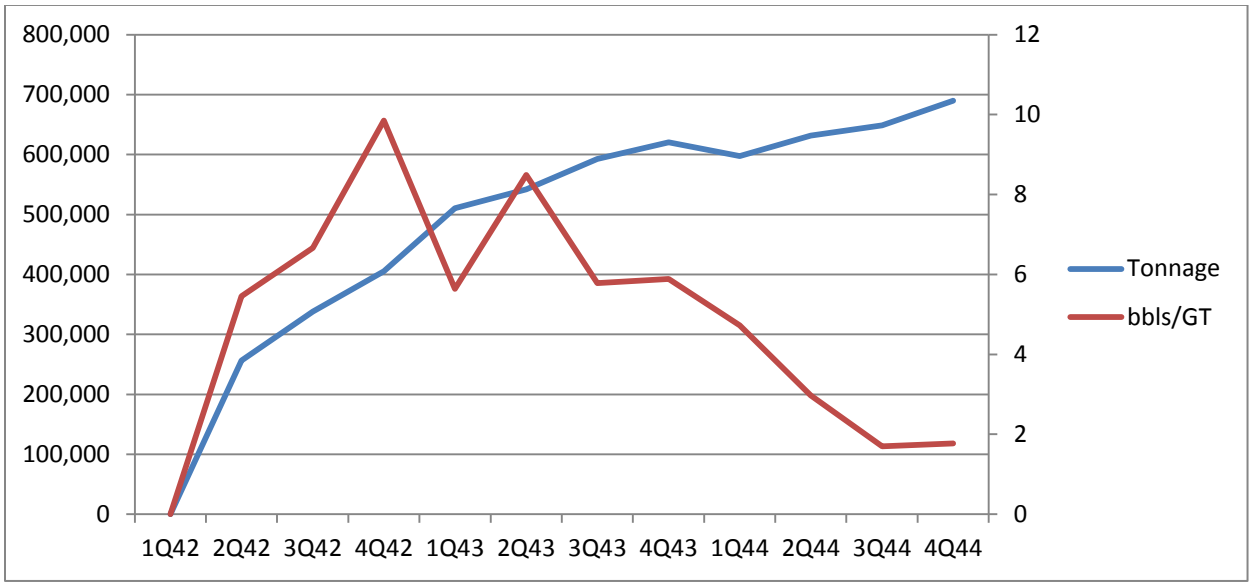
Aggregate Production of Refined Products by Quarters (000s of barrels)



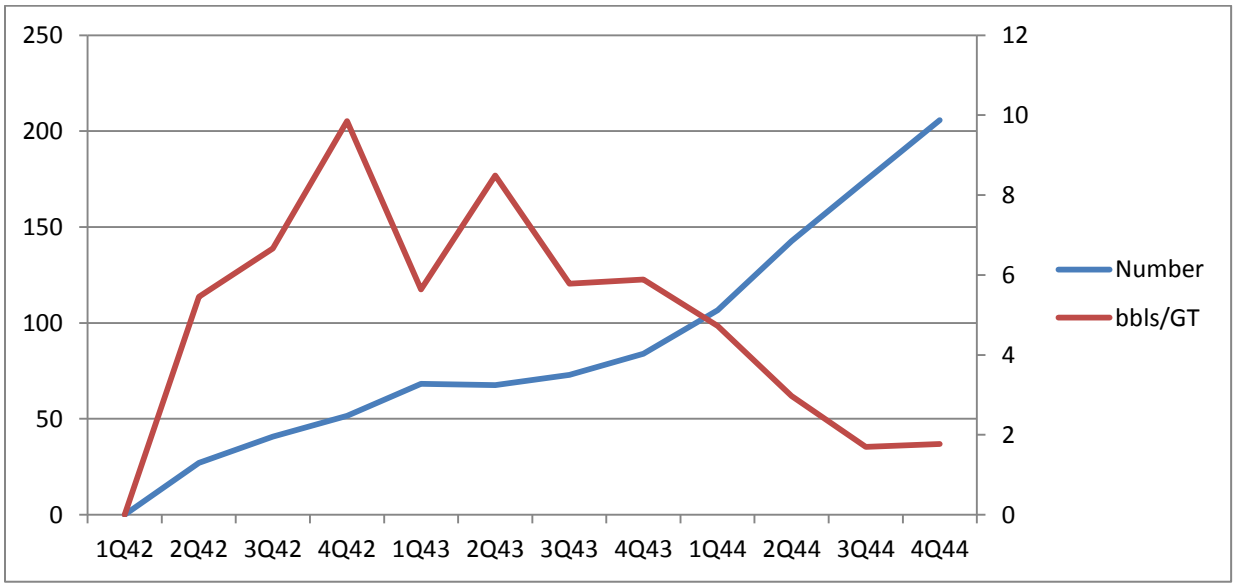
Aggregate Imports to the Inner Zone by Quarter (000s of barrels)



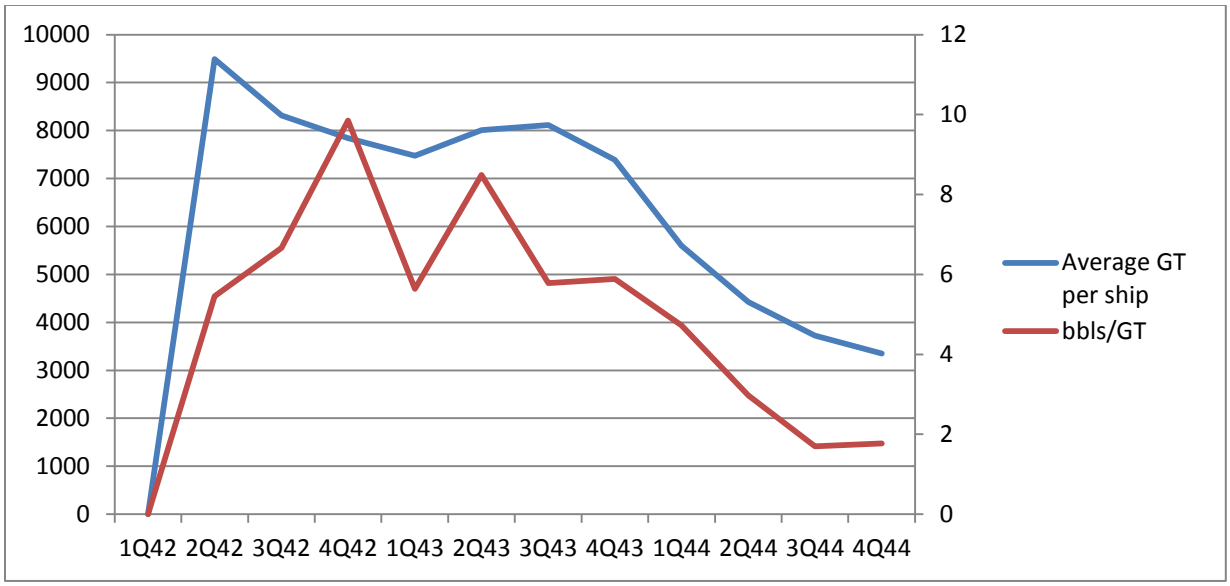
Average Tanker Gross Tonnage Importing Oil to the Inner Zone (Left Scale) versus Barrels Delivered per Gross Ton (Right Scale)



Average Number of Tankers Importing Oil to the Inner Zone (Left Scale) versus Barrels Delivered per Gross Ton (Right Scale)



Average Gross Tonnage per Ship of Tankers Importing Oil to the Inner Zone (Left Scale) versus Barrels Delivered per Gross Ton (Right Scale)



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