

COPY # 13 OF 34 COPIES



**Phase Analysis
Strategic Mini
Blockade of t
Japanese Emp**

~~CONFIDENTIAL~~

FOREWORD

Among the exploits of the Twentieth Air Force, the unique and effective mining of the home waters of the Japanese Empire by B-29's played a significant role in gaining an early victory. This Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire describes the operation. Many of the methods employed in the conduct of the B-29 aerial mining campaign were precedent breaking and in marked contrast with traditional techniques and with methods employed by other commands during the course of the war.

Significant facts and battle lessons gained in the course of the mining campaign are clearly described and illustrated in this condensed summary of the operation.

Since the B-29 mining campaign demonstrated for the first time that air power can carry the brunt of a strategic blockade of a powerful maritime nation, it is recommended that this Analysis be given careful consideration and evaluation in future military planning.

W.F. Durning

Lieutenant General, U.S.A.



~~CONFIDENTIAL~~

TABLE OF CONTENTS

	Page No.
Section A - Overall Planning.....	3
The Mission.....	3
The Target.....	3
Mission Planning Problems.....	4
The Weapon.....	5
Summary of Planning Decisions..	6
Section B - The Execution.....	8
Organization.....	8
Tactical Planning.....	8
Phase I.....	8
Phase II.....	10
Phase III.....	10
Phase IV.....	11
Phase V.....	12
Summary of Mining Operations.....	14
Section C - Conclusion.....	19
Reasons for Success.....	19
Lessons.....	19
Annexes.....	33
A. Statistical Summary.....	33
B. Flak Analysis.....	36
C. Minelaying Procedure.....	37
D. Mine Modification Unit.....	38
E. Mine Assembly Depot No.4.....	42
F. Wing Ordnance.....	44
G. Wing Operations.....	46
H. Psychological Warfare.....	48
I. Sunken Ships Photographed.....	50
J. Radar Minelaying Accuracy.....	52

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

PURPOSE OF THIS ANALYSIS

1. To present the basis upon which were reached the strategic decisions of the Mining Campaign carried out against Japan in the year 1945 by the 313th Very Heavy Bombardment Wing of the Twentieth United States Army Air Force.
2. To furnish a better background for the planning of future mining operations.

SCOPE

The decisions recorded herein were transmitted from Headquarters, XXI Bomber Command (later Headquarters, Twentieth Air Force), in general directives to the 313th Wing for tactical implementation. The detailed planning of minefields and the execution of specific mining missions by the Wing are not covered by Tactical Mission Reports, since they are outlined in the "Command level" planning involved in the operation. The Annexes chiefed in each phase of the operation describe in some detail which supplement the report the organization and operating procedures utilized by the various participating agencies.

INTRODUCTION

In the fall of 1944, the course of the war indicated that an early sustained mining campaign in great force against Japanese shipping was necessary. However, only B-29 aircraft possessed the capability of carrying out such a campaign. The Army had the aircraft -- the Navy had the mines. Therefore, in November of 1944, the Commander-in-Chief, Pacific Fleet, proposed to the Commanding General, Army Air Forces, that he undertake the imposition of a mining blockade of Japan. This suggestion was accepted by the Air Forces, and the Commanding General, XXI Bomber Command, was directed in December to initiate planning for operations scheduled to begin on or about 1 April 1945.

The mission given the XXI Bomber Command was an ambitious one -- the blockade of all Japanese sea commerce -- but within five months, with the cooperation of other anti-shipping forces, both Army and Navy, the Command was able to substantially to accomplish its objective. In the planning, advantage was taken of the lessons learned from the British Mining

Campaign against Germany, as well as from our own previous Army and Navy mining campaigns in the Pacific. The entire aircraft operation, both planning and execution, was conducted by the XXI Bomber Command, but all preparations, mine modification and logistics were provided by the Navy. Only B-29 crews carried out the minelaying missions, but both Army and Navy personnel were utilized in all phases of the planning.

The 313th Wing carried out the tactical planning and minefield design, as well as the execution of the mining missions. The preparation of the mines was carried out by Mine Assembly Depot No. 4.

In studying this report, certain facts should be kept in mind -- facts which show the extent of this operation and its effect on the Japanese desire and ability to continue the war:

- * As a by-product of the Mining Blockade, it is estimated that over 1,000,000 tons of enemy shipping were sunk or damaged by mines, while the number of sorties utilized was only about 6 percent of the entire Twentieth Air Force effort.
- * The total number of mines laid (over 12,000) was smaller than that laid in the European Theater, but the scale of the effort against Japan was larger when measured in terms of mines laid per month -- which is the criterion in attempting to establish a blockade.
- * In the process of the operation, the XXI Bomber Command flew its longest offensive combat mission of the war.
- * The 505th Bomb Group, in one month's sustained effort, exceeded by 15 percent the next highest command record of sorties flown per month per aircraft assigned. This was done without a single combat loss, and is merely one instance documenting the quality of the 313th Wing's flying, maintenance, and planning.
- * The Mine Depot, with the very minimum of personnel, exceeded all records of U S forces in the number and rate of mines prepared. The highest standards of inspection were maintained in spite of the fact that more than 200 different types of mines were required.

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

SECTION A-OVERALL PLANNING

The Mission

The mining mission was to complete the destruction of the Japanese shipborne lines of communication. The three principal objectives were:

1. To prevent the importation of raw materials and food into Japan.
2. To prevent the supply and deployment of her military forces.
3. To disrupt her internal marine transportation within the Inland Sea.

It was believed that the mining, if carried out in force, would terminate practically all imports into Japan; first of raw materials, finally of food. As a result, enemy industry would be starved for materials and eventually cease production, and the enemy population would be reduced to starvation. The effect of starvation would combine with the incendiary raids to reduce the civilian will to wage war. Therefore, the operation was called STARVATION.

The Target

When the mining campaign began, the enemy had approximately 2,000,000 gt of shipping of 1000 gt or over afloat. This shipping passed freely through Shimonoseki Straits into the Sea of Japan and the Yellow Sea, as well as to the southern areas conquered by the Japanese, via the Straits of Formosa. Very little Japanese shipping was able to challenge the mastery of the American submarines in Pacific waters, but on the other hand, enemy minefields and escorts, as well as air patrols, prevented any effective utilization of our forces against the shipping in the Japanese Inner Zone. The amount of shipping and the routes were adequate at the beginning of the year to supply the enemy's needs in the Inner Zone.

It is estimated that foods and raw materials were moving into Japan at a rate of from 1,000,000 to 1,500,000 tons per month. There were numerous indications that, whatever the shipping requirements were, Japan's shipping position was approaching a marginal point, and that any further substantial re-

duction in either the number or movement of available vessels would strike a severe blow to the Japanese war economy.

The mining was to be of a strategic nature, and was to supplement the strategic bombing of Japan. The estimates which follow show the importance of waterborne freight to the Japanese.

During 1944 the following percentages of imports required by Japanese industries were seaborne:

1. 80 percent of all oil supplies.
2. 88 percent of all iron (iron ore and ingots).
3. 24 percent of all coal (including 90 percent coking coal).
4. 20 percent of all food.

As regards food alone, the nutrition standards in Japan were such that the difference of 20 to 30 percent was the difference between actual subsistence and starvation for a large part of the population.

Inside the Japanese Home Waters, the Inland Sea forms a natural freight shipping route, well protected and free from the overland obstacles of terrain which have prevented the development of extensive railroads and motor transportation facilities. As a result, 75 percent of all transportation was waterborne, including 57 percent of all the coal used. One-half of the power used in the great industrial regions of Kobe-Osaka, Nagoya, and Tokyo was obtained from waterborne coal.

The number of Japanese ships available had been greatly reduced by our submarine warfare, but the remaining shipping, for the time being, was invulnerable to our submarine attacks because it was operating in the Inner Zone, and was protected by extensive minefields, difficult to penetrate.

The Japanese merchant fleet position as of 27 March 45 was as follows for steel ships of 1000 gt and over:

Total Gross Tons

Shipping afloat, 7 Dec 41 plus all subsequent acquisitions and construction, 7 Dec 41-27 Mar 45.....	9,000,000
Less sinkings, 7 Dec 41-27 Mar 45..	7,190,000
Total afloat, 27 Mar 45.....	1,810,000
Less 20 percent factor to cover ships in repair.....	362,000
Total operable, 27 Mar 45.....	1,448,000

More than 60 percent of the tonnage of this shipping was composed of ships with a size of 4000 gross tons or larger. These large ships were the prime targets, and one of the mining problems was to sink ships selectively. One mine could sink or seriously damage one 10,000 ton ship at ten times the profit that would be obtained if the same mine sank or damaged one 1000 ton ship.

The shipping necessary to support the faltering enemy war industry each year required approximately 12,000 passages from Chinese and Korean ports via Shimonoseki Straits, approximately 12,000 local voyages between Inland Sea ports, and 15,000 voyages to the Kobe-Osaka region. As the enemy attempted to disperse industries, a move made necessary by the strategic bombing of Japan by the Twentieth Air Force, his transportation requirements increased markedly. Since his railroads and motor facilities were already strained to the maximum, this had to be effected largely by sea transportation. Furthermore, the destruction of his stockpiles by incendiary and bombing raids required an abnormal transfer of raw materials between different regions. In particular, the transfer of his fuel supplies, which were stored in a few regions, could be greatly disorganized by strategic mine warfare. Because the flow of oil and aviation gas from his sources in the South had been reduced, such a disorganization would further seriously affect his war industry.

Plate I (page 20) represents schematically the railroad routes of Japan and indicates the ports served by railroads which might be used for diversionary ports.

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

Plate II (page 21) represents schematically the shipping routes used by the Japanese prior to the inception of the mining campaign and shows the proportionate amount in the various routes.

In addition to the merchant shipping, the enemy still possessed a formidable striking force of naval vessels, although this force was meager compared to that which he once possessed. These men-of-war were based principally at the great Japanese naval base at Kure, although units of the fleet were frequently found in other Inland Sea areas. Our invasion of Okinawa was imminent just prior to commencement of the mining operations. To prevent enemy naval interference during the first two critical weeks of the invasion, the Japanese naval forces were also a mining target.

At the inception of the mining program, the principal enemy naval units operable were:

- 3 BB
- 2 BB-KCV
- 10 CV, CVL, and CVE (approx)
- 7 or 8 CA and CL

It is believed that the carriers were substantially immobilized because of a lack of an adequate complement of aircraft. The BB Yamato was the backbone of the heavy fleet units. While a naval force could be assembled for a sortie against Allied naval units, such a sortie was expected only in connection with enemy defensive operations.

Mission Planning Problems

1. Mining Altitude. The most important decision in regard to operations was the altitude to be selected for the attack. Theoretically, mines were capable of release from any altitude up to and including 35,000 feet. Mines could be dropped either in daylight or at night. In the first case, visual methods could be used in a manner similar to bombing, and radar methods could be used either in the daytime or at night. Mines could be dropped either by single aircraft or by formations of aircraft. However, an analysis of these factors clearly showed the advantage of single flights at night dropping mines from low altitude by radar. The reasons were very evident.

a. First, mining by daylight necessitated formation methods for defense. The inherent design of minefields requires wide dispersal of mines covering large areas. It would have been exceedingly difficult to achieve this wide dispersal with use of large formations; that is, the mines could be dropped successfully but the minefields themselves would be of a concentrated character and therefore inefficient.

b. The second factor against daylight missions was the necessity to carry them out at very high altitudes. Study of the accuracy attained from 30,000 feet with the best possible radar wind measurements or with the best predicted weather, showed that at most an accuracy yielding an average radial error of about two miles could be counted upon. It was improbable that even this could be achieved. It was estimated that the accuracy from altitudes of 30,000 feet would be one-fourth of that which could be obtained at 5,000 feet.

c. The third factor against daylight high altitude operations was the limited mineload that could be carried; about one-half or less of that which could be carried at low altitudes by single flights.

d. A fourth factor was that high altitude formation flying resulted in heavy operational losses caused by excessive mechanical strain on the aircraft. The mechanical strain on single aircraft flying at night at low altitudes was rather slight, thus reducing operational losses by mechanical failures.

e. A fifth factor was that contact ditching in daylight returns would be possible if ditching was necessary, and Air-Sea Rescue operations would be more effective, since search for longer periods was possible on the day following the night operations. Ditching at night following day operations was dangerous and often meant a night's delay in search for survivors. More effective rescue would result in higher crew morale and better mining.

f. A sixth factor was that the operation of a single aircraft at night would probably result in greater safety against enemy anti-aircraft, especially if full radar operation were used and the target attacked during overcast periods. A special study of the flak problem for mining was made by AAF POA, as given in Annex B. It was concluded that for single aircraft flying at low altitudes at night an altitude of 5000 feet to 6000 feet gave optimum safety.

g. A seventh factor was that take-off and landing would occur during daylight, increasing the safety of the operations.

2. Night Operations. The advantages of night operations were evident from the above. Briefly, they could be summed up as follows:

a. More than double the load could be carried.

b. Four times the accuracy could be attained.

c. Efficient minefields could be designed and laid.

d. Maintenance of aircraft would be greatly improved because of lowered engine strain with a resulting reduction in operational losses.

e. Flak damage and loss would be much lighter.

f. Air-Sea Rescue facilities would be more effective in reducing loss of crews.

There appeared to be no reasonable arguments to favor high altitude night missions by single aircraft. It was concluded that night operations using single aircraft at low altitudes would be approximately twenty times as effective as daylight operations and approximately ten times as effective as high altitude night missions, and with lower losses.

Accordingly, plans for carrying out night mining missions at low altitudes, with single aircraft, were presented to the Commanding General on 27 January 1945, at which time he directed that mining be carried out at low altitudes using single aircraft at night.

3. Minelaying Methods. Several methods of laying mines at night had been previously used, and several modifications of these methods were proposed. The oldest method was to lay mines visually using visual methods of target identification. These methods were used most extensively by the British, by PBY aircraft in the SW Pacific, and by Navy PB4Y1 aircraft in the Central Pacific. They were also used by B-29 aircraft of the 58th Bomb Wing in mine-laying operations while based in India. However, it was clear that this method could not be used in the Empire where different weather conditions would permit visual methods less than 10 percent of the time. The very low altitudes required for visual recognition at night are impossible over Japan because of the mountainous terrain.

It was therefore necessary to rely entirely on radar methods of minelaying. Radar minelaying had been used by the British and was tried in drills carried out by CominPac at Oahu. B-29s of the 58th Bomb Wing, employing the AP-13 Radar, had also made limited use of radar methods of minelaying. The B-24s of the 42nd Bomb Squadron of the 11th Bomb Group had achieved reasonable accuracy in their extensive use of radar methods in the mining of the Bonins, particularly at Chichi Jima. The methods used by these two groups appeared to be suitable in principle, with some modifications, for a mining SOP

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

by the 313th Bomb Wing. The Naval Air Station, Patuxent, Md., had summarized and catalogued the various methods. The cross bearing technique of identifying the release point developed at the Naval Air Station, Patuxent, Md., was considered, but this offered no advantages.

The 313th Bomb Wing was therefore directed to develop a minelaying procedure essentially similar to the radar bombing methods in which the personnel of the Wing were already trained. The aim was to utilize all of the previous training of the Wing and to obtain the simplest possible procedure, accepting minor inaccuracies of smaller magnitude than that determined by the resolution of the APQ 13 Radar. For example, the effect of wind drift on the parachuted mines was minimized at low altitudes and the necessity to take wind into detailed account was reduced. This resulted in a simplified minelaying procedure.

Details of the SOP and training are given in Annexes C and G.

4. Force on Mining Missions. The Commanding General believed the most effective use could be made of Twentieth Air Force aircraft if the mining was carried out by full wing missions. This was compatible with the most effective use of mines in the initial effort. It was believed desirable to establish strong and heavy minefields at the principal mining targets in order to force the enemy to sweep and use specific channels. It was hoped these channels could be determined by reconnaissance and then re-mined. If only incomplete minefields were laid in the principal targets and over a very widespread area, it was considered that the enemy would be able to avoid the mined areas in wide harbors such as Kobe-Osaka and Shimonoseki. Therefore, in order to leave the enemy no choice, the early minefields needed to be complete. This effect could be achieved best with full wing efforts.

On the basis of this forecast of the enemy reaction, it was hoped that re-mining could be carried out on a continuous group basis at a later time.

Therefore, the first missions were directed by the Commanding General to be carried out as full wing missions.

5. Design of Minefields. In accordance with the mission, the objective of the mining was to achieve complete blockade of Japanese shipping. It was necessary to undertake this in a logical sequence of steps, each requiring different tactics.

Two courses of action were possible. The first was to mine all targets more or less uniformly. This gradual building up of the minefield in each area without achieving early blockade at any particular port would serve notice on the enemy that all his ports would be attacked and thus permit him to develop countermeasures at all areas. The advantage of this course of action was that widespread attack initially would be beyond his sweeping capability and probably would achieve very good attrition during the period. The disadvantage was that in many of the principal targets, light minefields would achieve little or no results because the enemy could avoid them.

The second course of action was to lay down the strongest possible minefields at the enemy's principal shipping bottlenecks, commencing with his Inner Zone in the Inland Sea and the Shimonoseki Straits, and working out as rapidly as the mine supply would permit. The advantage of this plan was that the enemy would be faced immediately with a major clearance problem in his most important harbors, their channels, and in the vital Shimonoseki Straits artery. These unavoidable minefields would result in the immediate maximum disorganization, blockade, and destruction of his shipping. It was hoped that succeeding mining missions could be scheduled rapidly enough so that, as the mining effort spread to the outer parts of the Inner Zone, the enemy would be unable to catch up in his countermeasures. Furthermore, the establishment of complete minefields would force the enemy into sweeping specific channels through them. It was hoped that these channels could be located by reconnaissance, and mined by smaller succeeding efforts.

The initial concentrated mining of a few targets in heavy force, had the further operational advantage that planning was practical for a full wing effort, whereas planning for 10 or 20 different targets for the initial effort would have been impractical.

The principal disadvantage of mining a few targets in great force appeared to be that it offered the enemy an opportunity to concentrate his sweeping or clearance methods in the regions first attacked and thus obtain quicker clearance. It was hoped that the choice of mine types would make this difficult.

6. Intelligence. There were two important intelligence tasks that were vital to the success of the mining campaign. The first was to ensure a maximum of continued reconnaissance over the minefields in order to locate swept enemy channels for re-mining and to disclose new type enemy sweeps. Reconnaissance carried out by the Twentieth Air Force re-

quired as an accompaniment, expert photo interpretation of shipping. This combined task was carried out by the Third Photo Reconnaissance Squadron and the Combined Central Interpretation Unit. All other intelligence was provided in two special mine intelligence summaries -- one prepared by the Military Intelligence Service and the other by JICPOA. These summaries provided some of the most decisive information used in the mining campaign.

The second task was to obtain the best possible records of mine locations, both in order to determine the accuracy of laying so as to evaluate the effectiveness of particular minefields and mining missions, as well as to provide data for future minesweeping operations by our own forces. Fortunately, radar scope cameras provided a means for an accurate and permanent record of mine drop locations, and more than 50 percent of the drops were recorded in this way. Prior to mining operations, a complete reporting system was established by the XXI Bomber Command, largely based upon the mining experience of the 42nd Bomb Squadron in the Bonins mining. This system ensured the accurate recording of mine positions from the start of the operation.

The Weapon

1. Mine Types Available. Five principal types of mines were either on hand or in production for use during the mining campaign. These consisted of two magnetic types, the M11 and M9 Mod 1, both of which were believed to be familiar to the enemy. Two others were acoustic types; one, the A-3, operating on propeller noise in the acoustic region, and the other, the A-5 (in production but not yet available), operating on ship hull vibration in the subsonic region. The acoustic A-3 was believed to have been recovered by the enemy from previous mining operations. A pressure mine type, the A-6, operating on the reduced water pressure under a ship resulting from its motion, was in production but not yet available. It was similar to a mine used on the Normandy beachhead by the Germans with great success. This type was believed to be unsweepable by the enemy, as well as by our own forces.

Only the magnetic mines and the A-3 acoustic mine were available for the first month's operations. Both of these types had been compromised.

Reliable intelligence indicated that the enemy had planned to rely principally on his towed catenary magnet sweep which was easily capable of sweeping our unmodified magnetic mines. Intelligence also indicated the enemy's ability to sweep our original acoustic A-3 mine. It was believed his method was explosive, but details were unknown. It was anticipated that the use of the A-6 pressure

~~CONFIDENTIAL~~

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

mechanism (and probably the subsonic A-5 mechanism) would yield better results. However, as these mechanisms were not yet available, it was believed early mining would produce a greater overall effect than could be achieved by waiting for several months to initiate operations.

2. Mine Modifications. In order to correct the defects and weaknesses of the standard M11 and M9 Mod 1 magnetic and A-3 acoustic mechanisms, local modification of these mechanisms was proposed to accomplish two things: First, and most important, to defeat the known enemy sweeps, and second, to select the largest enemy ships for sinking, so as to obtain maximum damage on a tonnage basis.

The first of these goals required modification of mine mechanisms to meet specific enemy countermeasures or sweeping.

The second required adjustment of the sensitivity of the mechanisms to make them insensitive against small ships.

Unwisely, the enemy had chosen a somewhat crude sweep of towed magnets for mass production because it could be used easily with small boats and unskilled personnel. This sweep had been recovered in quantity and had been analyzed. The M9 Mod 1 mechanism, and less effectively the M11 mechanism, could be modified by changing their timing in such a way as to defeat this enemy magnetic sweep almost completely. The change was therefore carried out from the beginning. It was fortunate that the need for ship selection required reduced sensitivity of these mechanisms, which further aided in reducing the effectiveness of the sweep. It was believed that for a short time, at least, the magnetic mines could be made almost unsweepable to the enemy by proper modification prior to laying. This modification was difficult but possible.

Although it was believed the enemy could sweep the original A-3 mechanism by explosive methods, modifications of this mechanism made by the Mine Modification Unit on Oahu had altered the characteristics of the mechanism so that it could no longer be cleared by simple explosive sweeps. This modification was not considered to be of continued effectiveness in defeating enemy countermeasures, but one or two months effort on his part would probably be required to defeat it.

As a result of these two modifications, it was believed that the two magnetic and the A-3 mechanisms, would be very effective for a limited period, possibly for two months.

The second important alteration in the mine mechanisms was the adjustment of their sensitivities. All mines were designed for use in very deep water, and most of the best targets had shallow water. An analysis of the accuracy which could be obtained in the mining operations and of the probable width of enemy channels, based on our own experience, indicated that the logistic limitations of the mining effort would prevent enough mines from being laid to threaten all ships attempting passage through the mined areas. As it later turned out, the ratio of mines to ship passages was small. In order, therefore, to make each mine of maximum effectiveness, it was necessary to adjust the sensitivity so that the tendency would be to sink the larger ships. Also it was necessary to adjust the target width so that enemy ships would tend to be sunk or seriously damaged, rather than to suffer slight damage or to "sweep" the mines without damage. These changes to the mines could not be ideally realized because of the complex consideration of sweeping, lack of exact information of the composition of enemy ship traffic, and the characteristics of the mines themselves. However, it was considered that in the case of the magnetic mines the effect of modification might be such as to double or triple the amount of tonnage sunk or damaged, and at least some increase in damage would be achieved by modification of the A-3 acoustic mechanism. The Mine Modification Unit and adequate supplies were not yet available in the Marianas so that it was not possible to put all of these decisions fully into effect for Phase I. As much modification as was possible was done on the mines prepared for the first two full wing efforts.

This decision tremendously increased the work of planning and execution, since each mine had to be adjusted for the particular target to be hit by the particular aircraft. Complex planning was therefore necessary, and in execution each aircraft had to hit the exact target assigned. This considerably reduced the flexibility of operations. The expected gain in tonnage mined was believed worth the additional effort.

Details of operation of the Mine Modification Unit are given in Annex D.

3. Mine Assembly. All mines were provided and prepared for use by the Navy. Figure 1 is a chart showing the flow of logistic information. Mine Depot No. 4 was established on Tinian and was ready for operation by 20 February 1945; approximately 1500 mines were available at that date. However, the shipment of new supplies of mines was slow, and therefore the mining campaign was logistically limited.

Details of operation and performance of the Mine Assembly Depot are given in Annex E.

4. Mine Loading. The mines were handled by the normal ordnance personnel of the 313th Bomb Wing, after special indoctrination in installation of safety and arming devices and parachutes. Particular attention was paid to inspection. Mines were loaded and the planes mined-up with the same rapidity as other ammunition in spite of the fact that each mine was differently prepared and was designated for a particular rack station in each aircraft.

Details of Ordnance operations are given in Annex F.

Summary of Planning Decisions

Prior to initiating the first mining operation, the following decisions had thus been made:

1. To use single aircraft unescorted, at low altitudes, at night, laying by radar.
2. To use all mines available as early as possible.
3. By successive steps to initiate and maintain the blockade of:

The main enemy shipping artery, Shimonoseki Straits.

The Inland Sea shipping routes which connect Japan's great industrial zones.

The NW Kyushu and Honshu ports.

Korean ports (if possible).

4. To select for sinking the larger ships of the enemy's merchant fleet.

5. To defeat enemy sweeping by mine modification when possible as new countermeasures occurred.

~~CONFIDENTIAL~~

ORGANIZATION OF B-29 MINING OPERATIONS

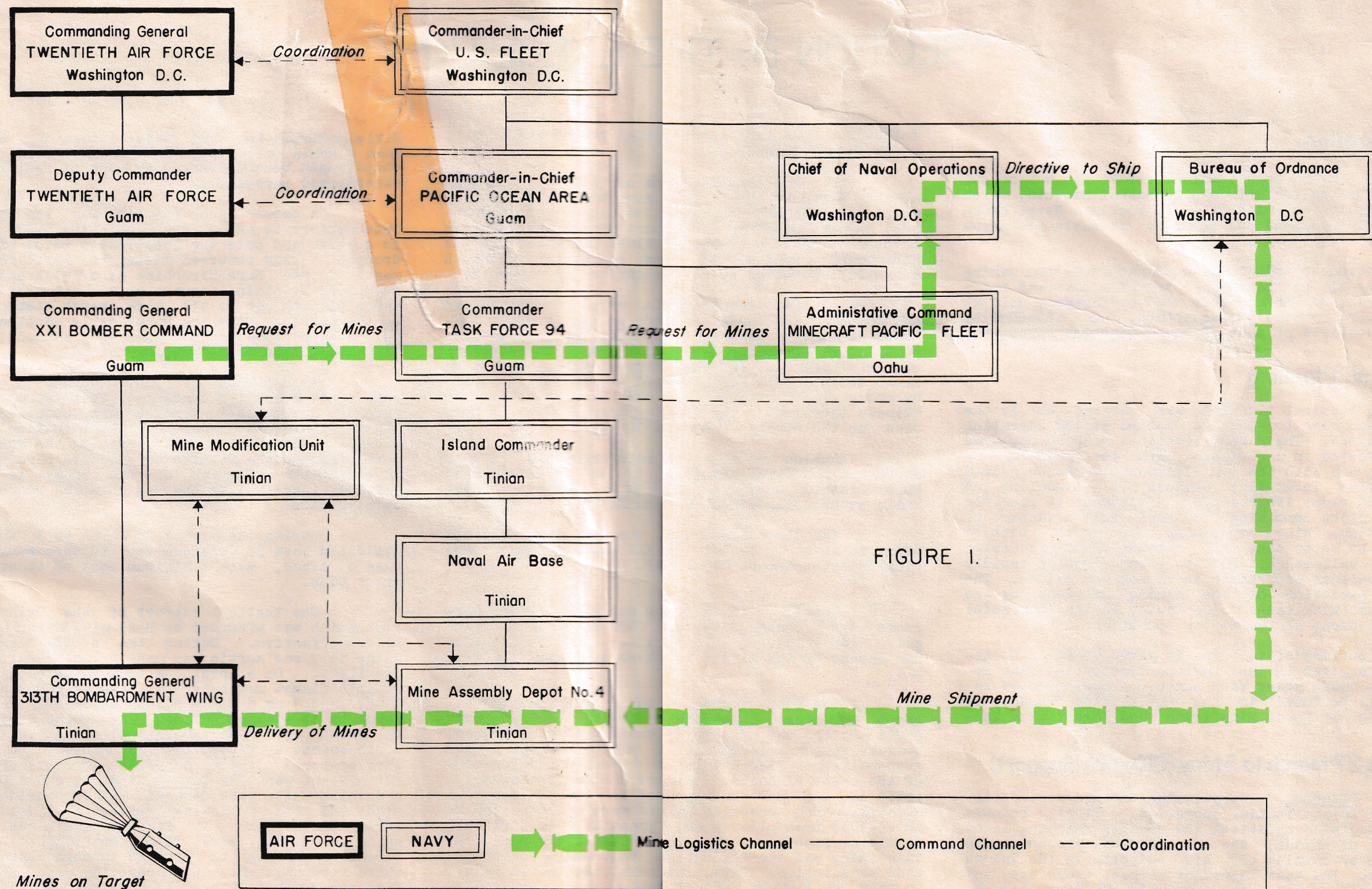


FIGURE 1.

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

SECTION B--THE EXECUTION

Organization

The command organization for mining was normal except for the logistic and technical aspects, which were coordinated with the appropriate Naval agencies. The command and logistic channels are shown in Figure 1.

Continuous and close coordination of the mining effort by all participating organizations was maintained by means of a weekly mine conference, held at XXI Bomber Command Headquarters, and attended by representatives of each of the activities concerned.

Tactical Planning

All tactical planning was carried out by the 313th Bomb Wing to whom the entire mining operation was assigned. The general tactical methods employed were directed in accordance with the preceding decisions, and with the low altitude experience gained in previous incendiary attacks in scheduling and choice of radar IPs and APs. This made it possible for the 313th Bomb Wing to take full advantage of all previous Wing experience, to modify tactics readily so as to take into account minefield design and mine ballistics, and to change tactics rapidly as operational experience in mining was gained. The capable execution of the mining missions by the 313th Bomb Wing was a major factor in the successful accomplishment of the mining operation.

An outline of tactics is given in Annex G; details are given in the various Tactical Mission Reports as noted under each phase. A consolidated report will be found in the publication "Summary of Twentieth Air Force Minefields and Minelaying Tactics".

Phase I, 27 March to 3 May (Okinawa Support)

1. Planning. Two planning factors were of importance to the initial operation. First, because of the decision to attack the enemy's shipping lanes by steps or phases, the most logical procedure was to begin by cutting off his shipping in the Inland Sea area. The most important target, therefore, was the Shimonoseki Straits; Kobe-Osaka came second,

followed by the general shipping routes and smaller ports in the Inland Sea.

Second, the invasion of Okinawa was scheduled to begin at about the same time as the mining missions. CinCPac requested the closure of Shimonoseki Straits by mines in support of Okinawa in order to prevent passage of enemy fleet units through the Shimonoseki Straits. The enemy could carry out such a sortie undetected by our submarines or aircraft.

The two requirements were compatible and the decision was therefore made to mine heavily Shimonoseki Straits as the first step in the blockade. At the same time, the decision was made to establish strong minefields in the Kure-Hiroshima region in order to interfere further with any attempted sortie by enemy fleet units during the early weeks of the Okinawa invasion. The mining operation was scheduled for the nights of 27 and 30 March.

Action was taken to reinforce gaps (due to aborts in the first mission) in the minefields at Kure-Hiroshima during April, and to harass the fleet units by dropping mines in Kure Harbor and Sasebo.

The directives and the execution of this plan are given in detail in XXI Bomber Command Tactical Mission Report 47 and 49.

2. Results. In carrying out Phase I, 246 aircraft were airborne, laying 2030 mines in the target, with a loss of 5 aircraft. The distribution and amount of the mining is shown in Plate III (page 22).

The enemy reacted with a most vigorous attempt to clear Shimonoseki Straits by sweeping, partly by the use of suicide craft. This clearance, carried out on a large scale, was documented by our reconnaissance aircraft which revealed the location of the swept channels. Figure 2 shows the sweeping craft in the Eastern Approach to the Shimonoseki Straits. The channels swept were very narrow -- about 2000 feet wide -- and presented a difficult re-mining problem. The most disturbing aspect of this sweep was the indication that small craft were used as suicides. This, if permitted, would result in many small and unprofitable ship casualties.

Early modification and desensitization, which had been planned originally to prevent firing on small ships, had been prevented by lack of facilities and experienced personnel.

A second enemy reaction was the use of his interceptors to escort the minelaying B-29s in order to observe and note the location in which mines were dropped. This occurred during the April reinforcements of the Kure-Hiroshima minefields and was accompanied by plain language broadcasts over the Japanese warning net to all mine watch stations to be on the alert. Thus the enemy early adopted and developed mine location and clearance methods, as distinguished from mine sweeping methods.

An estimate of the blockade produced by this first operation concluded that effective closure of Shimonoseki Straits was obtained for ten days or two weeks, resulting in a reduction of traffic to 25 percent of normal, cutting the monthly imports through the Straits to about 50 percent. The more complete reaction of the enemy is shown in Plate IV (page 23) in the new shipping routes caused by diversion.

During the period 28 March to 3 May, it is estimated that 35 Japanese vessels were sunk or damaged by mines, with a minimum loss of about 100,000 gross tons.

The tactical support of the Okinawa invasion which was afforded by B-29 minelaying apparently was effective. During the entire Okinawa campaign only one sortie was made by major units of the Jap Fleet. On 6 April, a task force consisting of Japan's finest remaining BB, the 42,000 ton Yamato, 1 CL, and 7 or 8 DDs was located by B-29 reconnaissance as it sortied through the Bungo Straits from the Inland Sea, and proceeded along the East and South coasts of Kyushu towards Okinawa. On 7 April, Carrier-borne torpedo planes and bombers of the U S Fifth Fleet sank the Yamato, the CL, and 3 DDs. The remaining units were damaged. It is considered that mines had the following effect: (1) delayed this sortie so that when it finally took place, beachheads on Okinawa were firmly established, and (2) forced the sortie to proceed through Bungo Straits where reconnaissance was certain, and around the East and South coasts of Kyushu, rather than through

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

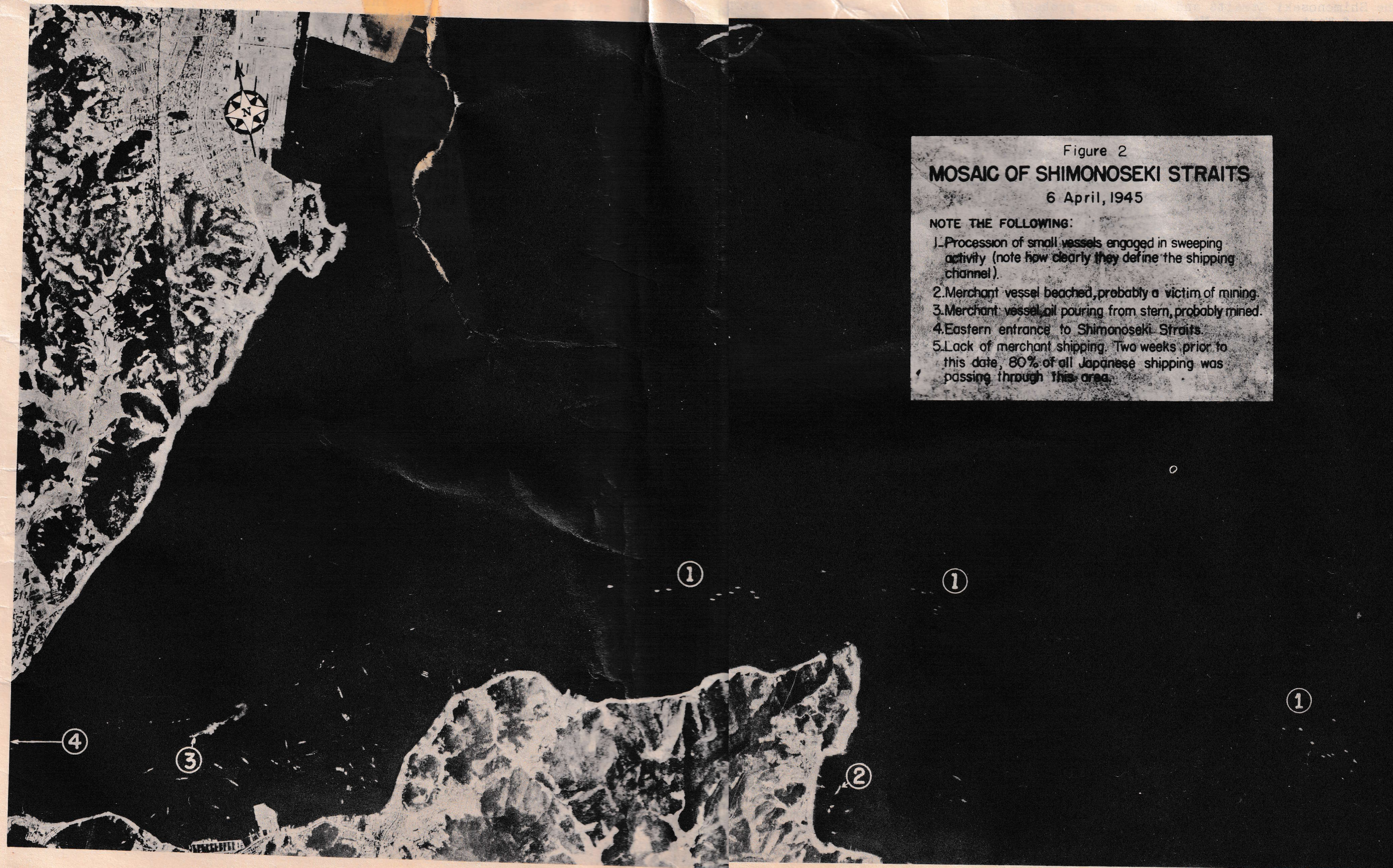


Figure 2
MOSAIC OF SHIMONOSEKI STRAITS
6 April, 1945

NOTE THE FOLLOWING:

1. Procession of small vessels engaged in sweeping activity (note how clearly they define the shipping channel).
2. Merchant vessel beached, probably a victim of mining.
3. Merchant vessel oil pouring from stern, probably mined.
4. Eastern entrance to Shimonoseki Straits.
5. Lack of merchant shipping. Two weeks prior to this date, 80% of all Japanese shipping was passing through this area.

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

the Shimonoseki Straits and the more protected waters of West Kyushu. No naval units sortied from Sasebo to the Okinawa area during the invasion.

Phase II, 3 May to 12 May (Industrial Center Blockade)

1. Planning. The second phase was planned on the same basis as the first phase, accompanied by a determined attempt to effect as complete modification of mine mechanisms and adjustment of sensitivity as was necessary to select large ships and to defeat enemy sweeps. A particular attempt was made to defeat effective enemy explosive sweeping of the A-3 acoustic mechanism by adjustment of the A-3 sensitivity and time constants.

The new unsweepable A-6 pressure mechanism was available for this phase. It was expected to present the enemy with an impractical clearance problem, thus appreciably increasing the effect of blockade and the accompanying attrition.

In this phase, the blockade was extended to the Inland Sea as originally planned, to Kobe, Osaka, and along the entire Inland Sea routes; the Shimonoseki Straits blockade was maintained by re-mining, and attrition mining of Tokyo and Nagoya was undertaken.

Details of directives and execution are given in XXI Bomber Command Tactical Mission Reports 139 and 150.

2. Results. A total of 195 aircraft were airborne to lay 1422 effective mines in the targets as shown in Plate V (page 24), with no loss of aircraft. As a result of this mining, an almost complete elimination was effected of the movement of large-type shipping between the Asiatic continent and Inland Sea ports. The effect of this blockade was increased by bombing and incendiary attacks on the Kobe-Osaka area early in June. It was believed that since Phase II, the amount of ocean-going shipping which moved between the continent and Inland Sea ports had been very small and there was good evidence that most of the vessels which had been operating in that area since the mining, were small sailing vessels or other type wooden ships.

The new shipping situation is shown in Plate VI (page 25).

Evidence of swept channels continued to accumulate, often from fragmentary information, since reconnaissance was frequently incomplete because of weather. The evidence for Shimonoseki Straits channels was very good.

The enemy continued to use suicide craft, his Mark 5 catenary sweep, and sound bombs.

Reconnaissance in the Shimonoseki Straits region was good enough to show that ship passages had been reduced to between two to four per day at the end of May as compared with an estimated 40 per day in March, and that tonnage had been reduced to less than 7000 tons per day as compared to an estimated 70,000 tons per day in March.

Japanese ship losses to mines were estimated to have increased greatly during early May. It was believed a high ratio of ship sinkings to damage was achieved with the A-6 pressure mechanism, and that the modified M9 Mod 1 magnetic mechanism was probably just as effective. On the other hand, the A-3 acoustic mechanism was believed to have been easily swept by the enemy and to have been almost ineffective for blockade mining.

Phase III, 13 May to 6 June (NW Honshu-Kyushu Blockade)

1. Planning. Phases I and II established the minefields at Shimonoseki Straits and the Inland Sea areas. These missions were composed of two efforts by the full wing plus a number of smaller missions using 20 to 30 aircraft. A study of the results obtained with full wing and with small mining missions indicated that the length of closure of a port obtained with larger efforts was not in proportion to the effort at any specific port. Therefore, it was concluded that in order to obtain closure of a particular port or channel, frequent re-mining was much to be preferred over large scale efforts carried out once or twice a month. Mining every other night using a single group was authorized.

A preliminary estimate of the accuracy of the positions of mine sticks was made using radar scope photo data. Reconnaissance also permitted an estimate of enemy ship traffic. It was clear that only a fraction of the mines laid could be placed in the narrow swept channels established by the enemy. It was determined that the number of ship passages per week at Shimonoseki Straits (and probably other targets) exceeded by a factor of four or five the number of mines per week which could threaten these ships. It was therefore concluded that a narrow target width was desirable in order that maximum damage be done to each ship actually mined. A delay of a few days or weeks in the firing of mines in the channel caused by the smaller threat of firing resulted from narrow target widths could be tolerated in order to obtain maximum mine effectiveness. The smaller target widths also advantageously decreased the efficiency of enemy sweeps.

This conclusion was of primary importance since it was in direct contradiction to the theoretical concept that maximum damage could be obtained if every ship passing was mined even with a very small damage. This theoretical concept would be true only if the number of mines available to sink ships was considerably in excess of the weekly ship traffic.

In the planning for Phase III the narrowing of target widths was combined with the selection of large ships. The ship distribution was as determined from reconnaissance. The Mine Modification Unit took on increasing importance and the complexity of planning was greatly increased.

It was evident from the reduction of the Straits traffic that shipping had been diverted to NW Honshu ports; accordingly the third phase was directed against these ports in continuation of the original plan.

Details of directives and execution are given in XXI Bomber Command Tactical Mission Report 173, 175, 177, 179, 180, 182, 184, and 185.

2. Results. A total of 209 aircraft were airborne to lay 1313 effective mines in the targets, with a loss of three aircraft. The effort is shown in Plate VII (page 26).

Reaction on the part of the enemy to the Phase III minelaying followed the same pattern as that previously noted. Ports apparently were closed for a short period and then reopened after a channel was swept. It did appear, however, that port closure obtained at the NW Honshu and NW Kyushu ports was, in general, a day or two longer than that obtained in the Shimonoseki Straits area. It was believed that the basic importance of the latter area had led the Japanese to provide a heavier concentration of sweeping equipment there, enabling them to sweep more rapidly.

Vessel casualties increased sharply during Phases II and III over those of Phase I. During May it was estimated that between 75 and 100 vessels, aggregating at least 300,000 gross tons were sunk or damaged by mines.

Japanese countermeasures observed during May did not show any great progress over those noted earlier. It was believed that the sound bombs were being used successfully against the A-3 acoustic mines. So far as is known, the use of the catenary sweep was continued against magnetic mines -- and probably with only limited success. A new double catenary appeared at Moji towards the end of May and is shown in Figure 3. This sweep was an expected development but was assessed as very clumsy, ineffi-

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

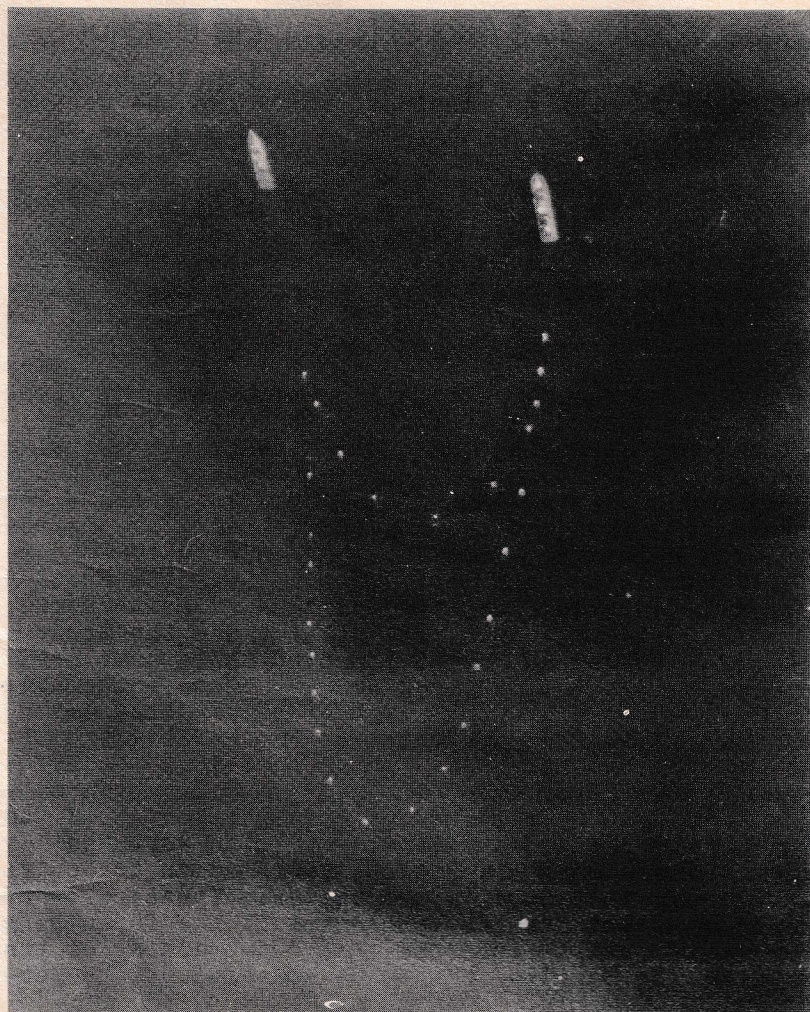


FIGURE 3. ENEMY DOUBLE CATENARY SWEEP

cient, and awkward to use. It did definitely indicate that the enemy had recovered and analyzed the modified magnetic mines. It was believed the effectiveness of the magnetic mines would not be appreciably affected by this sweep. It was believed that no sweep was developed for A-6 pressure mines, but evidence from a German prisoner-of-war revealed that the Japanese were informed of the pressure principle in mines. No information was available on sweeps which may have been developed against A-5 subsonic mines.

The ship traffic at Shimonoseki continued at a low level as before.

The estimated shipping situation after this phase is shown in Plate VIII (page 27).

Phase IV, 7 June to 8 July (Intensified NW Honshu-Kyushu Blockade)

1. Planning. A study of May operations confirmed the tentative conclusion adopted for the planning of Phase III that maximum effectiveness in operations would be obtained by the use of many small missions and with a single group carrying out the operations. The decision was therefore made to use a single group of the 313th Bomb Wing in mine-laying during the month, carrying out operations on every other night and hitting a number of targets on each mission. This policy was expected to spread the enemy's sweeping effort over a maximum area, and frequent hitting of the most important targets was calculated to obtain closure for maximum length of time. Phase III operations indicated that closure was obtained only for two to four days after each mining, even with very large efforts.

The experimental mining of certain harbor areas, in particular Moji, Matsure, and Hesaki anchorages, showed that it was capable of denying these anchorages completely to the enemy. Because of the extreme importance of the dock facilities at Moji and the convoy arrangements at Moji, Hesaki, and Matsure, it was determined to mine these harbors more intensively.

A general study of the enemy shipping indicated that mining of Tokyo, Nagoya, Nagasaki, Sasebo, and the general Inland Sea areas no longer would be profitable provided Shimonoseki Straits was kept closed. Exceptions were the harbors of Kobe-Osaka, which still maintained relatively heavy amounts of shipping of large size, probably shipping which had succeeded in crossing the Straits blockade or was engaged in local dispersal of the industrial facilities of Kobe-Osaka.

It was concluded that the enemy's probable reaction, caused by submarines and search plane attacks, would be to withdraw this shipping from the Yellow Sea to the Sea of Japan, and to make increasing use of NW Honshu ports.

In order to permit the maximum utilization of one group, it was desirable to plan missions one month ahead. This made it necessary to forecast the enemy's reaction as far ahead as possible. The heavy load on the Mine Assembly Depot, occasioned by the complicated preparation of the mines also made it necessary to specify the targets as far in advance as possible. The mines were prepared ahead of time and were designated for each specific target.

Shimonoseki Straits was still regarded as the first priority target, especially in view of the predicted transfer of shipping from the Yellow Sea.

Its closure was regarded as the primary objective; most of the remaining effort was to be devoted to the remaining ports of NW Honshu. This decision was implemented in the directives given to the 313th Bomb Wing. Modification of the original directive was necessitated by minor variations in the enemy's reaction from the forecast.

A study of the results obtained from Phase III confirmed the tentative conclusion adopted in planning these missions with respect to the preparation of mines. Reliable information indicated that enemy countermeasures were not yet fully developed, and that as a consequence, he would probably continue to pass ships through minefields regardless of losses in order to obtain badly needed supplies. However, there were strong indications, because of his heavy mining losses, that the enemy was attempting to develop extensive countermeasures to B-29 mining. At the conclusion of the June effort these countermeasures, especially clearance methods, probably would be well organized. Maximum effort during June was especially desirable with the use of the unsweepable A-6 pressure mechanism and with modified magnetic mines which were also believed to be temporarily unsweepable. The total effort, however, was limited by logistics, and complete blockade was not feasible. It was therefore important to obtain the maximum objective possible with limited means.

The distribution of ship sizes in the enemy traffic was again carefully studied, and it was concluded that maximum closure in tonnage and maximum attrition in total tonnage, also a very important factor, should be continued by selection of large ship sizes for sinking. This decision would permit passage of small ships but would make closure to large ships prolonged. Also, it was concluded that the amount of ship traffic would be sufficient to warrant the continued use of narrow target widths in order to get a maximum ratio of sinkings to damage. The relatively overall attrition effect would be the sinking and damaging of ships well above the average size.

It was believed that the A-3 acoustic mechanism was completely sweepable, and that its value was low except as a nuisance and anti-sweep mine. Every indication pointed to the same situation with respect to the A-5 subsonic mechanism. Little or no definite technical information regarding the operational characteristics of the A-5 subsonic mechanism was available. This made a reasonable assessment of its capabilities difficult. Although no final conclusion concerning the A-5 subsonic mechanism could be drawn at this time, it was believed that it would be necessary to use arming delays and ship counts in order to ensure its effectiveness. The A-6 pressure mechanism was still regarded as unsweepable. The magnetic mechanisms were regarded as very nearly so,

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

although strong indications had begun to appear that the enemy was developing new types of sweeps, showing definite knowledge of the altered characteristics of the magnetic mines.

It was necessary to make every mine as effective as possible. The most important consideration in the preparation of the mines, therefore, was to mine for the greatest possible number of larger ships, using a narrow target width in order to obtain a maximum number of sinkings and heavy damage, and to do this while at the same time confronting the enemy with maximum difficulty in the sweeping of minefields.

Details of directives and execution are given in XXI Bomber Command Tactical Mission Report 190, 194, 201, 202, 204, 205, 213, 214, 221, 222, 233, 239, 244 and 246.

2. Results. A total of 404 aircraft were airborne to lay 3542 effective mines in the target, with the loss of one aircraft. The effort is shown in Plate IX (page 28).

During Phase IV the normal two to four day port closure appeared to continue after each mining mission to the major ports. Substantially longer periods of closure, perhaps as much as two weeks, were obtained at the smaller ports, undoubtedly as the result of the enemy's unpreparedness for mine-sweeping at those ports.

During the latter part of Phase IV, a new type of enemy sweep for magnetic mines was photographed. This sweep appeared to be essentially a floating electric loop energized by a generator carried on a small vessel. A reconnaissance photograph of this sweep is shown in Figure 4. It was estimated that this sweep was practical and would be successful against our magnetic mines. By the end of Phase IV, the enemy apparently had the capability of sweeping successfully both A-3 acoustic and magnetic mines. Little intelligence was available on the development of sweeping methods for A-5 subsonic mines, but technical tests indicated that the mine was sweepable by explosive methods. Other tests indicated that the mine would fire spontaneously on a variety of everpresent underwater noises. The A-6 pressure mechanism was still considered unsweepable, but the enemy, having learned of the principle of the mine, was assumed to have adopted a known countermeasure, that is, sailing at slow speed in fields where the A-6 pressure mechanism was suspected to be present, in order to limit the pressure change to a point below that necessary to detonate the mine.

It was believed that enemy countermeasures to mining in the home islands of Japan were reaching



FIGURE 4. ENEMY FLOATING ELECTRIC LOOP SWEEP

the point at which, barring some major change in the pattern of the mining operations, the profit from mining would soon begin to decline.

Early in July it became apparent that the Japanese had abandoned the ports of the Yellow Sea as ports of export to the home islands. This fact meant that substantially all exports from the Asiatic continent to Japan would have to funnel through a limited number of ports on the southern and eastern coasts of Korea, principally Fusan, Masan, Genzan, Konan, Seishin and Rashin. There was evidence that the enemy was still intent upon using the Shimonoseki Straits port complex despite the constant re-mining and that efforts were still being made to keep open the major port areas of NW Honshu.

The estimated shipping situation is shown in Plate X (page 29). An estimated 300,000 gross tons of shipping were believed to have been mined during June.

Phase V, 9 July to 5 August (Complete Blockade)

1. Planning. Reliable intelligence concerning the Phase IV mining missions confirmed the conclusions adopted in planning these missions. The shipping attacks by our submarines and Fleet Air Wing-1 in the Yellow Sea area and off the southern tip of Korea had definitely forced the enemy to withdraw his shipping from the Yellow Sea into the Sea of Japan. It was believed that this withdrawal was very much hastened by the decrease in the amount of shipping available to him, a large part of this loss being occasioned by mining casualties.

Fewer and fewer ships were seen by Fleet Air Wing-1 during the month. Reconnaissance indicated very strongly that the amount of shipping traffic of 1000 tons or over through the Inland Sea areas had decreased to a very small figure. The enemy still made use of the Shimonoseki Straits region for unloading, but it appeared that the majority of the ships did not pass through the Straits area but unloaded at the various Straits ports. However, the principal port of Moji and the anchorages at Matsure and Hesaki appeared to be completely abandoned. No shipping was seen in these anchorages or ports in the reconnaissance of the area during the month. This was regarded as especially significant in the case of Moji, which contained the principal loading facilities in the area. Shipping continued to use those ports on the outer edges of the Straits narrows which had not yet been very heavily mined, while many ships now anchored in the swift current of the Straits themselves. These ports of the Shimonoseki Straits were not suitable for mining because of swift currents, although mining of the edges of the Straits channels appeared to be possible.

During the month of June, Navy submarines had made sorties into the Sea of Japan and destroyed approximately 80,000 tons of shipping there. This forced the enemy to adopt convoy tactics and to re-route much of his traffic into night routes, taking refuge during the day in sheltered anchorages. Fleet Air Wing-1 continued to attack shipping off the southern tip of Korea and made an increasing number of sorties across Tsushima Straits itself. The enemy shipping situation at the beginning of the month, therefore, presented a picture of concentration of most of his major shipping within the Sea of Japan in the heart of the Inner Zone, and with the major use of large ships abandoned in the Outer Zone. This shipping had as one group of termini, ports of E Korea stretching between Fusan, Rashin, and Yuki, with ports between Karatsu in Kyushu and Funakawa on NW Honshu as the other termini. Little or no shipping passed into the Inland Sea. Large imports of coal and fish products still passed into N Honshu from Hokkaido via railroad ferries there.

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

In the forecast of the enemy reaction for the month of July, account was taken of four other agencies which were preparing to attack shipping in the Inner Zone.

The first of these were Okinawa-based aircraft, both Army and Navy, which could extend the aerial blockade of shipping across Tsushima Straits, as well as attack land transportation facilities and shipping in the Shimonoseki Straits region. They could also attack shipping at Nagasaki and Sasebo.

The second agency was the Third Fleet whose operations plan was available. The Fleet planned attacks on the northern tip of Honshu and on Hokkaido with high priority given to shipping, especially to the railroad ferries between the two islands, and with anti-shipping sorties planned against NW Honshu ports between Sakata and Funakawa. Later attacks were planned by the Fleet against aircraft facilities between the regions of Kure and Tokyo with a strong possibility that attacks on enemy shipping were to be made by surface craft and Fast Carrier Forces. Further attacks were also planned on shipping at Fusan and Shimonoseki. There was every possibility that the Fleet would continue to attack shipping over the entire region ranging from Shimonoseki Straits to Hokkaido, including such ports as Maizuru.

The third force able to contribute to an appreciable extent was made up of the air agencies based on Iwo Jima, concentrating on shipping strikes in the general Tokyo region.

Finally, tentative plans also existed for a small scale renewal during July of attacks against shipping by our submarines inside the Sea of Japan.

It was expected that as a result of the heavy pressure in the South Korean and Shimonoseki Straits region, enemy shipping would probably shift during the month in such a way as to abandon the S Korean ports and possibly the Shimonoseki Straits itself; and provided the Fleet's strikes on Hokkaido were successful, shipping from Hokkaido would be very greatly reduced because of the destruction of port facilities and sinkings in the harbors. The tendency would be to drive shipping to ports lying between Yuya Wan and Funakawa on NW Honshu and between Genzan to Rashin on Korea.

There was increasing evidence that the enemy's countermeasures were becoming more successful in the ports which had been mined for a long time. This is attributed to several factors, one of which was the probability that the enemy's mine watch was becoming increasingly efficient. He continued to use searchlights to locate positions in which mines had dropped and to use aircraft to escort our mine-

laying aircraft to determine their dropping positions.

Special technical tests under the supervision of the Mine Modification Unit were carried out at Oahu on the A-5 subsonic mechanism. These tests provided positive evidence that this mechanism could be swept easily by explosive methods and would probably explode spontaneously due to noises which might often be present in the minefields. The tests and other reliable evidence indicated that the A-5 subsonic mechanism now could be easily swept by the enemy, so that its effectiveness was greatly reduced.

The enemy's new magnetic sweep appeared in numbers. This sweep was the floating loop type, considered to be a very effective countermeasure against the modified magnetic mines. No definite method of defeating it appeared to be feasible by further modification of the magnetic mines, and reduction in their effectiveness was expected. The A-6 mechanism was still regarded as unsweepable.

The plan for July was limited by logistic considerations in that only a limited number of magnetic mines and of unsweepable A-6 mechanisms was available. A very considerable proportion of acoustics was on hand. It was considered, however, that the enemy would still find it difficult to meet a large scale attack, even though a large proportion of acoustic mines was included in the mining -- this provided that a considerable amount of mining was carried out against the Korean termini of the shipping and at other diversionary ports where mine warfare countermeasures had not yet been organized. The enemy could be expected to consider his N Korean ports out of range of B-29 operations, and would therefore be surprised by the attack on these ports where he undoubtedly lacked appreciable preparation in either anti-aircraft defenses or mine warfare defenses. However, it was essential to maintain the blockade of the Shimonoseki Straits area, the ports of Niigata and Fushiki, and other major NW Honshu ports until attacks by other agencies could be completely implemented. This would probably not be possible until some time in September.

Shimonoseki Straits was believed to be very nearly closed. The amount of ship traffic there as shown by reconnaissance was about one-tenth of that estimated for the early months of the year. It was necessary to maintain this blockade.

Losses and flak damage at the Shimonoseki Straits indicated a heavy reinforcement of enemy defenses there and the use of new high altitude automatic weapons. During Phase V, the 313th Bomb Wing requested permission to use higher altitudes of attack at this target and at Maizuru. It was believed that accuracy would not be too adversely affected by

raising the mining altitude because increased experience of minelaying crews had made them much more skilled than in earlier operations. A long lapse in reconnaissance coverage caused by weather had made the positions of possible relocations of the Shimonoseki channels uncertain. This made a small reduction in accuracy less important. The decision was therefore made to raise the permissible mining altitude of these two targets during Phase V.

These decisions were implemented in directives to the Wing. Revisions were necessitated during the month because of the success of the Fleet attacks on Hokkaido and NW Honshu and by the success of Fleet Air Wing-1 in destroying rail traffic in Korea. The last was believed to have brought about a great reduction in traffic to Fusan. Reliable evidence also indicated continued improvement in enemy countermeasures, especially in the widespread appearance of the floating loop sweep. The overall result was a reduction in the length of closure being obtained. The enemy appeared to be concentrating this sweeping in limited areas. Because of his withdrawal of shipping to Korean termini between Genzan and Rashin, it was considered essential to prevent any ship movement at Seishin and Rashin by a very heavy mining attack. The same evidence indicated that mining of the ports of Fushiki and Niigata was becoming less and less effective.

At this stage the general conclusion in regard to mine preparation was that the A-6 mechanism was unsweepable; that the A-3 and A-5 mechanisms were easily swept, and that the magnetic mechanisms would rapidly become sweepable during the month because of the appearance of the enemy's new floating loop sweep, which was evaluated as effective. It was also considered that the enemy would make increasing and effective use of clearance methods, as indicated by his extensive use of mine watches. All of this evidence strongly indicated the need for the use of arming delays and ship counts on the magnetic and acoustic mechanisms in order to defeat sweeping methods, except where clearance would be easy because of a good mine watch and a small target area.

There was a strong indication that the average size of operable ships was smaller than in previous months. A re-evaluation was made of the effect the changed distribution in enemy ship sizes would have on modifications and sensitivity adjustments required to obtain the maximum return from mining.

Intercepts of Japanese home radio broadcasts clearly indicated that the Empire's food situation was in very serious straits. It was determined to utilize the emotional importance of hunger to heighten the effect of the mines. The pamphlets

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

shown in Annex N were designed to do this and were prepared in cooperation with the CinCPac Advanced Psychological Warfare Section. Approximately 4,500,000 leaflets were dropped by the 313th Bomb Wing over the major cities of Japan during Phase V.

Details of the directives and execution of Phase V are given in Twentieth Air Force Tactical Mission Report 256, 262, 268, 269, 275, 276, 282, 292, 296, 304, 305, 311, 318, 324, and 331.

2. Results. A total of 474 aircraft were airborne to drop 3746 mines effectively in the target areas, with a loss of 6 aircraft. The effort is shown in Plate XI (page 30).

Intelligence on the closure effect of the Phase V mining indicated that at the ports of Honshu, Japanese countermeasures were improving and that, on the average, closure effect was probably from 25 to 50 percent less than it had been previously. In the case of Fushiki, it was believed that substantially no closure was being achieved during this phase. Closure of the ports of Korea was somewhat longer than that at Honshu ports. Evidence on the Korean situation was far from complete, however. It is believed the enemy was unprepared to counter mining operations in Korea, and the longer closure noted was to be expected. It is of interest to note that on 6 August only about 15,000 tons of operational shipping were photographed at Fusan, whereas over 100,000 tons had been photographed there a few months earlier. During the course of Phase V, evidence became available that Task Force operations had sunk or damaged the Hakodate-Aomori rail ferries (with the possible exception of one or two). The volume of shipping at Rashin, in northern Korea, was increasing, and the volume of shipping at Fusan was decreasing (possibly caused in part by successful air attacks against rail bridges on lines leading into Fusan). As a result of this information, it was deemed advisable to augment the effort against Rashin. In order to accomplish that end, it was necessary to decrease the effort against other targets. Fusan, Niigata, Fushiki, Sakata, and Funakawa were dropped from the schedule of targets because of information that ship traffic was decreasing at these ports, or that the enemy was successfully sweeping our mines there. Most of the effort diverted from those five ports was scheduled for Rashin, although some missions were planned against smaller ports on the Japan Sea coast of Honshu where an increase in ship traffic was noted. It is believed that Rashin was closed for most of the period from 11 July through the end of the month.

No new mine sweeps or countermeasures were noted during Phase V, although there was an increase in the number of electric loop sweeps. At least six

of these sweeps were noted at different ports during this phase.

Reconnaissance indicated the amount of enemy shipping operable had dropped to less than 400,000 tons.

Ship losses during the Phase V were estimated to be 300,000 gross tons or more.

The enemy ship situation is shown in Plate XII (page 31). Only a small fraction of the once heavy enemy ship traffic still flowed to the Empire from the Asiatic continent. The shipment of all raw materials had ceased. The shipment of food was only a fraction of that required by the Home Islands. Japan was already blockaded as the Twentieth Air Force laid the last mines on the NW coast of Honshu, just as the war ended.

Summary of Mining Operations

1. Intelligence. The estimates made in this analysis are sometimes based upon inadequate information, since direct intelligence, such as photos of sunken ships, was rarely available on the complete effect of the mining. The estimates are based upon a synthesis of all known sources of information, including all types of aircraft reconnaissance, submarine reconnaissance, captured enemy documents and equipment, prisoner-of-war interrogation, and Japanese plain language broadcasts. Experience gained in previous mining campaigns was also very useful.

The estimates of results in mining are unusually difficult. Those presented here may require revision when direct access to enemy records is possible.

2. Effort. A total of 1528 aircraft were airborne to lay 12,053 mines effectively in the targets, with a total loss of 15 aircraft. Nine aircraft were lost to enemy action; eight on the approach to or at the heavily defended Shimonoseki Straits targets, and one at Niigata. All of the aircraft were lost when 0/10 to 5/10 cloud cover and many searchlights were reported over the targets, with numerous aircraft reported downed in the searchlights. No aircraft were lost when the targets were heavily overcast.

The requirements for continuous mining were not always compatible with maximum safety of the aircraft. During later missions every attempt was made to select overcast conditions for the most dangerous missions and to raise the mining altitude. This was partly nullified by increased enemy defenses and uncertainty as to weather.

It is clear that enemy radar fire control was ineffective, probably because of our RCM aircraft, and that the mining was carried out with the least losses during overcast conditions at the target. A more complete statistical summary is given in Annex A and in Plate XIII (page 32).

3. Blockade. Mining established an effective blockade at the end of four and a half months, and enemy shipping which remained operable was reduced to the status of blockade running.

After the first month of mining, imports to Japan fell below 50 percent and it is estimated they gradually declined to about 10 percent of the pre-mining figure.

Shipping through Shimonoseki Straits and the Inland Sea was reduced to 10 percent by June. The great port of Moji was abandoned at the end of May, together with the anchorages of Hesaki and Masure. By the end of June, the port of Niigata was little used; Fusan was abandoned early in July, and Rashin became unusable during the second half of July.

The documentation for blockade is voluminously covered in over one hundred reports by the Central Interpretation Unit. Typical results taken from these reports are given in Figures 5 and 6, which show the decline of shipping at Moji, and of ship traffic at Shimonoseki Straits. Figures 7 and 8 show photographically the effect of mining at the anchorage of Moji. Figures 9 and 10 show photographically the effect of the mining at the port of Kobe.

As a result of the mining blockade of Japan, the end of effective military and civilian production became inevitable, and the lack of food imports made starvation of a large part of the population a certainty. This was the situation when Japan surrendered.

4. Force. During our first tentative application of the general blockade in the Sea of Japan, the enemy shifted his shipping from port to port, avoiding temporarily, newly and heavily mined ports but returning at a later time if clearance had been effected. At first he apparently spread his sweeping effort over many harbors.

Only after all ports were mined in force was he reduced to a steady defense at a few ports.

It was clear that all ports had to be mined by a widespread effort to ensure blockade. As closure became shorter with enemy experience in clearance, it became necessary to mine all principal harbors continuously to ensure effective blockade.

DECREASE IN THE NUMBER OF SHIPS AT MOJI ANCHORAGE CAUSED BY MINING

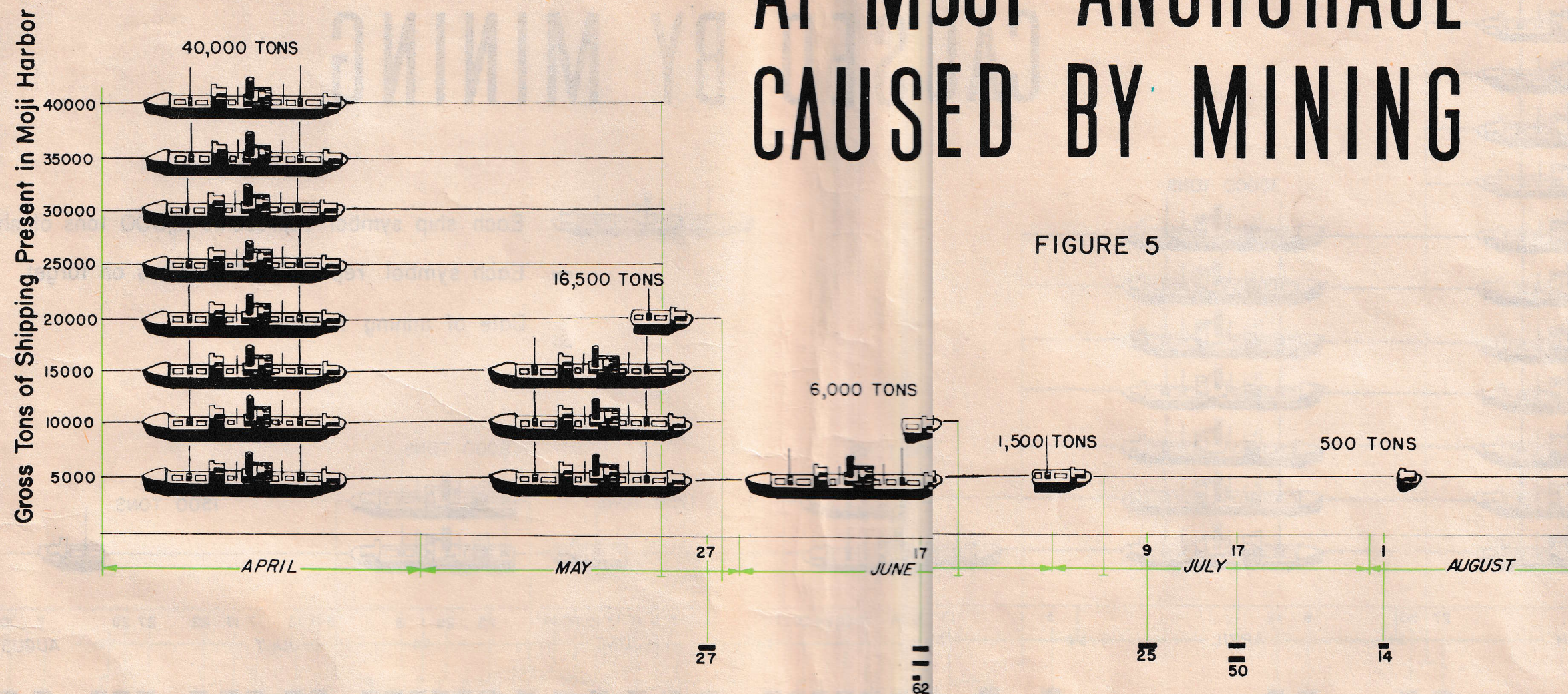


FIGURE 5



Each ship symbol represents 5000 tons of shipping.

— Each symbol represents 25 mines on target.

27 Date of mining mission.

DECREASE IN SHIP PASSAGES AT SHIMONOSEKI STRAITS CAUSED BY MINING

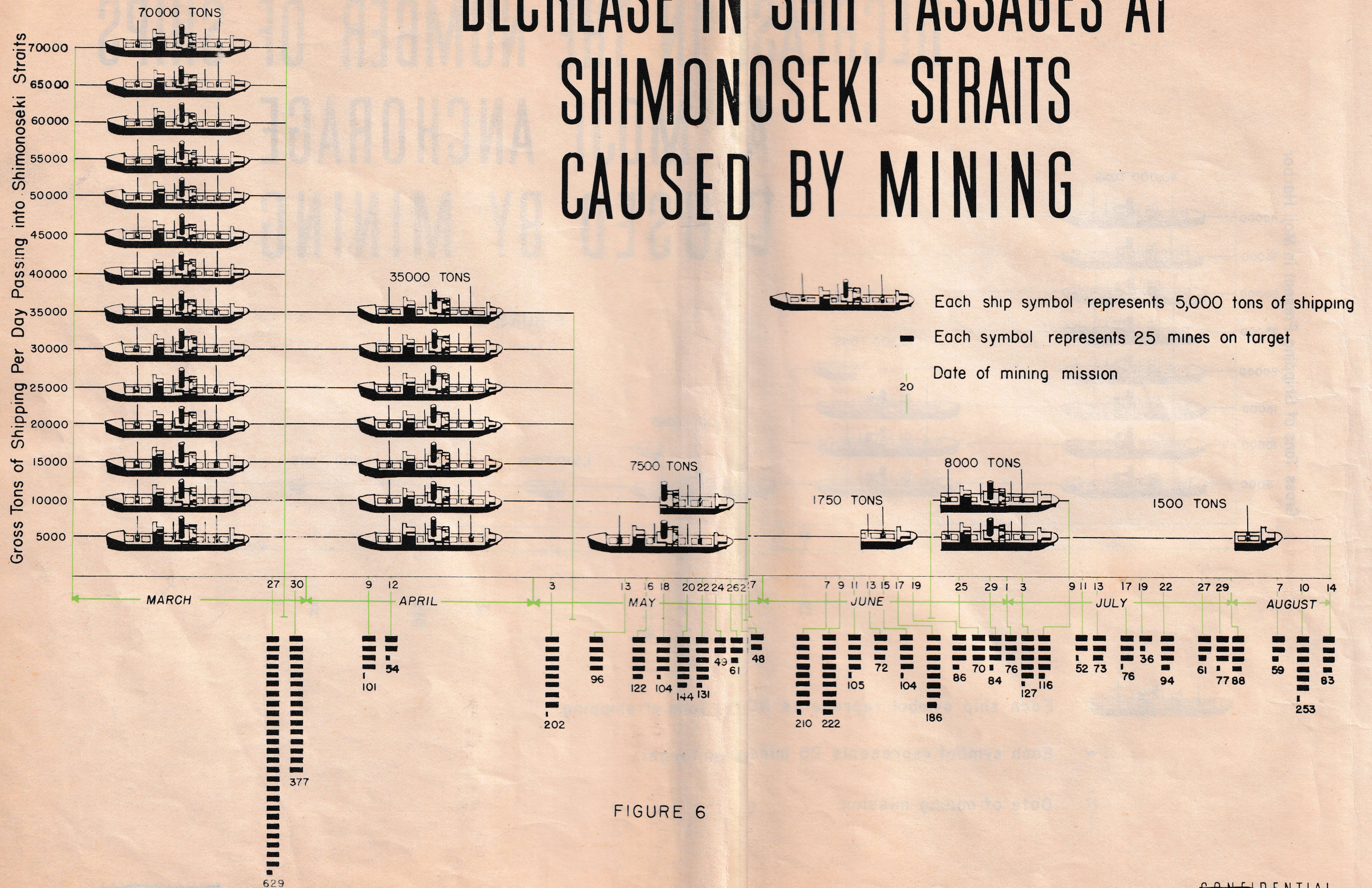
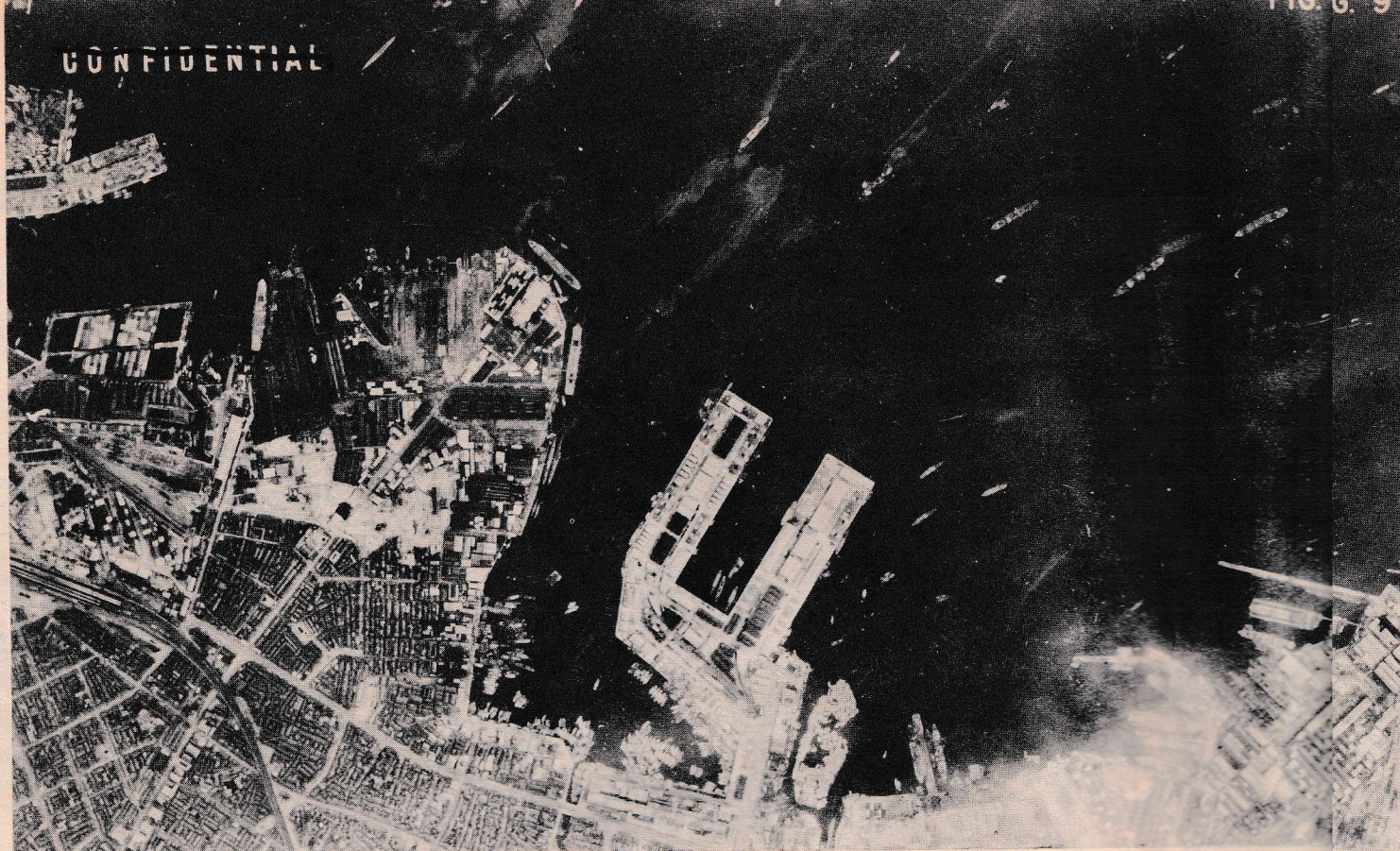


FIGURE 6

CONFIDENTIAL



Before (6 February, 1945)

KOBE HARBOR



After (22 July, 1945)



12 NAVAL VESSELS
59 MERCHANT VESSELS, 184,220 gt.
50 MERCHANT VESSELS OPERATIONAL, 118,740 gt.

12 NAVAL VESSELS
23 MERCHANT VESSELS, 90,644 gt.
10 MERCHANT VESSELS OPERATIONAL, 23,000 gt.

FIG. 10

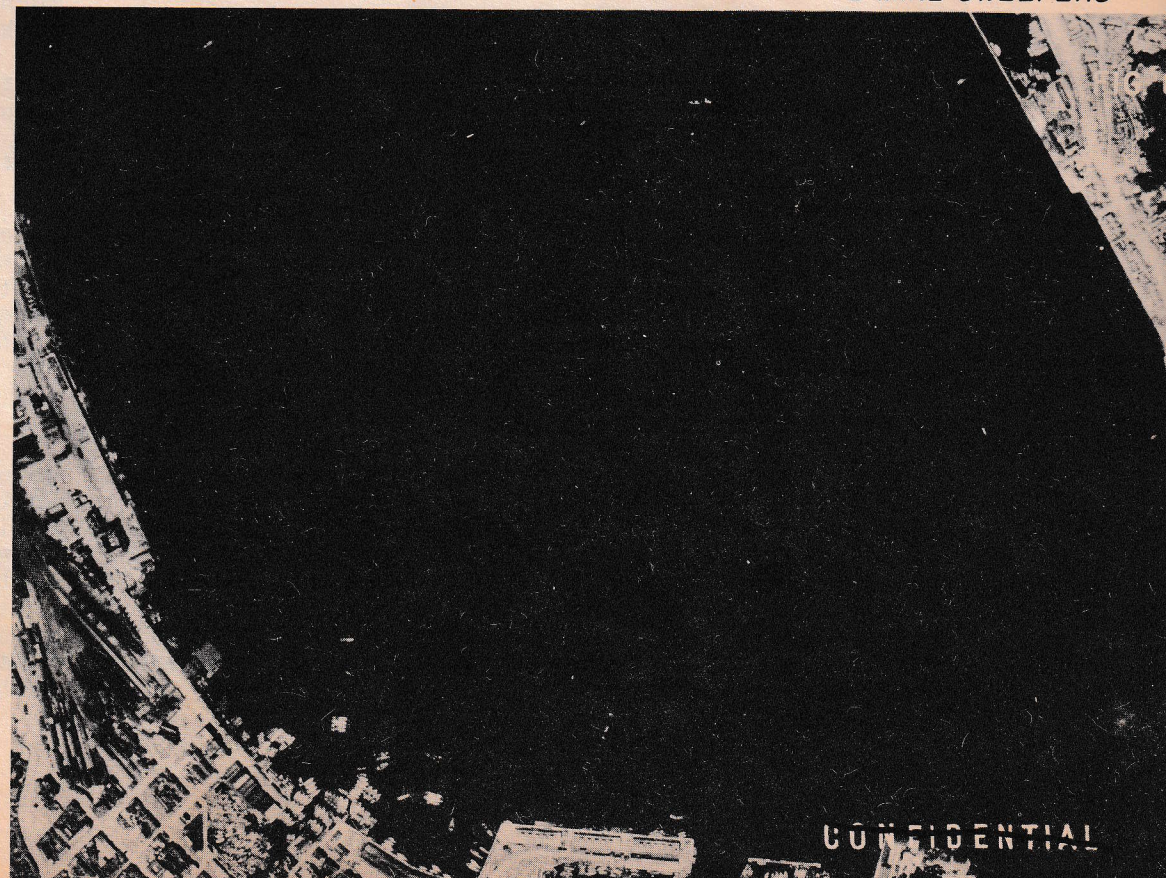


Before (6 May, 1945)

MOJI ANCHORAGE



After (21 June, 1945)



1 NAVAL VESSEL (Small)
19 MERCHANT VESSELS, 59,694 gt.
1 MINE SWEEPER

2 NAVAL VESSELS (Small)
5 MERCHANT VESSELS 5820 gt.
2 MINE SWEEPERS

CONFIDENTIAL

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

From the experience gained in enemy reaction at Shimonoseki Straits an average of ten mines per ship passage appeared necessary to ensure blockade. The figure is an estimate and may not be very accurate, but it appeared that if fewer mines were dropped, traffic seemed to increase and although more mines had some effect in increasing closure, this was not in proportion to justify the effort.

5. Attrition. It is estimated that a total of 1,000,000 tons, or more, of Japanese shipping was mined as a byproduct of the blockade. In spite of maximum possible enemy shipbuilding, enemy shipping afloat, of 1000 tons or over, declined from an estimated 1,800,000 tons in March to less than 660,000 in August (as determined by Twentieth Air Force reconnaissance), of which less than 350,000 tons was operable in the Sea of Japan and effective in the importation of raw materials.

Photographic evidence was abundant for the casualties. By August, in sinkings alone, 131,000 tons of ships sunk in very shallow water or beached were documented. The ships sunk in deep water could not, of course, be photographed. The casualties shown in Annex I are typical. A complete list is given in Annex I. There is good reason to believe that many other ships known from photographic reconnaissance to be inactive, had been mined so heavily as to require up to six months for repair. Typical was the 18,000 ton ex Count Verdi in Maizuru harbor, reported inoperative for several months. This ship had undoubtedly been mined.

6. Enemy Clearance. The enemy undertook mine countermeasures very intelligently after the campaign began. He established a mine watch and clearance methods which increased continually in effectiveness, until port closures were reduced to an estimated one to four days, depending on the target. Reconnaissance at Fushiki showed continuous use of the harbor towards the end of the mining operations. This was the target with the most concentrated mining target area. Niigata, a more important target, but with a larger mineable channel, was more effectively closed; while Shimonoseki Straits, Tsuruga and similar targets of large mineable area were closed for the longest periods. Thus closure was obtained most effectively for the larger targets, and not at all for the very smallest target.

Towards the end of the mining campaign, the enemy tended to concentrate his shipping (and presumably his sweeping) in fewer harbors. Maizuru, for example, eventually received the shipping once shared between Miyazu, Maizuru, Obama, and Tsuruga, after all of these ports had been heavily mined. Prior to heavy and continuous mining of all ports, traffic was shifted from one to the other as occasional mining dictated.

7. Accuracy. Mining by radar permitted night operations and efficient design of minefields. Mining could be carried out easily and with safety even under overcast conditions. The accuracy attained, however, was limited by the resolution of the APQ 13 Radar and by the skill of the radar navigators. The results of a study of the accuracy attained show that 59 percent of the sticks fell within one mile of the assigned position, 33 percent between one and three miles, and 8 percent between three and ten miles. Further details are given in Annex J.

The position of the enemy swept channels was sometimes known accurately. This was true of most channels at the Shimonoseki Straits. Figure 2 (page 9) shows the type of reconnaissance that permitted plotting of enemy channels. These channels were about 2000 feet wide in most cases.

Radar accuracy was not sufficient to ensure precise placement, and allowance for combat error in laying was necessary. The mine stick was adjusted in length so as to place a maximum of mines in the channel. The length depended upon the estimated effect of the target geography, the IP, and the AP. It is estimated that on the average, 10 percent or less of the mines fell into the known swept channels.

8. Effectiveness of the Mines. The effect of mining depends upon a number of complex factors, all of which have been discussed previously. These include: The accuracy of planting in enemy channels; the necessity for widespread and continuous mining, much of which produces blockade without in itself sinking ships; the efficiency of enemy clearance and the organization of his mine warfare countermeasures; and similar factors. However, the intrinsic technical characteristics of the mines themselves are of the greatest importance, and are a deciding factor in the final results achieved.

The mines used in this campaign consisted of one new and unsweepable type--the A-6 pressure mechanism, which was of excellent design; the two best standard magnetic types in existence--but whose general characteristics were in principle well known to the enemy, and indeed to all belligerents; and two simple acoustic types which were capable of being swept explosively.

It is doubtful if the mining campaign would have succeeded except for the Mine Modification Unit's ability to devise modifications of the magnetic mines which made them temporarily unsweepable. It was possible to capitalize upon a serious enemy mistake, namely his decision to mass produce the easily constructed and used towed catenary magnet sweep. This enemy decision was unimaginative and permitted effective modification of our magnetic mechanisms. For three months they were essentially

unsweepable; i.e., until the enemy had corrected his production error. When that time came, the effectiveness of the magnetic mechanisms was reduced to one-third or less.

The A-6 pressure mechanism was the only mechanism which was designed to permit ship selection. The magnetics had to be modified to allow selection. It is believed that the amount of tonnage sunk was doubled because of adjustment or modification of mines for ship selection. The A-3 acoustic and A-5 subsonic mechanisms were of small value in the campaign. The technical decision to produce these mines as simple acoustic mines rather than as combination magnetic-acoustic mines was unfortunate, and did not utilize the experience of the European Theater. As a result, the mines were easily swept and allowed no ship selection. Although they were undoubtedly a nuisance to the enemy, they did not greatly affect the blockade. It was never possible to overcome by modification of the A-3 acoustic mechanism or by adjustment of the A-5 subsonic mechanism the fundamental defects in their design.

The enemy used great intelligence, both in the organization of his minesweeping and in his technical attack on our mines. As a result, he was finally very nearly able to counter them.

The A-6 pressure mechanism was a very good mine and probably remained unsweepable, but its effectiveness was reduced by the absence of combination magnetic-subsonic and magnetic-acoustic mechanisms mixed with it in the minefield, since, when laid alone, it could be defeated by proceeding at very slow speeds.

9. Logistics. An average of about 2500 mines per month were received on Tinian as compared to the 4000 per month required. CinCPac authorized and desired a reserve of 4000 mines but this was never available; as a consequence, missions were planned for mines while they were still enroute and the composition of the shipment was unknown. This made mission planning, minefield design, and mine preparation difficult. Mines were sometimes laid 36 hours after they arrived at Tinian.

The number of mines logistically available was too small to ensure complete blockade from the beginning, or to utilize all the sorties made available by the Twentieth Air Force. At least double the quantity should have been available to ensure blockade. It was only by constant improvisation and by capitalizing upon the enemy's originally unforeseen weaknesses that the mission was successfully accomplished. Its success depended upon the weak position of the enemy shipping situation and upon the supplementary blockade and attrition obtained by direct air and submarine attacks.

Phase Analysis of the Twentieth Air Force Strategic Mining Blockade of the Japanese Empire

SECTION C-CONCLUSION

Reasons for Success

It is clear that the mining campaign succeeded only because of the fact that at the beginning of the campaign, the enemy's shipping situation already had so seriously deteriorated that the effect of any further attrition was grossly magnified. The mining is estimated to have produced 60 percent of the attrition of enemy ships between March and August; alone, this would have been insufficient to produce the collapse of Japanese shipping. The coordinated attack by mining aircraft, anti-shipping aircraft (both Army and Navy), and submarines, fortunately combined to achieve the final effect.

U S submarines had taken the heavy and early toll of enemy shipping. Mining simply provided the knockout blow.

Lessons

1. Mining by aircraft in sufficient force can by itself obtain blockade of an enemy's entire merchant or naval fleet.

2. Mining will produce heavy attrition as a byproduct of blockade. About 100 tons of shipping can be mined per mine laid effectively in the target, or about 85 tons per mine airborne.

3. Mining must be widespread as well as heavy, so that the enemy cannot avoid the blockade.

4. The force to produce blockade at the vital ports or channels must be great and the operations continuous. Mining of every target every night or every other night at a minimum, must be undertaken, and at least one mine must be laid in position so as actually to threaten ships in the channel for each ship passage attempted. To lay one mine in a channel, an average of ten mines are required in the target area.

5. Effective mining can be obtained by area methods -- pinpoint precision is not required or possible for large aircraft engaged in a large scale effort. An average radial error of one mile is adequate. Sufficient intelligence data to warrant pinpoint precision generally is not available.

6. Mines must be unsweepable to be effective over a long period (three months).

7. If the target is small the enemy can and will use effective clearance methods even against unsweepable mines.

8. Clearance methods are difficult if not impractical against targets of large area if the mining is done in force.

9. The best defense against an aerial mining campaign is to prevent the mines from being laid by attacking the enemy's minelaying aircraft.

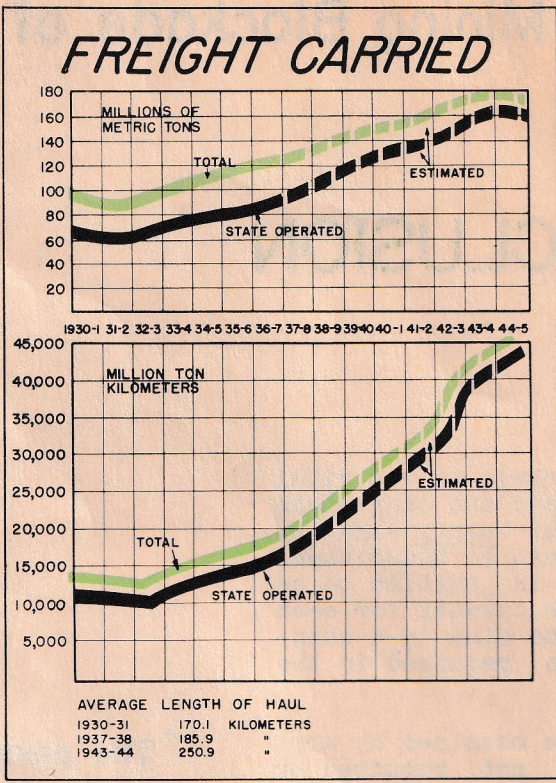
"The planning, operational and technical execution of Twentieth Air Force aircraft mining on a scale never before attained, has accomplished phenomenal results and is a credit to all concerned"

- NIMITZ

RAILROAD CAPACITIES OF JAPAN

Prior to the mining operations the Japanese railroads carried approximately 25% of the freight within the Japanese Homeland. It is estimated that they were operating within 80% of capacity. These facts alone indicate that rail shipping proved a poor substitute for water transportation. This situation was further aggravated by the fact that the main lines all ran from Shimonoseki Straits along the S coast of Honshu to Kobe , Osaka, Nagoya, and Tokyo. If the Shimonoseki Straits could be closed to sea-borne commerce, the strained railroad capacity of Japan would drastically limit the use of NW Honshu ports as diversionary ports for the great industrial centers on the south coast.

The mapping of the Korean rail system is on approximation only, based on the best information available; it is not as accurate as the rail system map of the Japanese home islands.



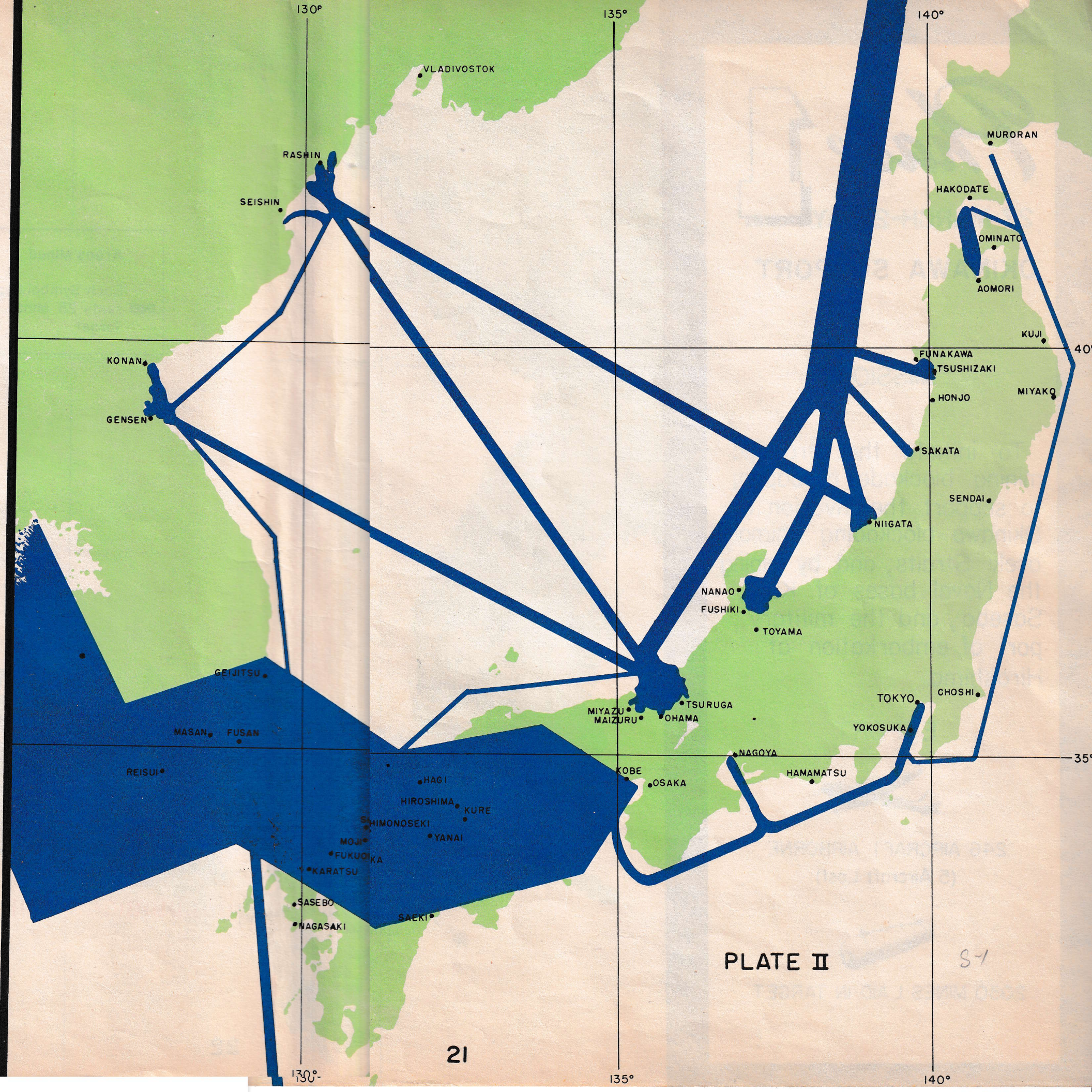
FREIGHT CARRIED					
SELECTED SECTIONS & LINES					
Short Tons Daily in each Direction					
LINE	SECTION	1934	1944	ESTIMATED CAPACITY	ESTIMATED CAPACITY
TOKAIDO	NAGOYA	7,995	26,891	33,345	3,345
TOKAIDO	OSAKA-KOBE	11,035	26,675	33,345	3,345
KAGOSHIMA	KOKURA-YAWATA	5,137	26,813	33,345	3,345

CAPACITIES (IN SHORT TONS)	
BULK COMMODITIES	MILITARY SUPPLIES
1000-4000	(800- 2500)
5000-8000	(3000- 5000)
10000-11000	(6000- 7000)
14000-18000	(9000-11200)
24000-34000	(14400-18000)

ESTIMATE OF SHIPPING SITUATION OF THE JAPANESE EMPIRE *PRIOR TO MINING OPERATIONS* 27 MARCH, 1945

Approximately 2,000,000 gt of Japanese shipping of 1,000 gt or larger was afloat at this time. Most of this shipping passed freely from the Yellow Sea and the Sea of Japan through the Shimonoseki Straits to the Inland Sea. 75 percent of all freight transportation within the homeland also moved by water.

About a million and a half tons of food and raw materials were moving into Japan per month at this time. This volume was approaching the marginal point beyond which any substantial reduction in either the number or movement of vessels would strike a severe blow to the Japanese war economy.



Phase 1

27 MARCH-2 MAY

OKINAWA SUPPORT

MISSION

To initiate the strategic mining blockade of Japan; to support the invasion of Okinawa blockading Shimonoseki Straits, and by mining the Naval bases of Kure, Sasebo, and the military port of embarkation at Hiroshima.

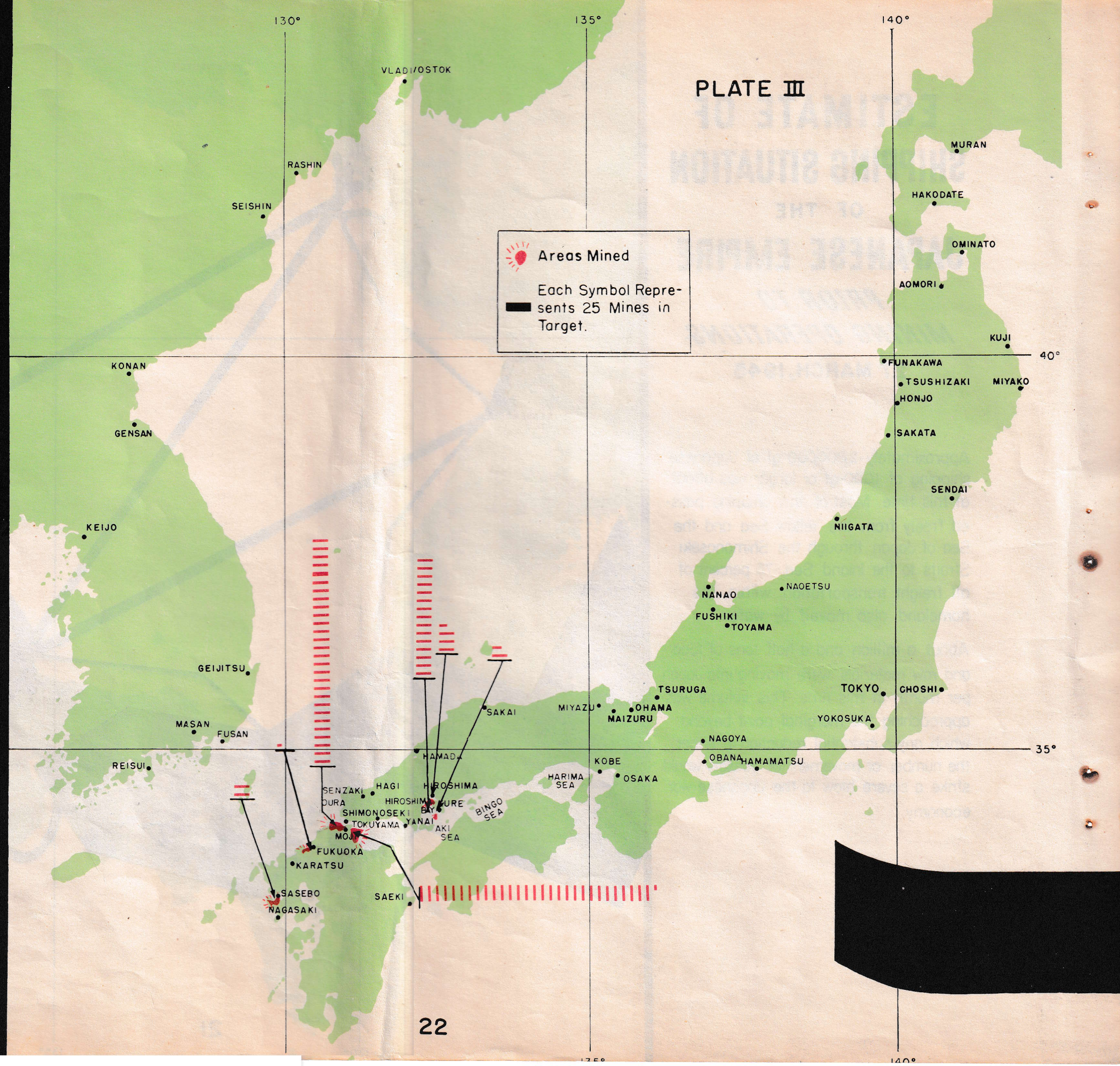
EFFORT



246 AIRCRAFT AIRBORNE
(5 Aircraft Lost)

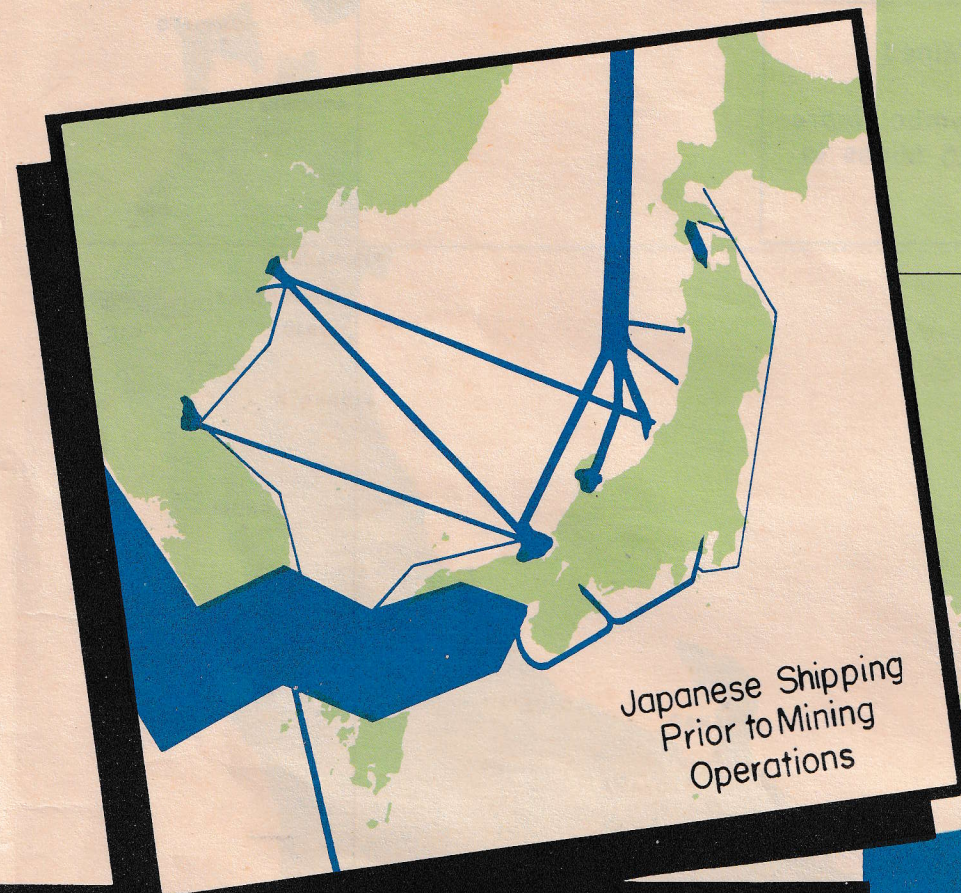


2030 MINES LAID IN TARGET



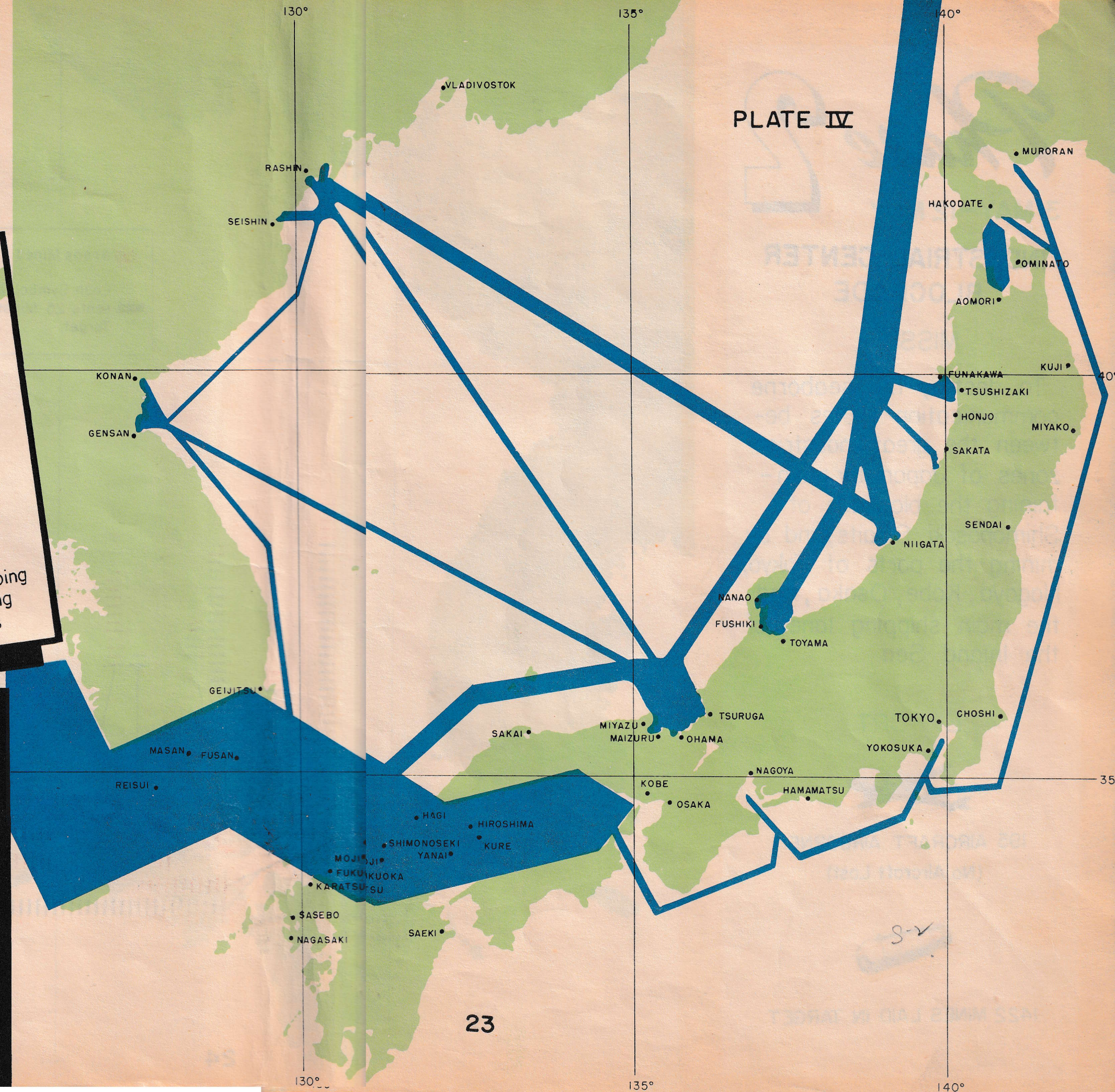
DIVERSION OF ENEMY SHIPPING AFTER *Phase 1*

PLATE IV



SHIPPING SITUATION

1. Enemy naval activity was successfully neutralized in support of Okinawa invasion.
2. Traffic at Shimonoseki Straits was reduced to 25 percent of normal volume.
3. Estimated 35 ships sunk or damaged (100,000 tons).



Phase 2

3 MAY-12 MAY

INDUSTRIAL CENTER BLOCKADE

MISSION

To destroy the seaborne communication routes between the great industrial zones of Japan by maintaining the blockade of Shimonoseki Straits, and by mining the ports of Tokyo, Nagoya, Kobe, Osaka, and the main shipping lanes of the Inland Sea.

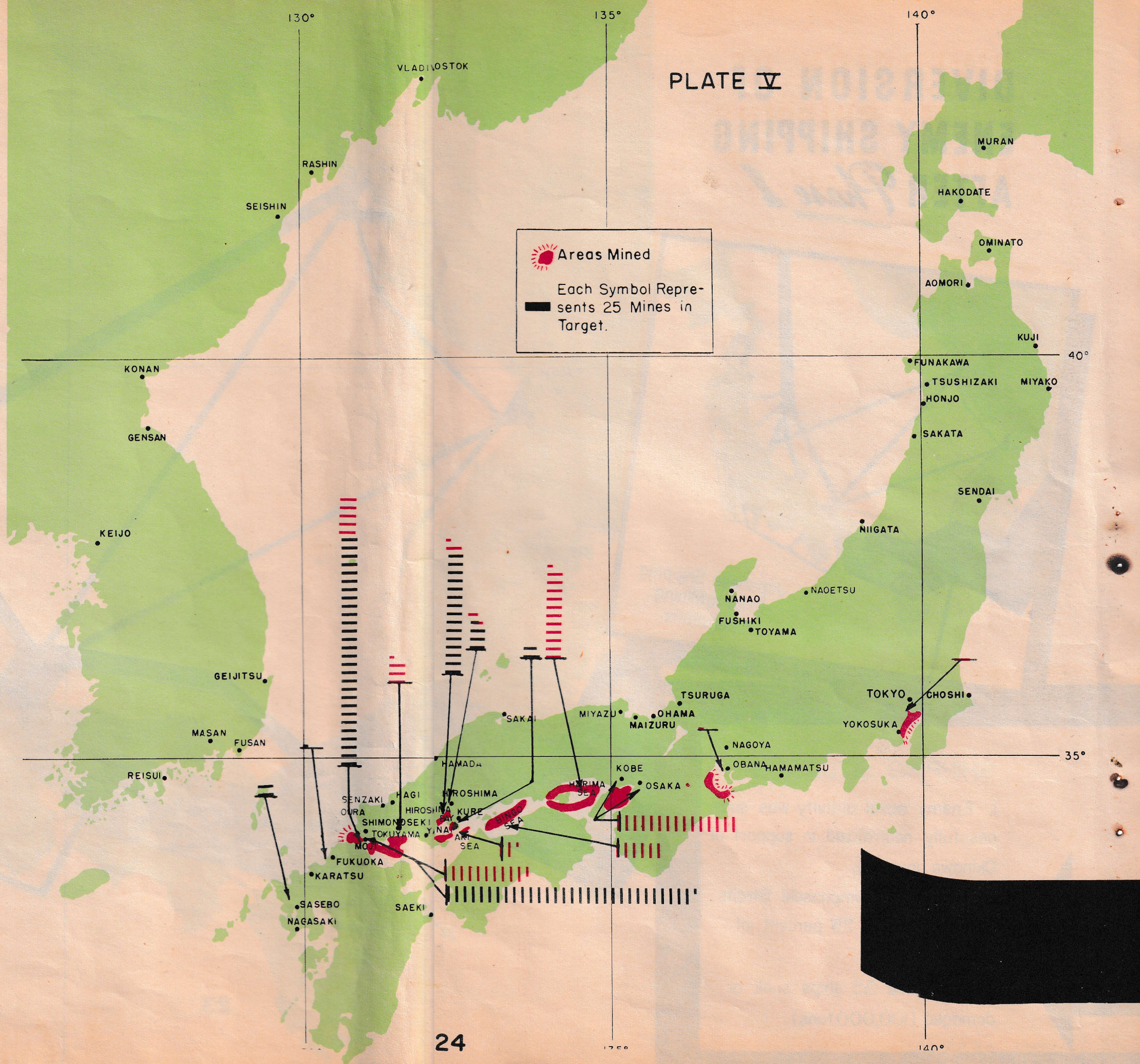
EFFORT



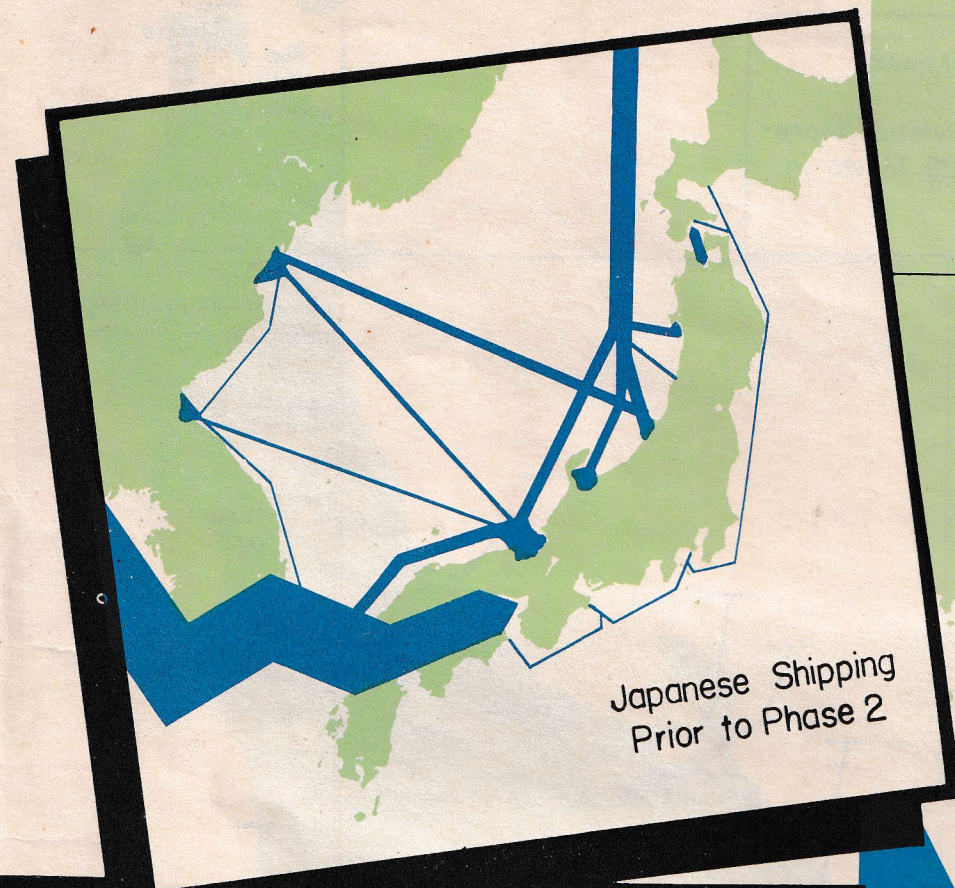
195 AIRCRAFT AIRBORNE
(No Aircraft Lost)



1422 MINES LAID IN TARGET

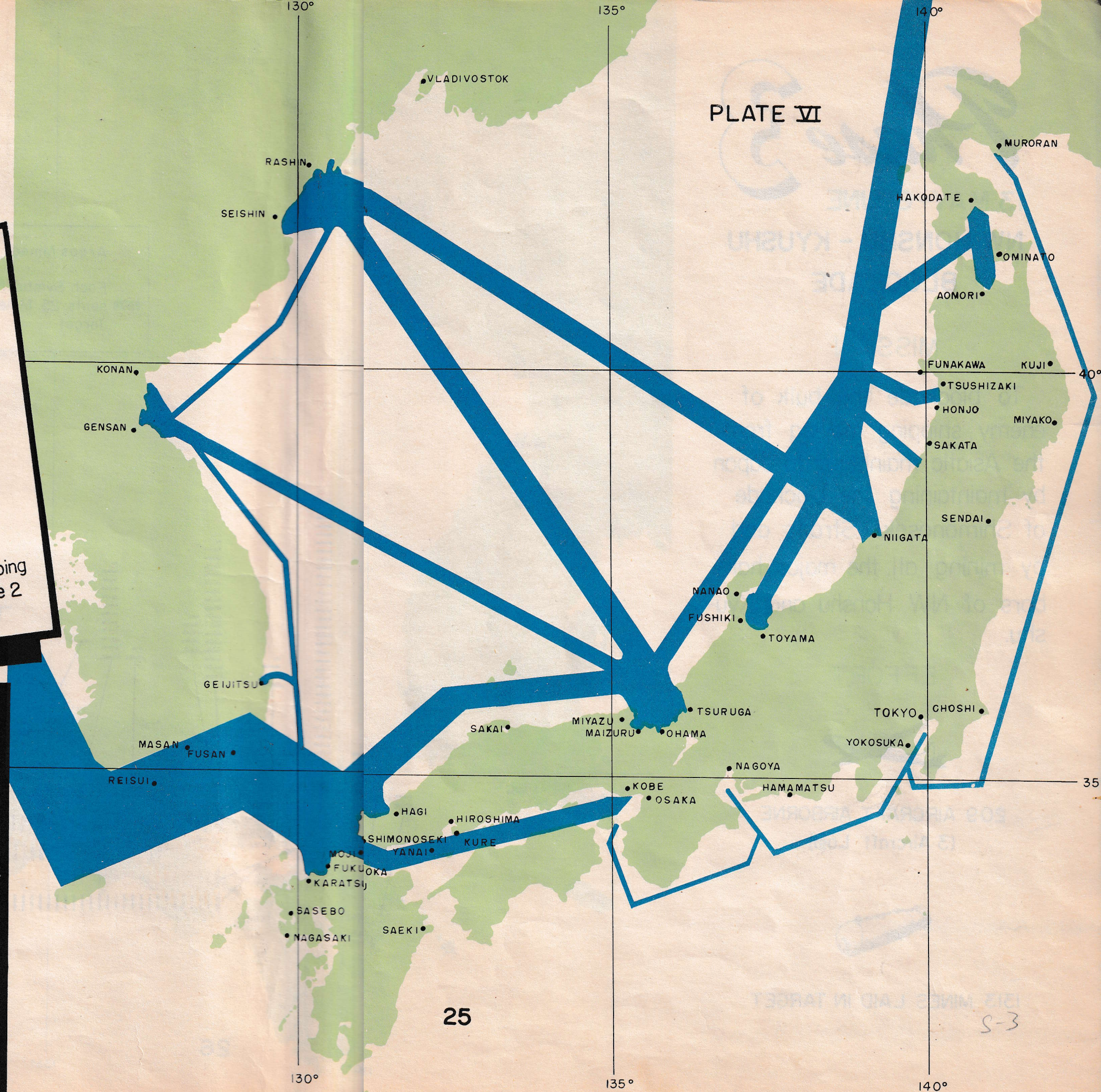


DIVERSION OF ENEMY SHIPPING AFTER *Phase 2*



SHIPPING SITUATION

Ship passage at Shimonoseki was reduced from an estimated 40 per day in March (70,000 tons) to 2 to 4 per day (7,000 tons). The remaining shipping operating in the Inland Sea was reduced to sailing vessels and other types of wooden ships, plus an occasional blockade runner.



Phase 3

13 MAY-6 JUNE

NW HONSHU - KYUSHU BLOCKADE

MISSION

To blockade the bulk of enemy shipping moving from the Asiatic mainland to Japan by maintaining the blockade of Shimonoseki Straits and by mining all the major harbors of NW Honshu and Kyushu.

EFFORT

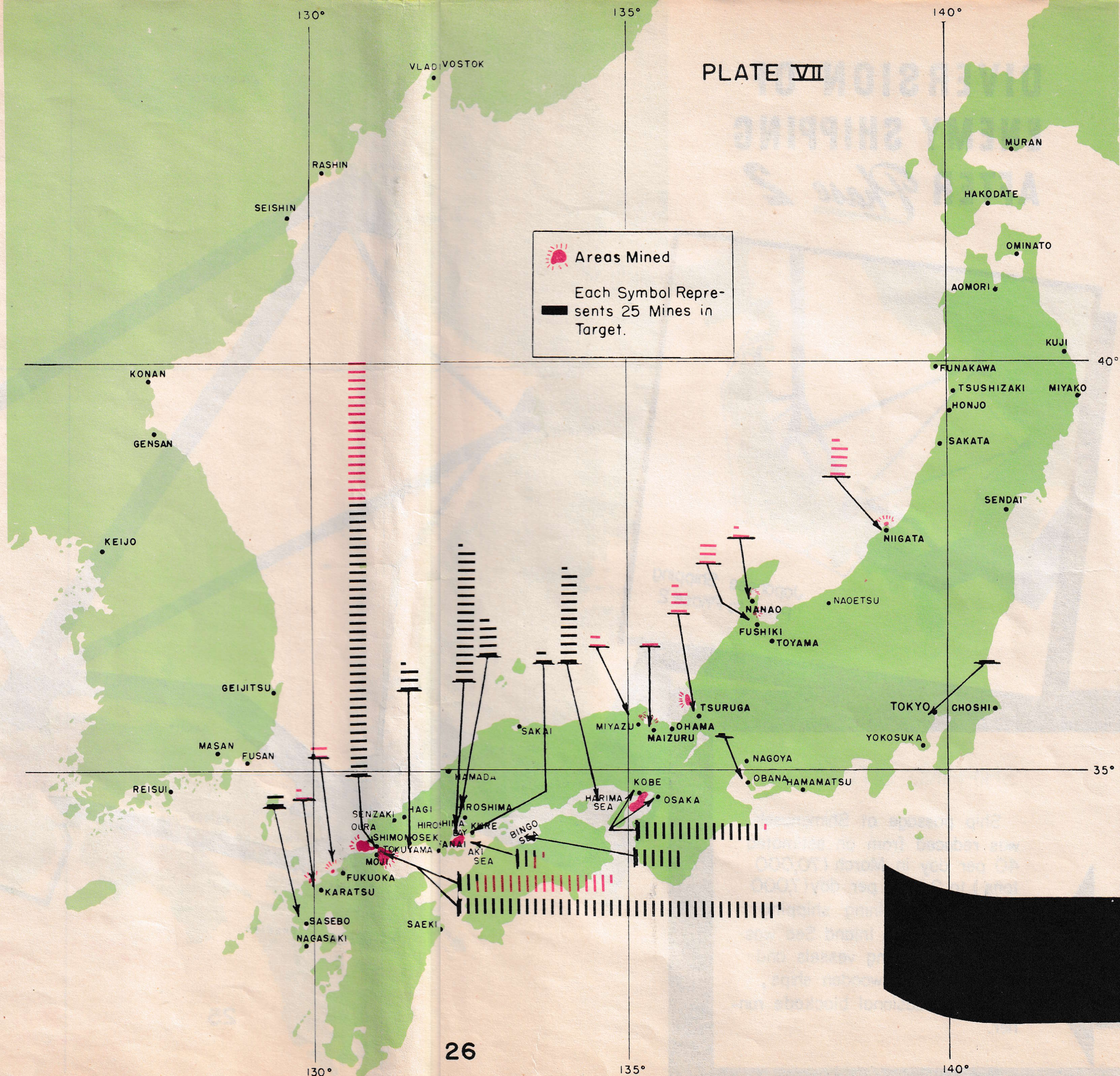


209 AIRCRAFT AIRBORNE
(3 Aircraft Lost)



1313 MINES LAID IN TARGET

PLATE VII



DIVERSION OF ENEMY SHIPPING AFTER *Phase 3*

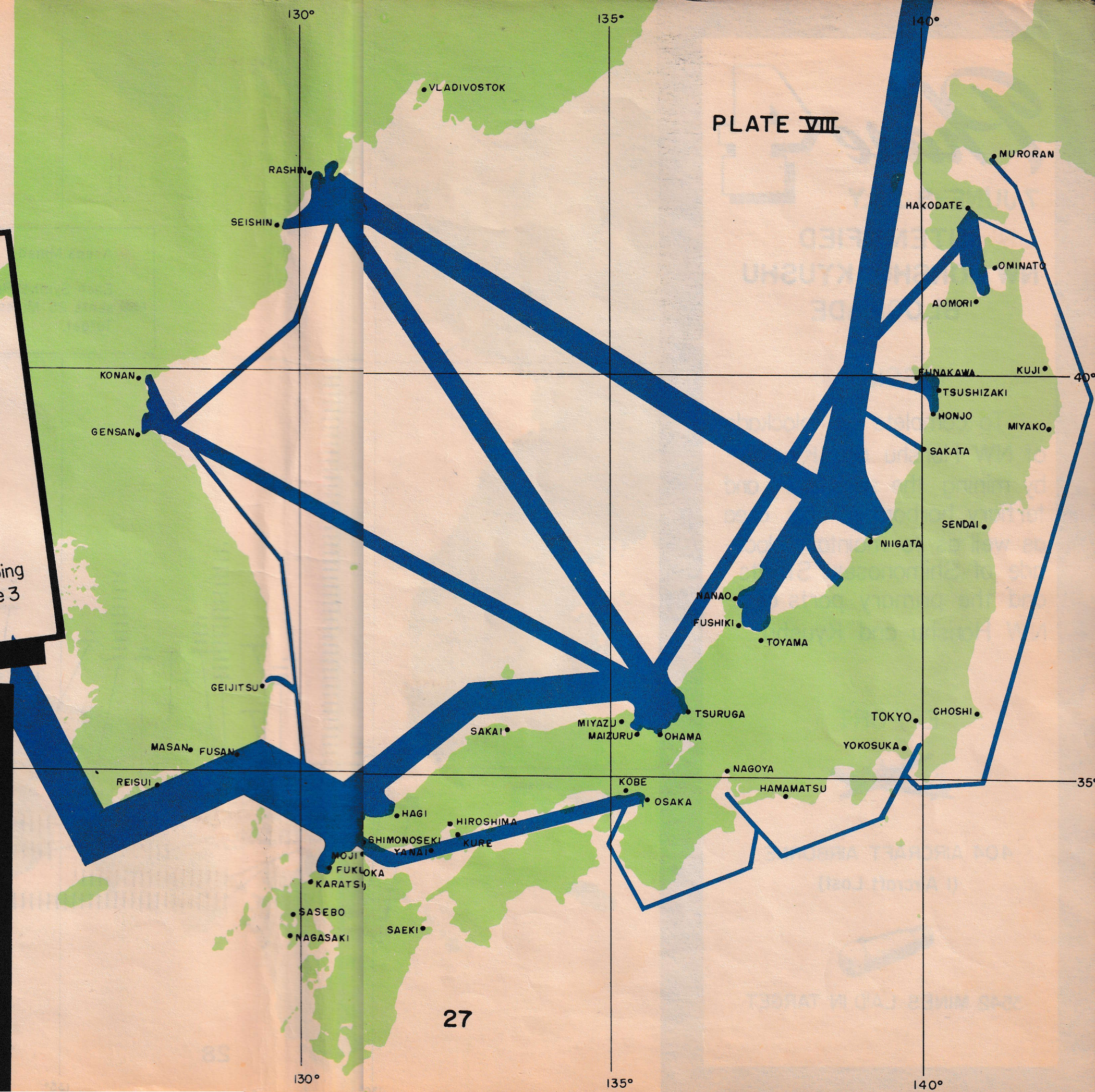
PLATE VIII



Japanese Shipping
Prior to Phase 3

SHIPPING SITUATION

The shipping at the primary ports of Honshu and Kyushu was somewhat reduced. Shipping at Shimonoseki Straits remained at 1/10 of normal. During the entire month of May it was estimated that between 75 and 100 vessels, aggregating at least 300,000 gross tons, were sunk or damaged by mines.



Phase 4

7 JUNE-8 JULY

INTENSIFIED NW HONSHU-KYUSHU BLOCKADE

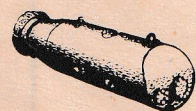
MISSION

To complete the blockade of NW Honshu and Kyushu by mining the secondary and tertiary harbors in this area as well as to maintain blockade of Shimonoseki Straits and the primary ports of NW Honshu and Kyushu.

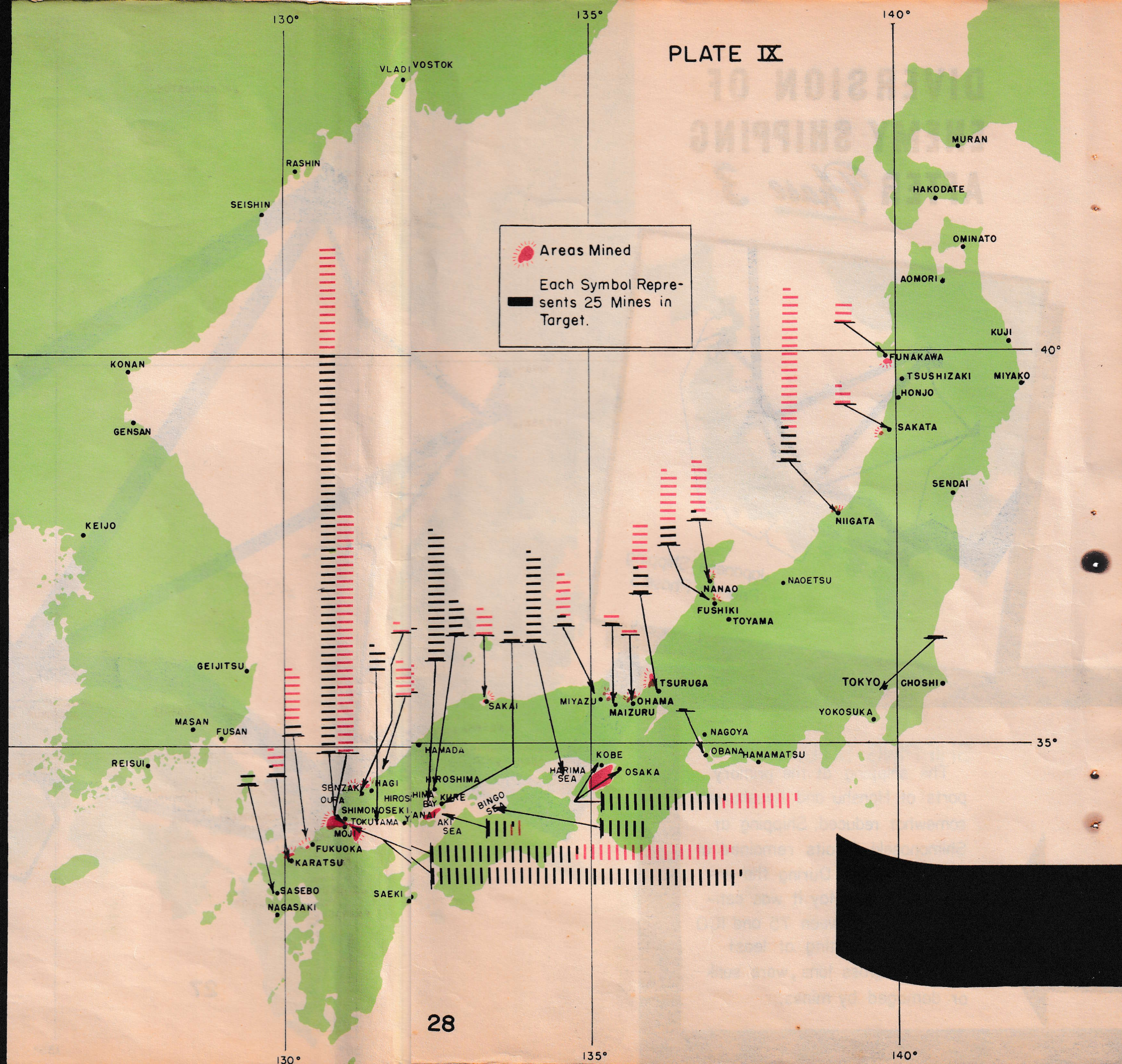
EFFORT



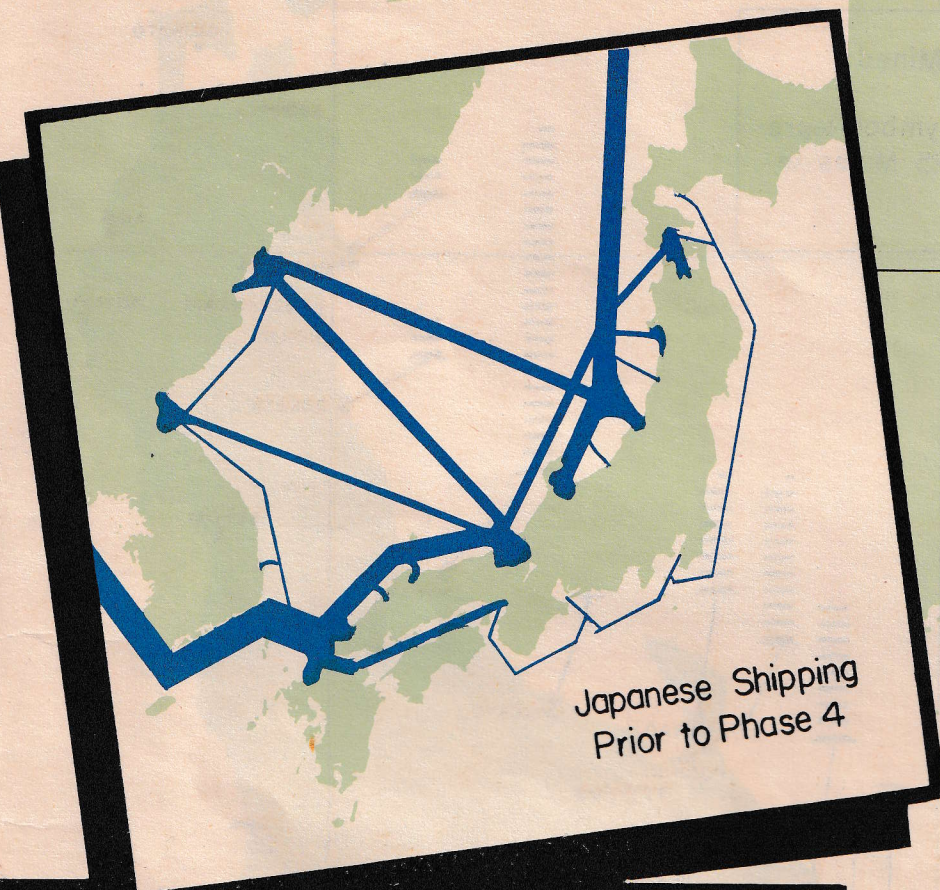
404 AIRCRAFT AIRBORNE
(1 Aircraft Lost)



3542 MINES LAID IN TARGET



DIVERSION OF ENEMY SHIPPING AFTER *Phase 4*



SHIPPING SITUATION

The shipping to NW Honshu and Kyushu was drastically reduced. Traffic at Shimonoseki Straits remained at 1/10 normal. Approximately 300,000 tons of shipping was estimated to have been mined during June.



Phase 5

9 JULY-15 AUGUST

TOTAL BLOCKADE

MISSION

To blockade the remaining enemy shipping at every point possible by mining all the ports of Korea while maintaining the blockade of Shimonoseki Straits and the entire NW Honshu-Kyushu Blockade.

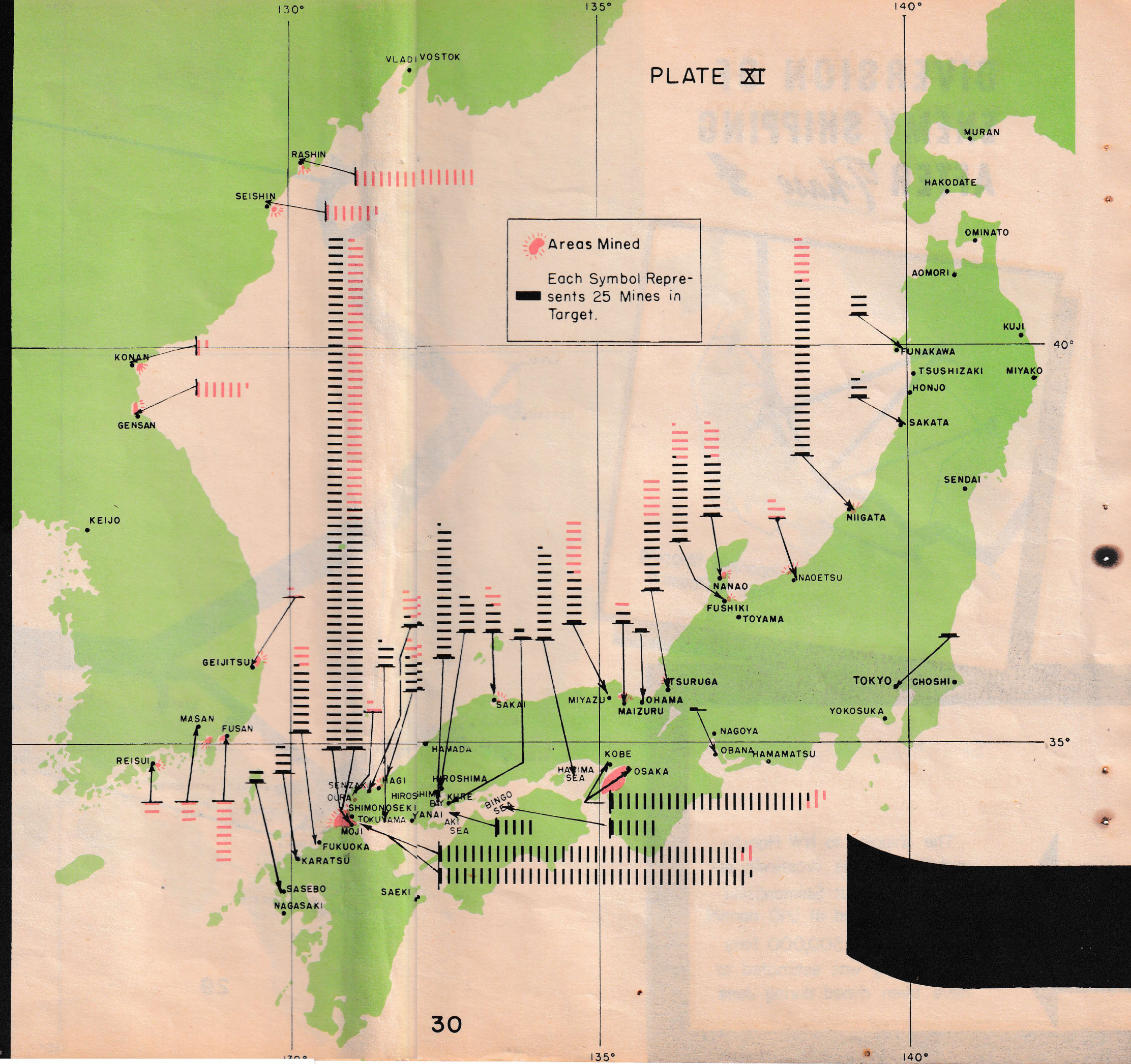
EFFORT



474 AIRCRAFT AIRBORNE
(6 Aircraft Lost)

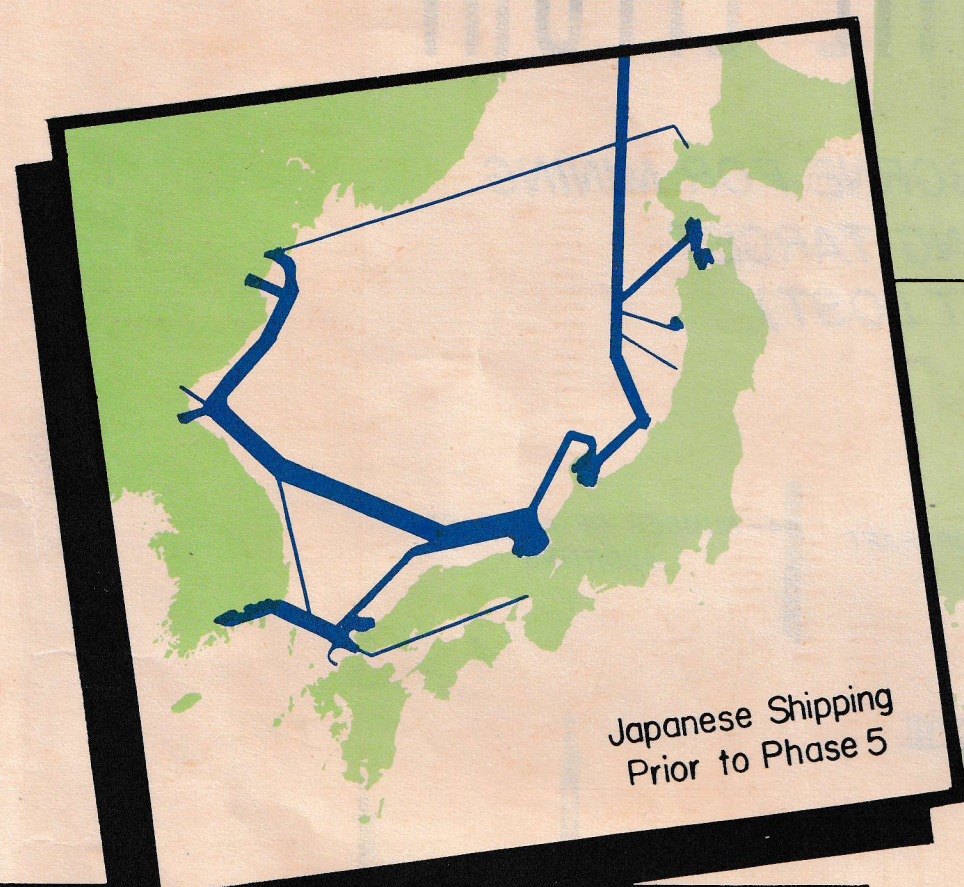


3746 MINES LAID IN TARGET
4 1/2 MILLION LEAFLETS DROPPED



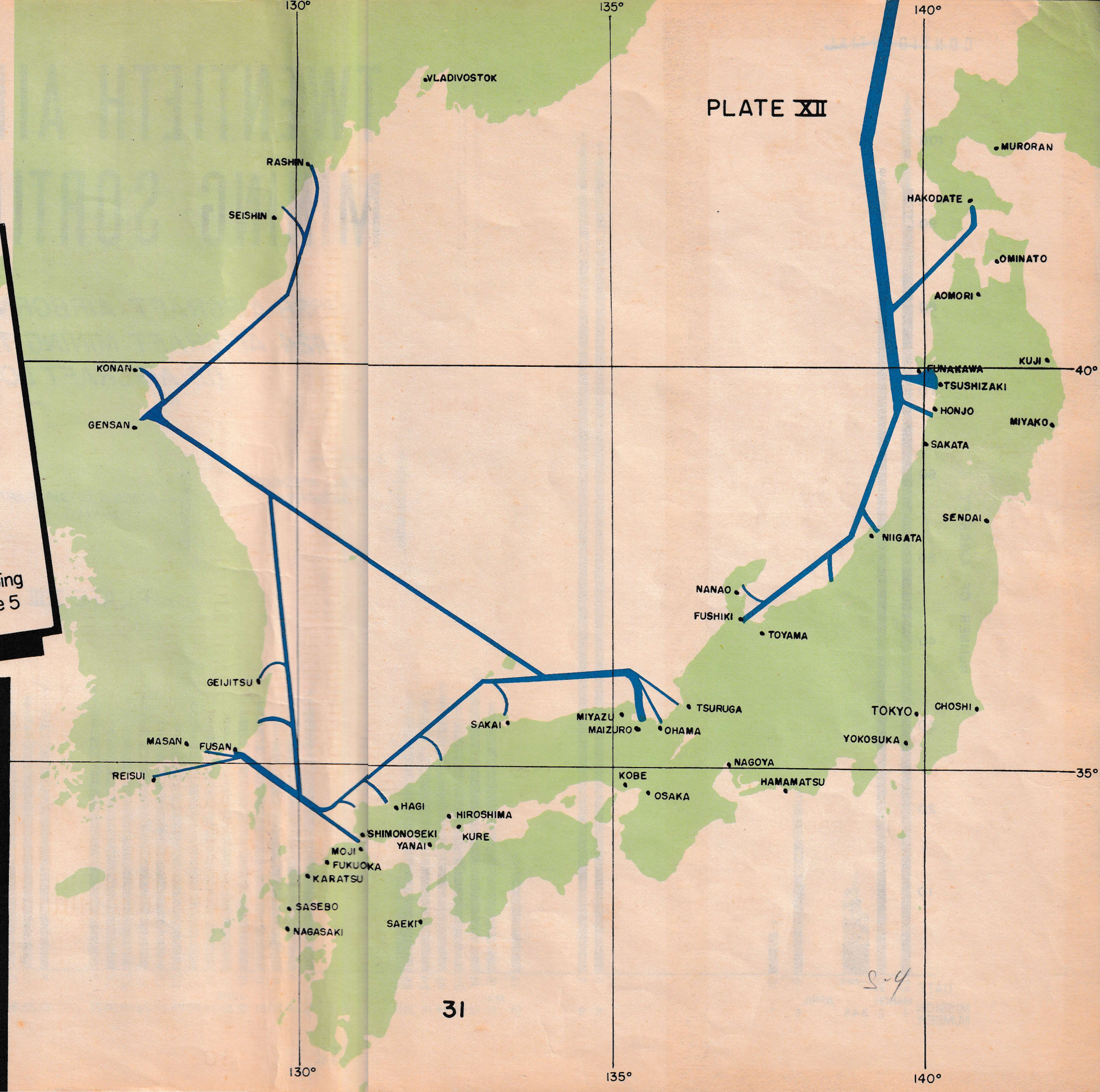
DIVERSION OF ENEMY SHIPPING AFTER *Phase 5*

PLATE XII



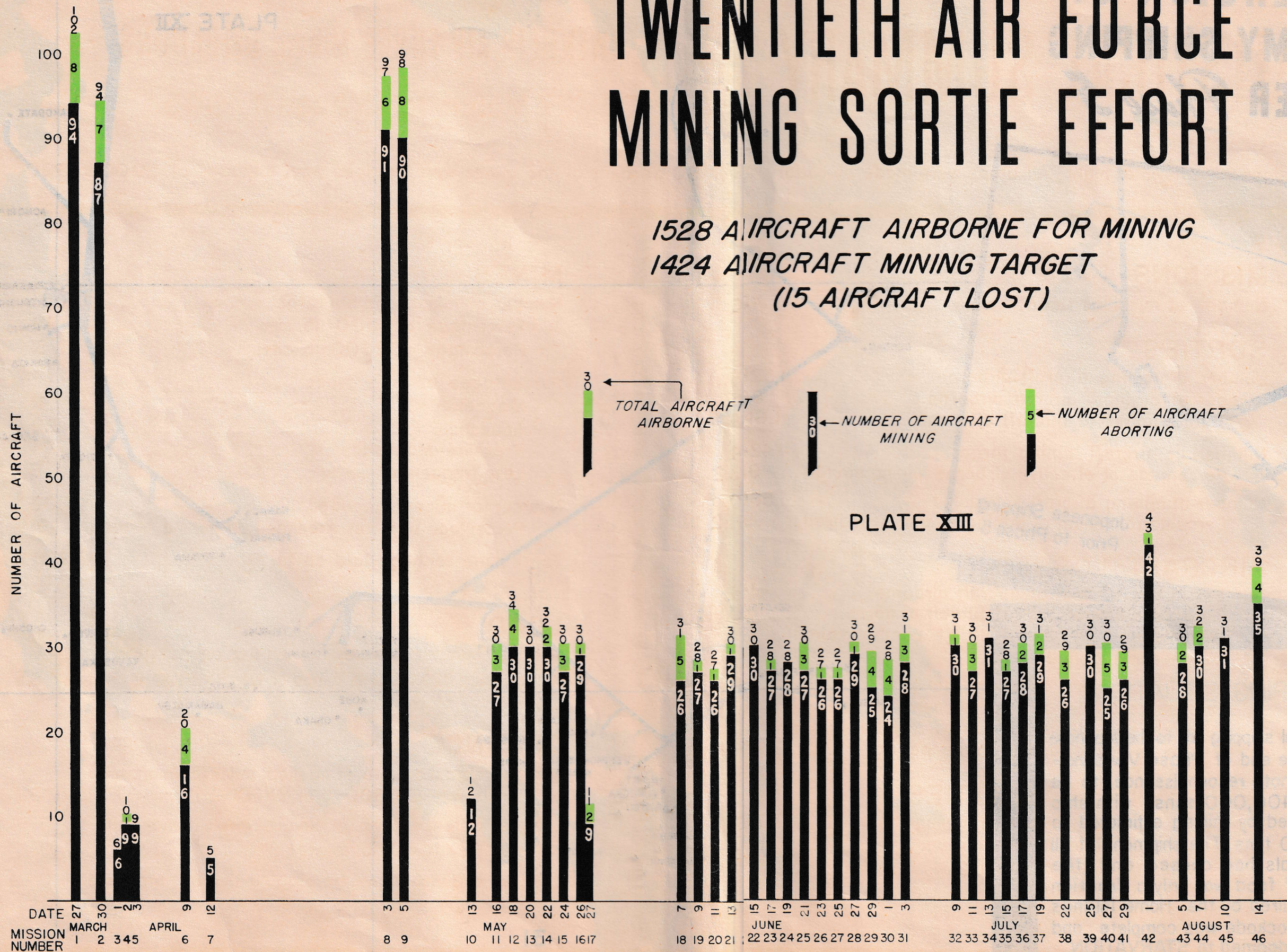
SHIPPING SITUATION

Operational shipping left to the Japanese Empire at the end of Phase V was indicated by photo reconnaissance to be less than 400,000 tons, with ship losses caused by mining estimated to be 300,000 tons. The shipment of all raw materials had ceased and the shipment of food was only a fraction of that required by the Home Islands of Japan. Blockade was complete and Japan was doomed to STARVATION.



TWENTIETH AIR FORCE MINING SORTIE EFFORT

1528 AIRCRAFT AIRBORNE FOR MINING
1424 AIRCRAFT MINING TARGET
(15 AIRCRAFT LOST)



STATISTICAL SUMMARY

TWENTIETH AIR FORCE MINING OPERATIONS

27 March to 15 August, 1945

All missions were flown at night. All drops were made by radar. Over 90 percent of the mines were dropped from altitudes of 5000 to 8000 feet

MISSIONS

Number of missions flown..... 46

SORTIES

Number of mining aircraft airborne..... 1,528

Number of auxiliary aircraft airborne..... 86

Total number of aircraft airborne..... 1,614

Number of aircraft mining target..... 1,424

Percentage of effective airborne mining aircraft..... 93.2

Number of mining aircraft scheduled..... 1,560

Percentage mining of mining aircraft scheduled.. 91.2

AIRCRAFT LOSSES

Number of aircraft lost of aircraft airborne..... 15

Percentage aircraft lost of aircraft airborne..... 0.9

Percentage of all other 20th AF combat aircraft lost in same period..... 1.01

Number of aircraft lost to enemy action..... 9

Percentage of aircraft lost to enemy action.... 0.6

Percentage of all other 20th AF combat aircraft lost to enemy action in same period..... 0.4

PERSONNEL CASUALTIES

Number of men participating in mining flights..... 17,791

Number of men killed or missing..... 103

Percentage killed or missing..... 0.6

Total number of casualties..... 117

Percentage of casualties..... 0.7

MINES

Number of mines laid on target..... 12,053

Percentage of 1000-lb. size..... 49

Percentage of 2000-lb. size..... 51

Percentages of mine types

Magnetic..... 41

Acoustic..... 29

Pressure-Magnetic..... 24

Low frequency..... 6

Number of mines expended..... 13,102

Percentage of mines expended on mining target.. 91.9

Total mine tonnage laid on target..... 8,989.6

LOAD

Average number of mines carried per aircraft per mission (12X1000-lb. mines or 6 to 8X2000-lb. mines). 8.5

DISTANCE

Average distance flown, in nautical miles (Shimonoseki straits, with 12X1000-lb. or 7X2000-lb. mines)... 2,870

Longest distance flown, in nautical miles (Funakawa, with 12X1000-lb. mines)... 3,110

Longest distance flown by staging through Iwo Jima (Rashin, with 12X1000-lb. mines or 7X2000-lb. mines). 3,675

STATISTICAL SUMMARY

PHASE I. OKINAWA SUPPORT

20 th AF Mission Number	Mining Mission Number	Date 1945	Target Name	A/C Scheduled for Mining	A/C Airborne for Mining	A/C Mining Target	Aux. A/C Airborne	Total A/C Airborne	A/C Lost to Enemy Action	A/C Lost to Other Causes	Total A/C Lost	Mines expended	Mines in Target	Altitude in Feet
47	1	27 March	Shimonoseki S., Suo Nada	105	102	94	2	104	3	0	3	924	837	5,000
49	2	30 March	Shimonoseki S., Kure, Hiroshima, Sasebo	102	94	87	2	96	0	2	2	906	825	5,000
52	3	1 April	Kure	6	6	6	2	8	0	0	0	48	48	25,700-26,450
53	4	2 April	Kure, Hiroshima	10	10	9	1	11	0	0	0	84	78	6,000-6,100
54	5	3 April	Kure, Hiroshima	10	9	9	2	11	0	0	0	84	83	6,000-6,150
62	6	9 April	Shimonoseki S.	20	20	16	1	21	0	0	0	132	106	5,000-6,300
66	7	12 April	Shimonoseki S.	5	5	5	1	6	0	0	0	53	53	6,800-7,710
TOTALS	7 Miss.	17 days		258	246	226	11	257	3	2	5	2231	2030	

MINE SIZES: 68%, 1000 lb. size; 32%, 2000 lb. size

FIRING MECHANISM TYPES: 25% Magnetic; 75% Acoustic

PHASE II. INDUSTRIAL CENTER BLOCKADE

139	8	3 May	Shimonoseki S., Kobe, Osaka, Suo Nada	100	97	91	2	99	0	0	0	740	694	4,800-8,650
150	9	5 May	Inland Sea, Kobe, Osaka, Tokyo, Nagoya	99	98	90	4	102	0	0	0	809	728	6,000-8,400
TOTALS	2 Miss.	3 days		199	195	181	6	201	0	0	0	1549	1422	

MINE SIZES: 36%, 1000 lb. size; 64%, 2000 lb. size

FIRING MECHANISM TYPES: 23% Magnetic; 27% Acoustic; 50% Pressure Magnetic

PHASE III. NW HONSHU-KYUSHU BLOCKADE

173	10	13 May	Shimonoseki S., Niigata	12	12	12	2	14	0	0	0	140	139	5,800-8,030
175	11	16 May	Shimonoseki S., Miyazu, Maizuru	30	30	27	1	31	0	0	0	186	165	6,200-11,000
177	12	18 May	Shimonoseki S., Tsuruya	34	34	30	2	36	0	0	0	216	192	5,800-6,700
179	13	20 May	Shimonoseki S., Maizuru, Miyazu	32	30	30	1	31	0	1	1	184	184	5,500-6,600
180	14	22 May	Shimonoseki S.	32	32	30	1	33	1	0	1	192	178	5,300-8,100
182	15	24 May	Shimonoseki S., Niigata, Nanao, Fushiki	31	30	27	2	32	0	0	0	210	186	5,900-8,200
184	16	26 May	Shimonoseki S., Fukuoka, Karatsu, Fushiki	30	30	29	2	32	0	0	0	220	206	5,900-8,200
185	17	27 May	Shimonoseki S., Moji	11	11	9	0	11	1	0	1	77	63	7,450-7,700
TOTALS	8 Miss.	15 Days		212	209	194	11	220	2	1	3	1425	1313	

MINE SIZES: 12%, 1000 lb. size; 88%, 2000 lb. size

FIRING MECHANISM TYPES: 54% Magnetic; 9% Acoustic; 24% Pressure Magnetic; 13% Low Frequency

PHASE IV. INTENSIFIED NW HONSHU-KYUSHU BLOCKADE

20th AF Mission Number	Mining Mission Number	Date 1945	Target Name	A/C Scheduled for Mining	A/C Airborne for Mining	A/C Mining Target	Aux. A/C Airborne	Total A/C Airborne	A/C Lost to Enemy Action	A/C Lost to other Causes	Total A/C Lost	Mines Expended	Mines in Target	Altitude in Feet
190	18	7 June	Shimonoseki S., Fukuoka	33	31	26	1	32	0	0	0	337	279	5,700-8,400
194	19	9 June	Shimonoseki S.	29	28	27	1	29	0	0	0	241	234	6,200-8,400
201	20	11 June	Shimonoseki S., Tsuruga	28	27	26	2	29	0	0	0	189	182	7,200-8,200
202	21	13 June	Shimonoseki S., Niigata	30	30	29	2	32	0	0	0	330	311	7,000-7,700
204	22	15 June	Shimonoseki S., Fushiki, Fukuoka, Karatsu	31	30	30	2	32	0	0	0	320	297	7,800-9,000
205	23	17 June	Shimonoseki S., Kobe	28	28	27	2	30	0	0	0	301	277	6,200-8,350
213	24	19 June	Shimonoseki S., Niigata, Miyazu, Maizuru	28	28	28	2	30	0	0	0	256	256	8,000-8,800
214	25	21 June	Oura, Senzaki, Nanao, Fushiki, Osaka	30	30	27	2	32	0	0	0	320	284	6,500-8,600
221	26	23 June	Karatsu, Fukuoka, Sakai, Niigata	28	27	26	2	29	0	1	1	289	277	4,200-8,700
222	27	25 June	Shimonoseki S., Tsuruga, Ohama	28	27	26	2	29	0	0	0	209	201	6,300-8,700
233	28	27 June	Hagi, Niigata, Kobe, Osaka	30	30	29	2	32	0	0	0	290	275	6,700-8,700
239	29	29 June	Shimonoseki S., Maizuru, Sakata	30	29	25	2	31	0	0	0	263	225	4,200-8,500
244	30	1 July	Shimonoseki S., Nanao, Fushiki	29	28	24	1	29	0	0	0	241	203	7,200-8,700
246	31	3 July	Shimonoseki S., Maizuru, Funakawa	31	31	28	2	33	0	0	0	262	241	7,200-8,900
TOTALS	14 Miss.	27 Days		413	404	378	25	429	0	1	1	3848	3542	

MINE SIZES: 63%, 1000 lb. size; 37%, 2000 lb. size

FIRING MECHANISM TYPES: 55% Magnetic, 21% Acoustic, 21% Pressure-Magnetic, 3% Low Frequency

PHASE V. TOTAL BLOCKADE

256	32	9 July	Shimonoseki S., Niigata, Fushiki	31	31	30	1	32	1	0	1	292	274	6,900-8,800
262	33	11 July	Rashin, Fusan, Maizuru, Shimonoseki S.	30	30	27	2	32	0	0	0	221	199	6,900-9,400
268	34	13 July	Seishin, Masan, Reisui, Shimonoseki S., Fukuoka	31	31	31	3	34	0	0	0	262	254	6,900-12,550
269	35	15 July	Rashin, Genzan, Konan, Fusan, Noetsu, Niigata	28	28	27	2	30	0	0	0	256	244	6,900-8,400
275	36	17 July	Shimonoseki S., Seishin, Nanao, Fushiki	30	30	28	3	33	0	0	0	260	238	7,100-8,500
276	37	19 July	Niigata, Kobe, Osaka, Maizuru, Miyazu, Genzan, Konan	31	31	29	2	33	0	1	1	242	228	7,100-8,400
282	38	22 July	Shimonoseki S., Rashin, Fusan, Masan	30	29	26	2	31	0	1	1	228	207	7,600-8,300
292	39	25 July	Seishin, Fusan, Fushiki, Nanao, Ohama, Tsuruga	30	30	30	2	32	0	0	0	245	243	6,900-8,400
296	40	27 July	Shimonoseki S., Niigata, Miyazu, Maizuru, Senzaki	30	30	25	3	33	0	3	3	235	189	8,000-10,400
304	41	29 July	Rashin, Fukuoka, Shimonoseki S.	30	29	26	3	32	0	0	0	228	196	7,900-12,900
305	42	1 Aug.	Rashin, Hamada, Seishin, Shimonoseki S.	45	43	42	2	45	0	0	0	376	354	6,500-12,000
311	43	5 Aug.	Rashin, Geijitsu, Tsuruga, Oura, Hagi	30	30	28	0	30	0	0	0	275	253	7,000-8,600
318	44	7 Aug.	Shimonoseki S., Maizuru, Sakai, Rashin	32	32	30	2	34	0	0	0	279	255	7,900-12,000
324	45	10 Aug.	Hagi, Yuyawan, Shimonoseki S., Genzan	32	31	31	3	34	0	0	0	272	269	7,500-12,900
331	46	14 Aug.	Nanao, Shimonoseki S., Maizuru, Hamada	39	39	35	3	42	0	0	0	378	343	8,000-12,800
TOTALS	15 Miss	37 Days		479	474	445	33	507	1	5	6	4049	3746	

MINE SIZES: 44%, 1000 lb. size; 56%, 2000 lb. size

FIRING MECHANISM TYPES: 37% Magnetic, 19% Acoustic, 31% Pressure-Magnetic, 13% Low Frequency

FLAK ANALYSIS

BACKGROUND

On 7 March 1945, a conference was held to discuss the capabilities of the Japanese AA to oppose B-29 mining of waters in the vicinity of Shimonoseki, and to arrive at conclusions regarding the most advantageous altitude for aerial minelaying. The following officers participated in the discussion:

Flak O, AAFPOA
Flak O, XXI Bomber Command
Ass't. Flak O, XXI Bomber Command
Flak O, 11th Bomb Group (H)
Flak O, 30th Bomb Group (H)
Naval Mining O, XXI Bomber Command
Army Mining O, XXI Bomber Command

The 11th and 30th Bomb Groups had recently participated in mining operations in the Bonin Islands. Consequently, it was felt that their views on flak, based on recent experience, would provide valuable information for the projected B-29 operation.

The conference was handicapped by a complete lack of photo intelligence showing the defenses of the area in question. However, it was assumed that AA defenses of all types were likely to be encountered, and the conclusions which were reached were based on this assumption. Another factor influencing the conclusions was that the operations would be conducted during hours of darkness. A third factor which had to be kept in mind was that the altitudes for the projected mining operation were limited to a maximum of approximately 8,000 feet.

CONCLUSIONS

The conclusions reached by the conference were these:

1. The optimum altitude for safety from AA below the limiting altitude of 8,000 feet, was estimated to be 5,000 to 6,000 feet.

2. While within range of possible defenses, a tight and level flight should be maintained for as short a time as possible.

3. The conduct of operations over widely scattered areas would add to the difficulty of the enemy's defenses.

4. The enemy would not be able to move AA weapons from any given area to the mining area in time to obtain additional concentrations of weapons in that area.

ENEMY AA CAPABILITIES

The conference discussion included a consideration of the following enemy AA capabilities:

Flak Barges

Practically no evidence was available which would indicate any use of Flak Barges on the part of the enemy. Therefore, consideration of this type of opposition was omitted.

Heavy AA Guns

Fire from enemy AA guns could be expected. However, the enemy's heavy AA fire had not proved effective during hours of darkness. He had resorted to barrage fire and to predicted concentrations during most of his night firing. This type of fire could be more accurately delivered at altitudes of 10,000 to 20,000 feet than at altitudes of approximately 5,000 feet. B-24 aircraft which had mined the Bonin Islands received meager fire (few bursts) from heavy AA guns at altitudes in the vicinity of 5,000 to 6,000 feet.

Automatic Weapons & M.G.'s

These weapons had been used quite effectively by the Japanese on aircraft attacking at altitudes of 100

feet up to 3,000 feet. The maximum hitting range of the 25 mm guns, the primary automatic weapon of the enemy, was 15,000 yards. Hence, at altitudes of 5,000 to 6,000 feet, fire from these weapons would, in most cases, prove a deterrent. For defense against B-29 mining operations, the enemy probably would attempt to place an AA barrage in the path of attacking aircraft. In order to minimize the effect of such fire, it was concluded that straight and level flight should be kept at a minimum, that the time interval between attacking aircraft should be staggered and as short as possible, and that different headings should be used for the run over the minefield.

Searchlights

In general, the enemy's operation of searchlights had been fairly ineffective. His searchlights had been less effective at low altitudes (4,000 to 7,000 feet) than at high altitudes (10,000 to 20,000 feet). Furthermore, the problem of tracking with searchlights was more difficult at low altitudes than at higher altitudes. Therefore, it was evident that the probability of being effectively illuminated was less at 5,000 feet than at 10,000 feet.

Barrage Balloons

Barrage balloons had been employed by the Japanese in Formosa, China, Kyushu and Honshu. Two types had been encountered: (1) the conventional barrage balloon with cable, and (2) a free balloon reported at altitudes of 20,000 to 30,000 feet. The exact purpose of the latter had not yet been determined at the time of the conference, but it was evident that it was not an anti-aircraft weapon. Consideration of the free balloon was therefore omitted.

Three conventional barrage balloons had been sighted at altitudes varying

from 2,000 to 5,000 feet, with the majority seen at 4,000 feet. It was concluded, therefore, that flight at 5,000 feet should carry aircraft above barrage balloons. However, it was recommended that crews should be warned emphatically of the possibility of encountering barrage balloons and of the necessity for maintaining a sharp lookout.

Miscellaneous AA Weapons

The Japanese also utilized two types of AA mortars, both of which fired a projectile which on detonation emitted explosive charges suspended from small parachutes. The maximum altitude attainable by this projectile was 3,000 feet. The parachute-suspended explosive would not detonate unless it made contact with the aircraft.

SUMMARY

From the discussion described above, which considered all the factors of enemy AA opposition, it was concluded that an altitude of 5,000 to 6,000 feet was the optimum altitude for the projected B-29 mining operation. The decision was based not only on the capabilities of enemy AA but also on the limitations in choice of altitude imposed by mining operations. It was also recognized that careful routing of aircraft to avoid known AA defenses was an obvious consideration that required discussion. It was concluded that the element of surprise would be a significant factor in reducing AA effectiveness, and one which should be fully exploited.

MINELAYING PROCEDURE

GENERAL

Aerial mining presents two problems that must be solved by different methods than those of normal bombing. The two problems are outlined herein to present the basis for definite minelaying procedures.

1. The parachute attached to the mine, which protects it from excessive shock on impact with the water, retards its rate of fall and offers a much larger area to air resistance than is presented by a free falling bomb. This allows wind and resistance to the force placed in the direction of heading of the aircraft on the mine to be much greater than on a bomb. The trail and crosstrail of a mine are therefore so great as to be beyond the limits of the bombsight. This necessitates the plotting of the dropping point by using the reciprocal of the trajectory of the mine from the desired impact point to determine the release point. Tables showing the ballistic wind for the wind at altitude, the wind drift of mine for various wind velocities and altitudes, and the no-wind range of mines for various true airspeeds and altitudes have been computed.

2. As mines are planted in water and neither the point of impact nor the point directly beneath the point of release can be directly identified, the position of release must be determined with reference to adjacent points of land.

SOLUTION OF PROBLEM

Basically there are two separate mining situations, one where the reference point is beyond the point of release and the other where the point of release is beyond the reference

point. The same methods of calculating the point of release are used in both situations.

1. General Method

a. Mark aiming point and point of desired mine impact.

b. Using true altitude enter ballistic wind table and find what percentage of the wind at altitude affects the mines during fall.

(1) Multiply the measured wind by this percentage.

c. Using the wind drift of mine table for the size mines to be dropped, enter the table using altitude and effective wind velocity. This figure gives the distance in nautical miles that the mine will drift.

(1) Plot this distance (the wind drift vector) back into the wind from the desired impact point of the first mine.

d. Using the no-wind range table for the size mine to be dropped, enter table with true airspeed and true altitude to find the distance in nautical miles the mine will fall along the aircraft's heading.

(1) From the point established by the wind drift vector draw the range vector back into that heading which gives the course from this point to the reference point. Use the wind at altitude to establish this heading. (This applies to the case of reference point beyond release. If the release point is beyond the reference point, the heading is determined by the course from the reference point to the point of release and the wind at altitude.) The final point established is the point of release.

TACTICAL SOP

e. Measure the distance from the point of release to the reference point. Convert this ground range to slant range. Set this slant range on the computer drum of the radar set.

f. Set the measured true course from release point to reference point on the track line of the radar scope.

g. At the time of intersection of bomb release circle, track line and reference point, release the first mine. Other mines will be released at timed intervals after the first mine release. When using the system with reference point beyond the release point use this intersection when the bomb release circle first reaches the reference point. If release point is beyond the reference point the release will be made at the intersection of the bomb release circle, track line and reference point on the back azimuth of the track.

2. Special Methods

Occasionally conditions exist in which either there is no definite reference point on the prescribed course of the mining run or where the dropping position and reference point are located too near each other to identify the reference point for the release accurately.

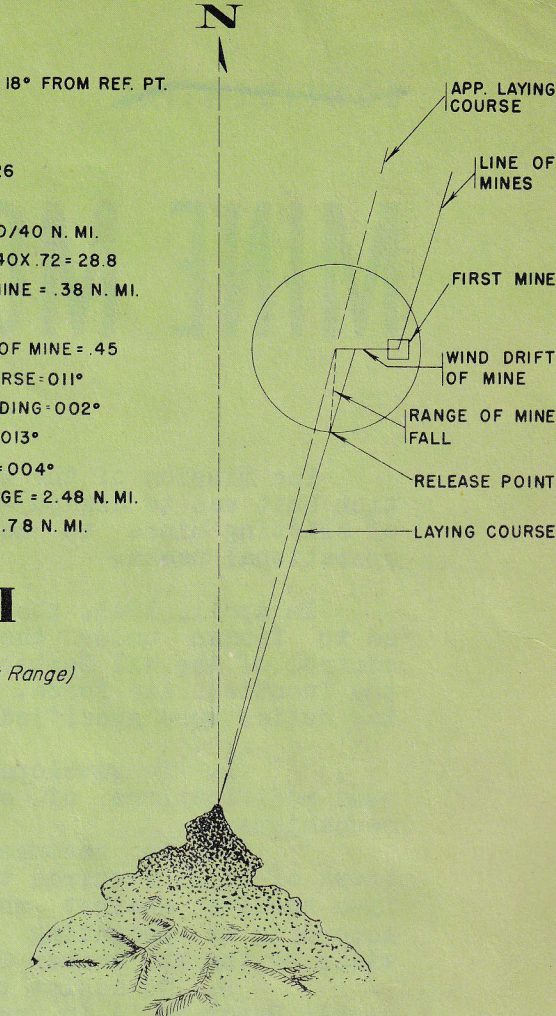
a. The first of the problems will be solved by use of two bearings from off-course reference points to fix the release position.

b. The second will be solved by using a combination of an arbitrary slant range from the reference point to establish a position, and then a timed run from this position to identify the dropping position.

TARGET 3 MILES / 18° FROM REF. PT.
TEMP. + 8° C
CIAS 230 MPH.
MINE TYPE MK. 26
TRUE ALT. 8000
WIND AT ALT. 270/40 N. MI.
BALLISTIC WIND 40X.72=28.8
WIND DRIFT OF MINE = .38 N. MI.
TAS = 230 N. MI.
NO WIND RANGE OF MINE = .45
APP. LAYING COURSE = 011°
APP. LAYING HEADING = 002°
LAYING COURSE = 013°
LAYING HEADING = 004°
HORIZONTAL RANGE = 2.48 N. MI.
SLANT RANGE = 2.78 N. MI.

CASE I

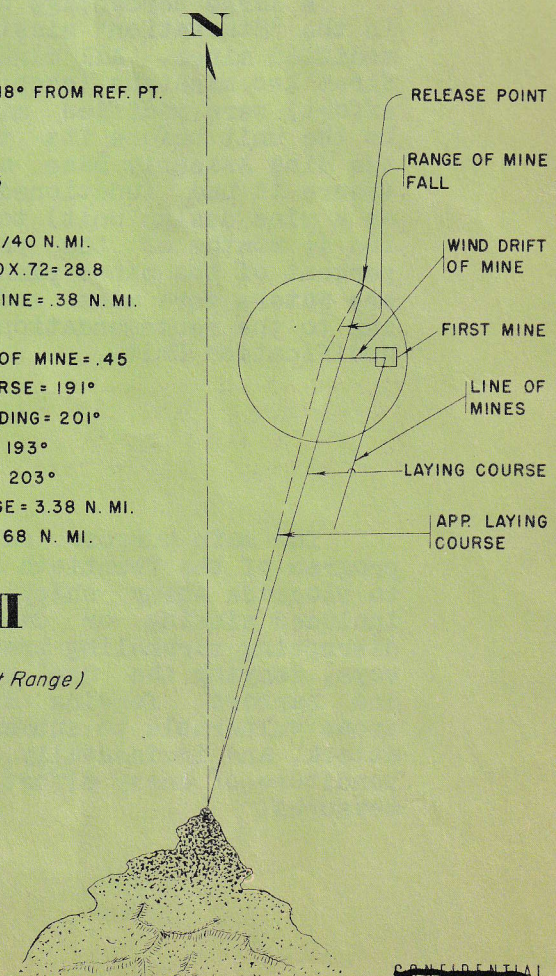
(Forward-Slant Range)



TARGET 3 MILES / 18° FROM REF. PT.
TEMP. + 8° C
CIAS 230 MPH.
MINE TYPE MK. 26
TRUE ALT. 8000
WIND AT ALT. 270/40 N. MI.
BALLISTIC WIND 40X.72=28.8
WIND DRIFT OF MINE = .38 N. MI.
TAS = 230 N. MI.
NO WIND RANGE OF MINE = .45
APP. LAYING COURSE = 191°
APP. LAYING HEADING = 201°
LAYING COURSE = 193°
LAYING HEADING = 203°
HORIZONTAL RANGE = 3.38 N. MI.
SLANT RANGE = 3.68 N. MI.

CASE II

(Backward-Slant Range)



MINE MODIFICATION UNIT

The mission of the Mine Modification Unit was to design modifications of existing mines to meet immediate operational needs.

In April, 1945, the unit was moved to Tinian under the operational control of the XXI Bomber Command, now the Twentieth Air Force. The following duties were specified:

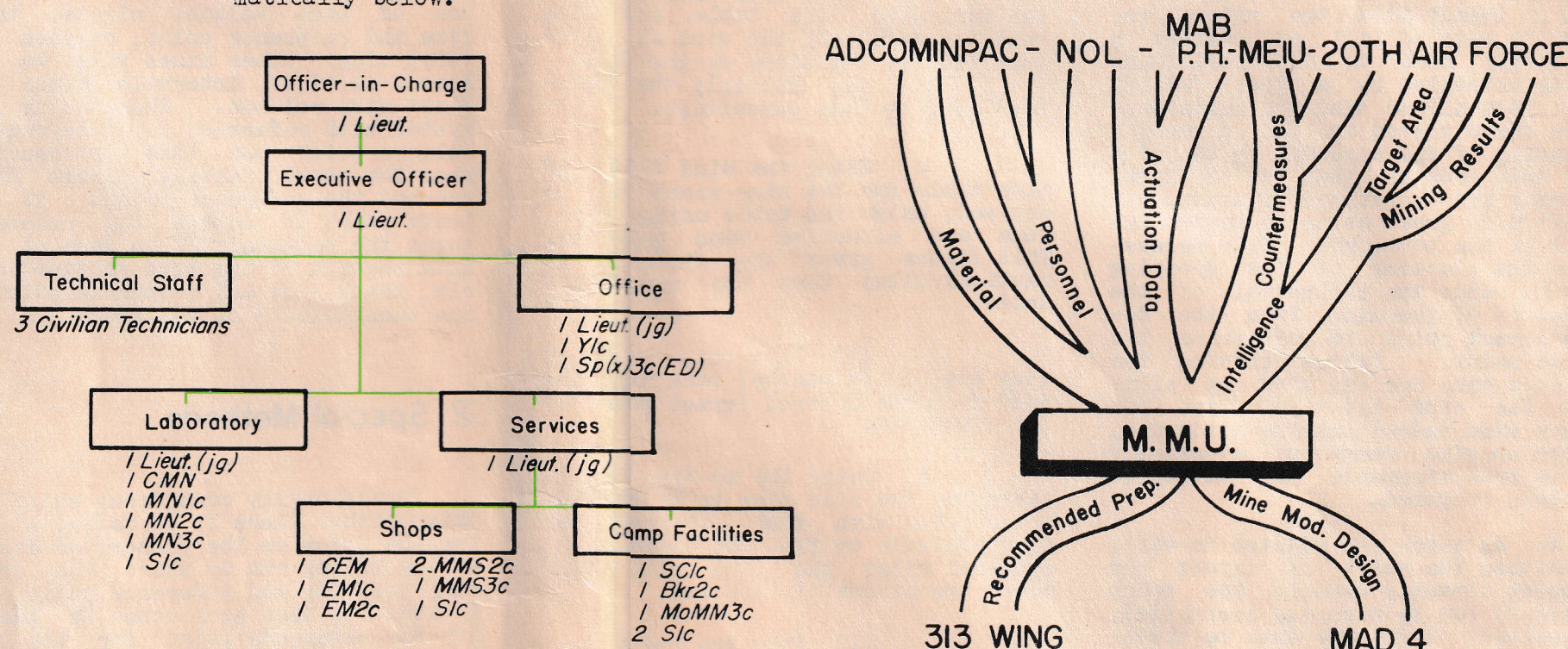
1. To develop and recommend modifications of existing mine mechanisms.
2. To recommend preparations of mines required to obtain maximum results against ships selected according to weighting factors provided by the XXI Bomber Command.
3. To assist the Mine Assembly Depot No. 4 in preparation of new mine modifications when necessary.

A large percentage of mines used in the "Starvation" missions have been modified mines. All mines laid in the first two missions (each a full Wing effort) were modified mines designed by the unit before its transfer from the Mine Assembly Base at West Loch (where it had functioned principally as a mine design unit) to Tinian. In the 4½ months of the program eighty percent of the mines planted in Japanese waters were mines modified according to the recommendations of the Mine Modification Unit.

The main purpose of the mining program of the Twentieth Air Force was to blockade enemy shipping. Methods included sinking or damaging ships, disrupting marshaling areas for convoys, denying the use of anchorages and harbors, forcing shipping into areas vulnerable to submarine or air attack, and incidentally, causing expenditure of enemy effort on countermeasures.

ORGANIZATION

The organizational chart of the Unit is shown below. The members of the technical staff were specialists from the Naval Ordnance Laboratory and it was their duty to design modifications and to make recommendations concerning mine sensitivities. The Unit's laboratory and shops offered facilities for testing new designs and for producing modified components for the Mine Assembly Depot No. 4. The Unit's relationship to other organizations while under control of the Twentieth Air Force is also shown diagrammatically below.



In order to accomplish these ends it was necessary to modify some mines. Modification did not necessarily mean improvement; it meant tailoring an already effective weapon for specific operations. The new mines had built-in tailoring devices; e.g., a switch allowed sensitivity adjustment by turning a knob; a hydrostatic switch automatically adjusted sensitivity with depth.

It was also necessary to furnish

the XXI Bomber Command with mine planting data. The Unit also assisted the Mine Assembly Depot No. 4 in producing modifications.

The urgency for new designs and the lack of facilities for tests in the forward areas made determinations of sweepability impractical. In order to make use of modifications at the time of their tactical demand, the Commander in Chief, U.S. Fleet, authorized the use of unsweepable mines that

were equipped with sterilizers. All mine modifications made at Tinian that altered actuation characteristics of the mine were considered unsweepable with available U.S. gear.

All modifications were developed for a particular need in a particular area and their indiscriminate use in

MINE MODIFICATION UNIT

other areas was neither recommended nor justified. The modifications were instigated by the XXI Bomber Command on the basis of intelligence information about enemy countermeasures and shipping, and by material shortages. Arming delays were provided for mines in which they were not previously available and mine firing mechanisms were modified to make enemy minesweeping more difficult. Athwartship firing characteristics of some mines were reduced in order to localize firing near a ship and thereby make each mine more effective. Some mine firing mechanisms were modified to allow sensitivity settings commensurate with the target. Existing mine components were adapted for new uses; and minor components, which were not available in sufficient quantities, were supplemented by substitutes designed and produced in the field to make more mines available for planting. Instructions for making modifications were furnished the Mine Assembly Depot No. 4.

Enemy Shipping

The principal purpose of mine countermeasures is to maintain clear channels through which ships may pass. Mines may be equipped with various devices that make sweeping operations difficult, time-consuming, costly, and to an appreciable degree, ineffective. These devices are principally arming delays, ship counters, and timing sequences within firing mechanisms themselves, all designed to defeat known sweeping methods. Many U.S. mines included these devices as standard features. Nevertheless, effective use of these various anti-sweep devices required their modification in some mines and their addition in others.

1. Arming Delays

Preparation of mines so that they would arm at various selected intervals after planting served to complicate enemy sweeping by requiring that even effective sweeping be continuous, and be making it unlikely that even continuous sweeping would render a mined passage completely safe. Generally, if a particular type

of mine was considered unsweepable by the enemy, delayed arming was not used. Although satisfactory arming delays had been included in the original design of the newer type mines, modification and installation of available delayed arming devices had to be made in older types.

The Mark 25 MM4 mine, a 2000-lb. acoustic mine utilizing the A-3 type firing mechanism, was provided with arming delays. Three methods were devised, the sequence being determined by the availability of the necessary components.

The first method utilized a British delayed arming device, the MK.III electric clock. This clock previously had been used in another U.S. naval mine having a similar electric circuit, and was available in limited quantity complete with mounting brackets. A minor modification was made to the mine case battery cover in order to mount the clock, and electrical cables salvaged from rejected mine mechanisms were used to connect the clocks into the mine circuit.

Shortly after this first method was adopted, the arming cell MK.2, a seawater electrolytic type delayed arming device, became available. It had a short, fixed delay period, but by changing the resistor in the cell, different operating times were obtained. This arming cell was then used for all short delayed arming periods, and its use conserved the British clocks for providing longer delays.

A third method was devised when the supply of British clocks was finally exhausted. The CP-14, an arming and sterilizing clock-delay mechanism, was used. A clock mounting plate (originally designed for another mine) and the battery cover plate of the mine case were modified so that the clock could be mounted, and salvaged electrical cables were used to connect the clock into the mine circuit. Connections, unconventional for this type of clock, were used to protect the mine from noise created by the operation of the

clock itself.

2. Mechanism Timing

In addition to the use of arming delays, some mine firing mechanisms were modified to defeat a particular type of sweep. An example is the M-9 Model firing mechanism, used in induction-type ground mines. When released by the Navy for service, the mechanism incorporated a feature that protected the mines from being swept by aircraft-type sweeps. This protective feature was a 3-second dead period that immediately followed the initial signal caused by a proper magnetic field charge. The firing mechanism was designed so that this period could be lengthened to 5.5 seconds merely by connecting a jumper between two external terminals.

Intelligence indicated that the Japanese were making extensive use of a permanent-magnet type sweep, with magnets attached to a submerged catenary. By lengthening the 3-second dead period to 10.5 seconds by means of a fairly simple internal wiring change, the effectiveness of this sweep was decreased 10 to 90 percent, depending upon the speed of the sweep and the distance off the bottom at which the magnets were dragged. A decrease in mine sensitivity accompanied this change in timing in most instances. Further reduction in sensitivity was desired for ship selection and to reduce athwartship firing; and by accomplishing this, even greater reduction in the efficiency of the magnet sweep was obtained.

A similar anti-sweep measure was added to the M-11 firing mechanism used in the Mark 25 Mod 0 magnetic mine. This mechanism originally had a protective or insensitive period (rather than a dead period) of about 1 to 6 seconds immediately following the initial signal. This period was increased by changing the time constant of one part of the electronic circuit, and this change was also accompanied by a desirable reduction in mine sensitivity.

That these anti-sweep

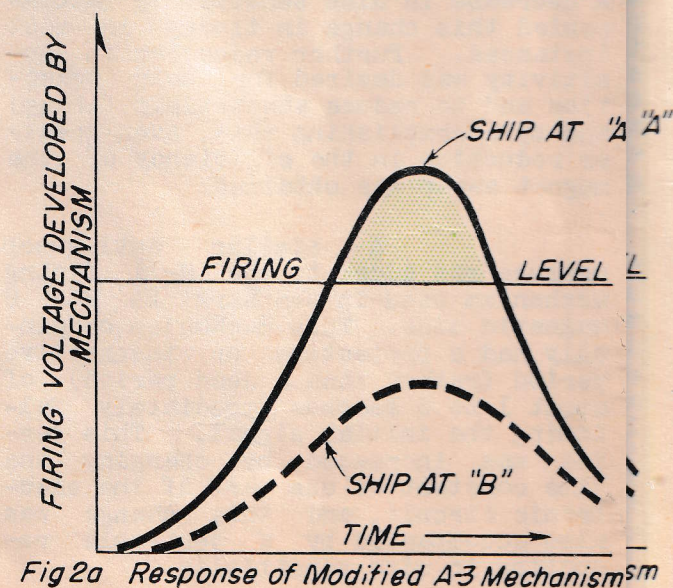
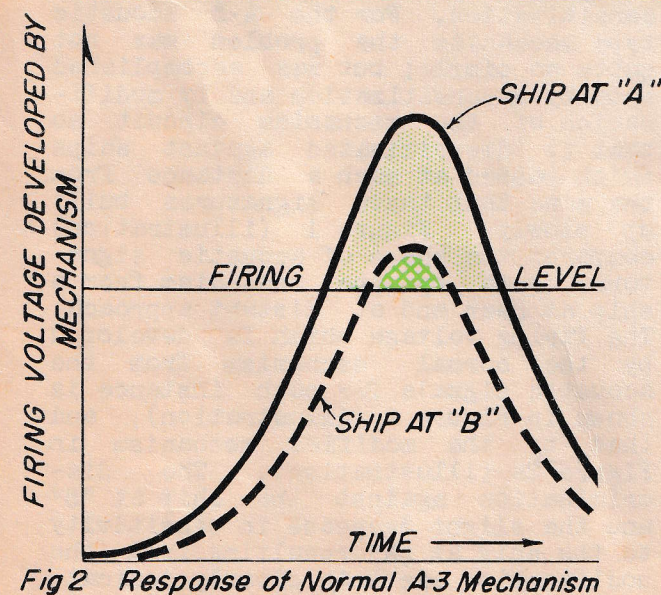
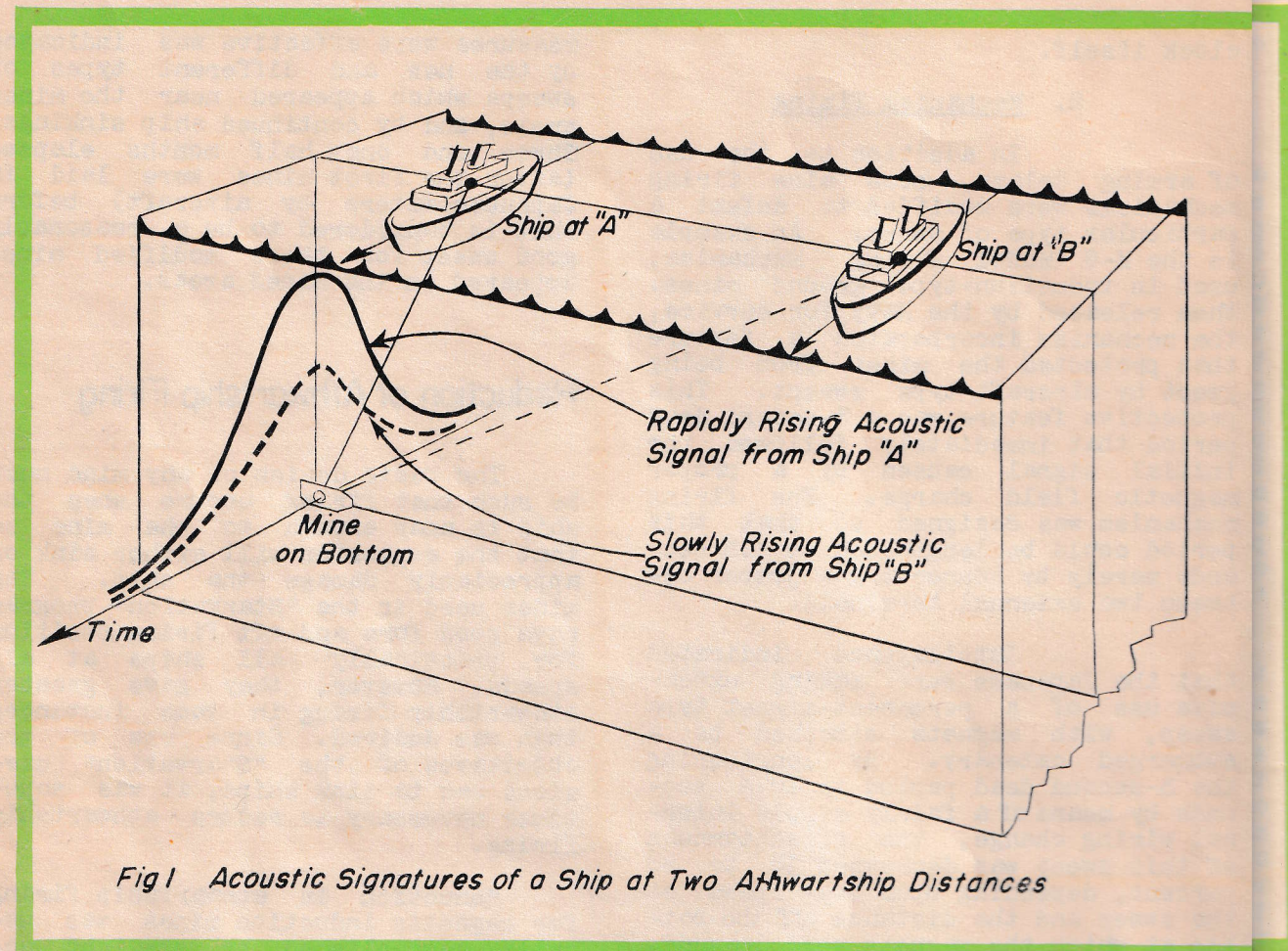
measures were effective was indicated by the new and different types of sweeps which appeared near the mined areas, and by continued ship sinkings. Three and one-half months elapsed (after the first mines were laid in Japanese waters by aircraft) before what is considered to be a reasonably good sweep for these modified mines appeared in the mined areas.

Reduction of Athwartship Firing

The basic design of any mine must be such that firing occurs when the ship is near enough to the mine so that the explosion will either sink or appreciably damage the ship. The mines used in the "Starvation" program gave good fore and aft firing position for practically all ships at all speeds. However, they gave greater athwartship firing in some instances than was desired. Since one of the objectives of the "Starvation" missions was to sink ships, it was sometimes necessary to reduce athwartship firing.

Reduction in athwartship firing for magnetic induction mines was usually accomplished by straight desensitization. For the A-3 acoustic type mechanism the problem was not quite so simple; but was accomplished both by desensitization and by modification of the mechanism circuit so that it discriminated against ships which passed at such a distance from the mine that their signatures built up slowly. Figure 1 (illustration) compares the shape of acoustic signatures seen by the mechanism from a ship at near and at distant approach. The firing voltage which is developed by the normal mechanism from the acoustic signals for each instance is shown in Figure 2 (illustration), and that by the modified mechanism in Figure 2a (illustration). The discrimination against the ship at "B" and the slight decrease in sensitivity to the ship at "A" resulting from the modification are both clearly indicated. This sensitivity effect was easily compensated for when desired.

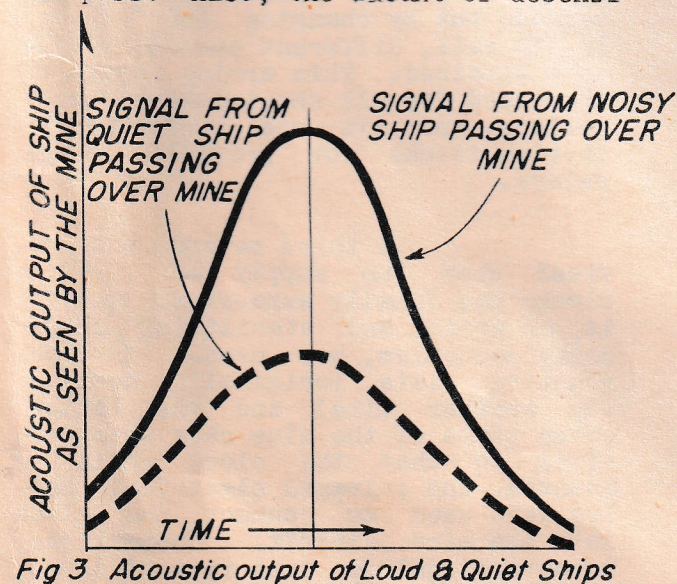
MINE MODIFICATION UNIT



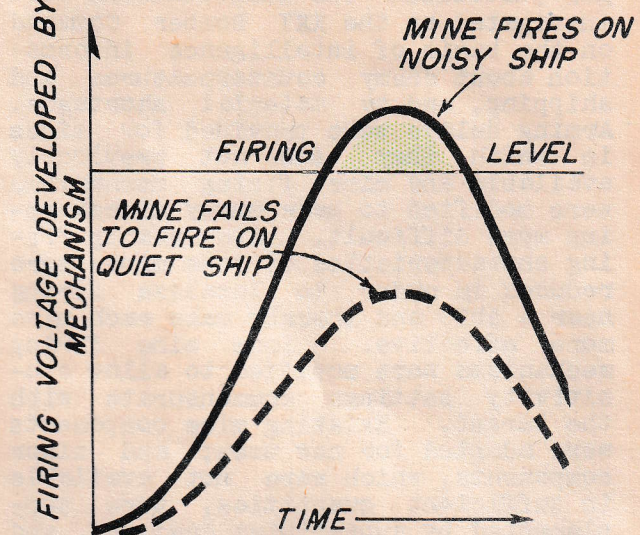
Selection of Ships

The selection of certain sized ships and the elimination of others, particularly the smaller classes, was necessary in order to sink a maximum tonnage of shipping with a limited number of mines. The apportioning of mines of various sensitivities to be commensurate with different types and sizes of ships was closely allied with reducing athwartship firing. It was usually a matter of making sensitivity adjustments. Most mines allowed this without requiring modification; but the A-3 Mod 1 MM-1 acoustic firing mechanism, for example, already modified to localize firing, needed further modification.

Large ships with diesel or reciprocating steam propulsion are usually accompanied by intense acoustic fields. It was possible to discriminate in favor of those targets and to eliminate firing by small ships in a manner illustrated diagrammatically in Figures 3 and 4 (illustrations). Figure 3 is a plot of two typical ship signatures as seen by the acoustic mechanism (or mine). Figure 4 illustrates the response of the desensitized (or modified) mine to these signatures. It is apparent that the mine fires on one ship but allows the other to pass. Also, the amount of desensi-



tization must be controlled to avoid missing both ships.



Alleviation of Mine Component Shortages

The Mine Assembly Base occasionally ran short of critical mine accessories during a heavy assembly program. In some of these instances the Mine Modification Unit assisted by adapting other components for use or by designing substitute parts. The effect of materiel availability on modification development has been illustrated in the discussion of delayed arming.

At one time a shortage of Mk. 3 Mod 3 parachutes in the Mk. 3 Mod 1 pack was anticipated. These were to be used on Mark 25 mines for a scheduled mining mission. Another 9-ft. parachute, the Mk. 3 Mod 2 in the Mk. 3 Mod 0 pack, was available in sufficient quantity but could not be attached to the Mark 25 mine with the regular adaptor. A special adaptor was designed and enough were made by the 50th Naval Construction Battalion on Tinian to insure that the desired number of mines would be available for that particular mission, in the event that the proper parachutes did not arrive.

MINE MODIFICATION UNIT

OPERATIONAL ANALYSES

The effective use of normal and desensitized or modified mines required full knowledge of the following:

1. Mine actuation data. It was necessary to know the effect of variables including mine sensitivity; depth of water; and the size, speed, and type of ships.

2. Target characteristics. It was necessary to have complete intelligence about enemy ships, their size, speed, power plants, and magnetic character.

3. Enemy countermeasures. Sweeping techniques could be developed for most mines, but with a knowledge of techniques in use, mine modifications could be made to complicate the enemy's sweeping effort.

4. Mining results. The degree of success of each mission had to

be known. If mines sank ships and mine fields prevented or retarded shipping, further modifications were unjustified. Practically all the modifications devised by this unit were prompted by reports of the XXI Bomber Command that observed or correctly anticipated a weakness in the minefields.

The XXI Bomber Command originally specified that narrow firing widths against all ships be maintained. Proper mine sensitivities then had to be selected so that this provision would be maintained for all Japanese merchant ships at reported sizes and speeds and for all depths of water in which the mines were to be planted. This selection was based upon actuation data available for normal and desensitized or modified mines.

The XXI Bomber Command specified at regular intervals the speed and percentage distribution of sizes of ships that were to be attacked. It was then necessary for the Mine Modification Unit to prepare tables giving the optimum distribution of mine sensitivities to be used at various water depths, in order to maintain localized firing near the ships and to make the best use of anti-sweep features.

It was realized that a more sensitive mine designed for a smaller or a quieter ship might be fired by a larger or a noisier ship too far athwartship to do appreciable damage, but the overall effectiveness of a mine-field was measurably increased by selecting mine sensitivities commensurate with the target.

ASSISTANCE TO THE MINE ASSEMBLY DEPOT NO.4

The development of new modifications necessitated going over from the laboratory test stage to mass production in a few days, and adequate testing of electrical modifications at times required test equipment not available at a mine assembly depot. The Mine Modification Unit had a modern electronics laboratory containing not only the standard mine test sets but also a wide variety of electrical test equipment of general utility. For these reasons it was advantageous for the Unit to produce and test modified mine accessories for the Mine Assembly Depot No. 4, even though this was normally a function of the Depot.

This work formed a large part of the effort of the Mine Modification Unit and was made possible only because of the very adequate laboratory facilities and the highly skilled petty officers assigned to the Unit.

MINE ASSEMBLY DEPOT NO. 4

MISSION

The mission of Mine Assembly Depot No. 4 was to provide assembled mines upon request, to fill operational requirements of either the Twentieth Air Force or Fleet activities. It was necessary to test individual components and complete assemblies carefully to insure that a maximum possible number of mines would be effective after laying in the Japanese waters.

ORGANIZATION

Mine Assembly Depot No. 4 had an authorized allowance of 11 officers and 162 enlisted men.

In order to expedite the work of the Depot, the organization was divided into two divisions. Division Number 1 was charged with the responsibility of testing mine components and with the assembly of mines. Division Number 2 was charged with the responsibility of maintaining all motor equipment, hauling, warehousing, and

delivery of mines and material, and the maintenance of all camp facilities. A complete organizational chart is shown below.

GROWTH

Mine Assembly Depot No. 4 landed on Tinian on 19 January 1945, and was composed of one J11A Component and one N2B Camp Component. The total complement was 4 officers and 72 enlisted men. The actual construction work was begun approximately 10 days later, and the Depot was ready to assemble mines on the 20th of February. The Depot began to assemble mines at the rate of approximately 70 mines per day on 1 March, when the first shipment of mines arrived.

Since it was necessary to prepare approximately 1900 mines in about 20 days for a Wing mining strike, the 2 officers and 15 men of Mine Detail 22 were ordered to Tinian. Also, 2 officers and 30 men of Mine Assembly Depot No. 5 were ordered to Tinian for duty.

Since none of the original personnel of Mine Assembly Depot No. 4 were familiar with the new A5 and A6 mechanisms and assemblies, 3 officers qualified in these mechanisms were sent out from the Naval Ordnance Laboratory, to join the Depot.

The Twentieth Air Force requested that the Depot be organized to assemble 4,000 mines per month, so additional personnel and equipment were requested from Commander, Administrative Command, Minecraft, U.S. Pacific Fleet. In compliance with this request, 37 men were ordered to Tinian from Mine Assembly Base, West Loch, along with 24 men from Mine Assembly Depot No. 2. When these men reported at Mine Assembly Depot No. 4, the complement was 12 officers and 171 men.

During this period, additional bomb trucks and trailers were required. The Depot started operations with 2 Bomb Service Trucks, 24 Bomb Trailers, and 2 OCT-9 Tractor Cranes. During the peak production period of nearly 150 mines per day, 12 Bomb Service Trucks, 60 Bomb Trailers and 6 CT-9 Tractor Cranes were in operation. The additional bomb trucks and trailers were obtained on "Memorandum Receipt" from Island Command, Tinian, and the additional cranes were obtained as follows: 2 from Commander, Administrative Command, Minecraft; 1 from Mine Assembly Depot No. 5; and 1 from Mine Detail 22.

At the peak of production the personnel of the Depot were working in the following departments:

Mine Assembly Number 1	30
Mine Assembly Number 2	30
Sub Assembly	15
Mine Hauling	9
Revetment Crews	17
Warehouse and Supply	7
Camp Maintenance, Truck Drivers, Security, etc.	46
Galleys	15
Administration	3
Total	171

OPERATIONAL PROCEDURE

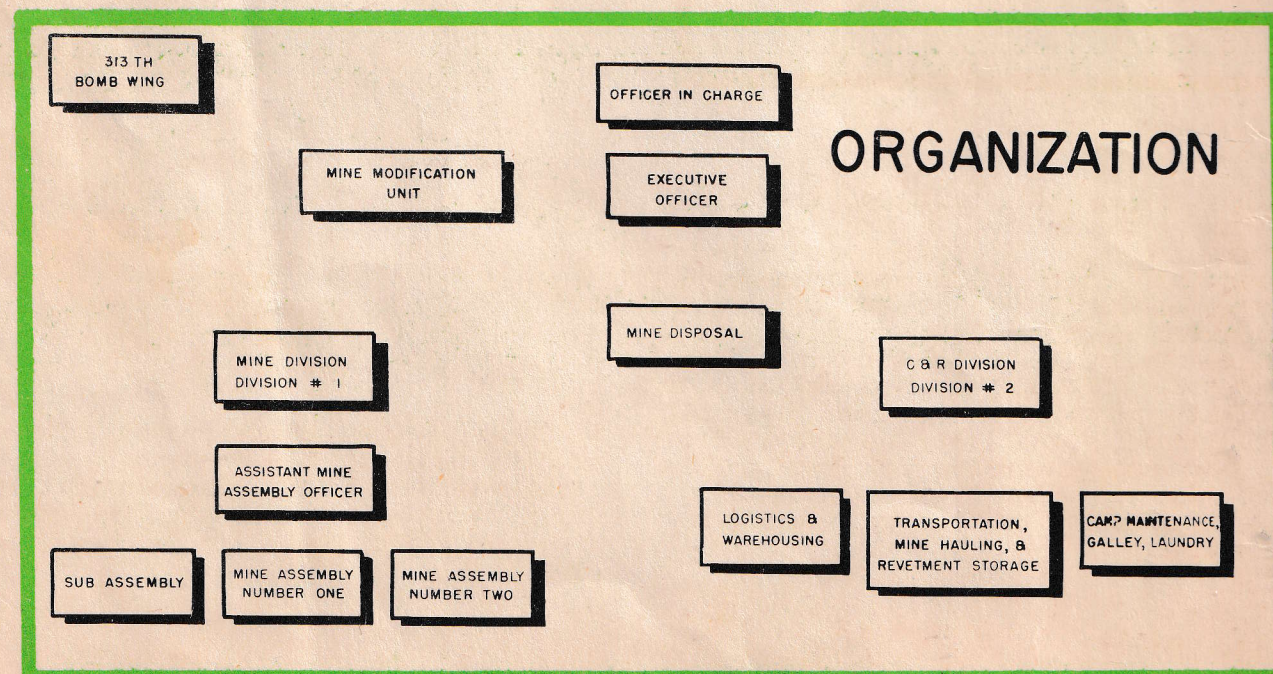
All mines and mine components shipped to Tinian were unloaded and delivered by the Island stevedore and transportation facilities. All inert components were delivered directly to the Depot and unloaded and warehoused by Depot personnel. All mine cases were delivered to the Army's Masalog Bomb Dump and unloaded into revetments by Army Ordnance personnel.

The Mining Section of the 313th Wing requested that mines be assembled in accordance with a detailed Mine Assembly Order. The Depot then took steps to assemble the mines using the procedures outlined below. Frequently, these orders were given to the Depot before the ships carrying the mines arrived in the Marianas, and it was necessary to work with the utmost speed and efficiency to meet the operational schedules.

The Depot's mine-handling crews loaded the mines on trailers and hauled them to the two assembly buildings. The mines were assembled on the trailers to eliminate extra handling. Four 1,000 pound or two 2,000 pound mines were carried on each Mk 3 Navy Type Bomb Trailer. Previously tested mechanisms and components were issued to the assembly buildings from the sub assembly building.

After the mines were completely assembled and tested, detonators were installed and the cases stenciled with a proper code which covered all details of assembly; e.g. delay arming, sterilization time, etc. Then the finished mines were hauled to the Depot's ready revetments for storage prior to issue to the Wing.

The mines, parachutes, release mechanisms, and delay arming washers were issued to the Army Ordnance crews of the various groups of the 313th Wing. The Wing provided all handling facilities and a portion of the loading and handling equipment, when draw-



MINE ASSEMBLY DEPOT NO. 4

ing mines from the Depot. The Ordnance crews installed flight gear on the mines and loaded them into the planes.

COMMAND RELATIONSHIPS

The command relationships are indicated in the accompanying diagram. Very close liaison was maintained by the Depot with the 313th Wing and with Headquarters, Twentieth Air Force. The Officer in Charge or his representative made a weekly trip to Guam to confer with the Twentieth Air Force Mining Section on any problems or difficulties encountered during the previous week.

SUPPLY & LOGISTICS

All mines and major components were requested by the Twentieth Air Force and Commander Marianas, hence the Depot was not confronted with the principal supply or logistics problems. However, the Depot kept close check on material being shipped from the States to insure that all necessary components were included. Upon several occasions it was only through this close check that operational schedules were met; at times an item being shipped in insufficient quantities had to be supplemented by a requested air shipment.

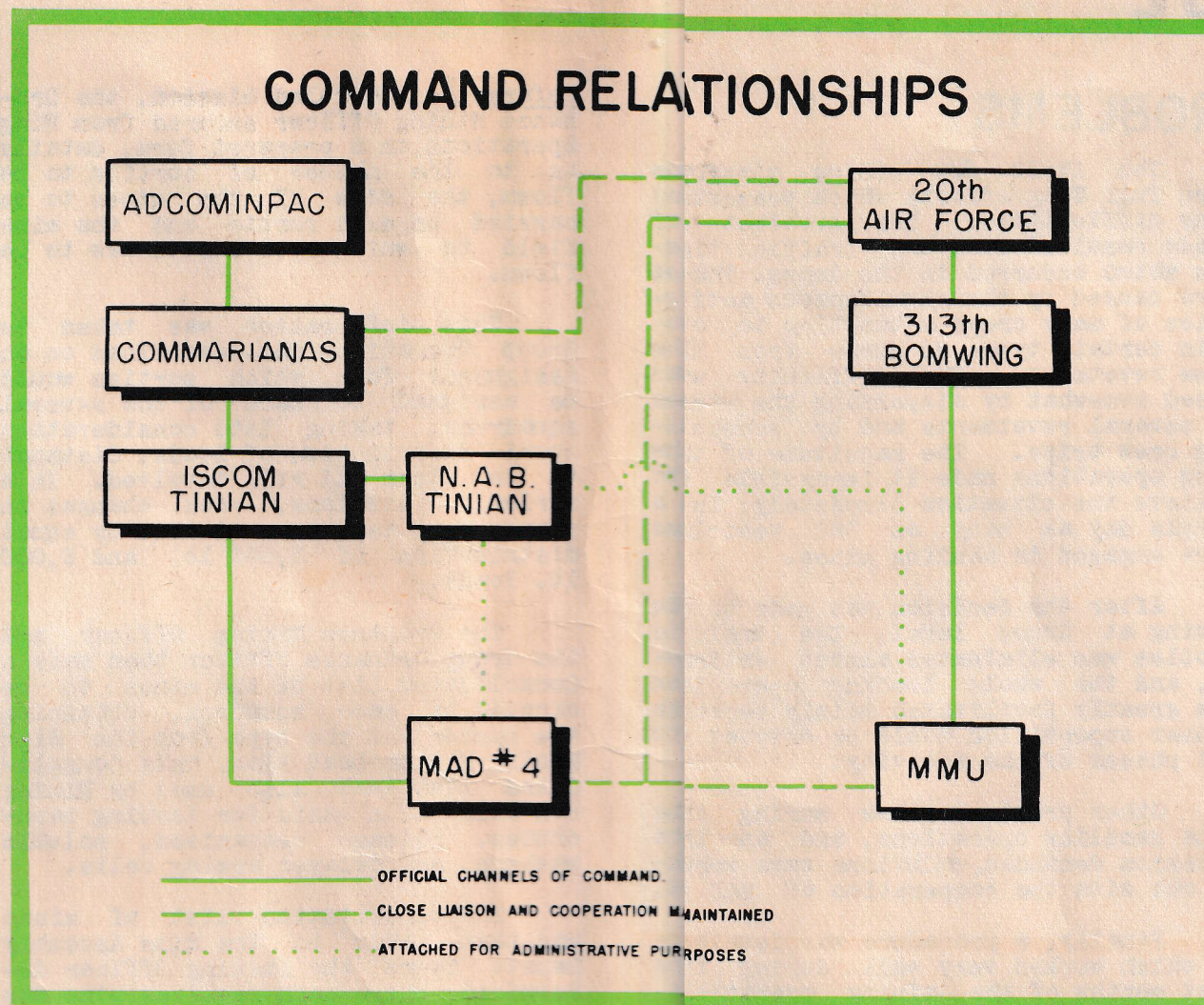
TECHNICAL READINESS

The Depot had personnel qualified in the assembly, testing, repair, and adjustment of all mines and mine firing mechanisms. A J4B Mine Disposal Unit was attached to the Depot for emergency disposal of assembled mines after airplane crack-ups, etc.

DEVELOPMENTS

Developments or required modifications of mines or mine components were furnished the Depot by the Mine Modification Unit.

COMMAND RELATIONSHIPS



COMPARISONS

It is not possible to make an accurate comparison of the operations of the Mine Assembly Depot No. 4 with those of any other mine depot, either in the United States or in any foreign country. However, it is believed that the total of 13,000 mines of all types assembled during a five-month period exceeded the peak production of all U.S. mine depots combined during an equivalent period of time.

In addition, it is understood

that during the heaviest minelaying done by the British, a total of 7,000 mines were laid in a three-month period. It is probable that these mines were assembled at a number of depots located throughout the British Isles. Accordingly, it is believed that Mine Assembly Depot No. 4 established a world's record for sustained assembly of large quantities of mines, with a peak reached during the two months of June and July, 1945, when a total of 7,225 mines of various types were assembled.

RATE OF PRODUCTION MINES PER DAY

Month (1945)	Mines Per Day
March	109
April	120
May	130
June	142
July	135

MINES ASSEMBLED PER MONTH

Month (1945)	Number of Mines
March	1900
April	1700
May	2125
June	3975
July	3300

Total Production as of July.....13,000

MINES ON HAND

Week	Number of Mines
16 April	127
23 April	965
30 April	1692
7 May	280
14 May	292
21 May	764
28 May	767
4 June	2067
11 June	2304
18 June	1771
25 June	1458
2 July	376
9 July	712
16 July	1558
22 July	865

* These figures cannot present a true picture since, in some instances, mines were received and expended in fairly large quantities between the days shown on the graph.

WING ORDNANCE

MISSION

The mission of Ordnance in the mining activities of the 313th Bombardment Wing was to transport mines from ready dumps to the line, to distribute them to aircraft, attach parachutes, install soluble washers or arming cells, and, in conjunction with Armament, to load the mines into the aircraft so they would drop in the sequence called for in the Field Order.

ORGANIZATION, TRAINING

In order to accomplish the mission expeditiously, one Ordnance Officer and two enlisted men, all mining specialists, were assigned the responsibility of coordinating all Wing Ordnance functions. All Ordnance and Armament personnel had to be trained in the handling of mines and in the techniques of preparation for loading (attaching parachutes, correctly orienting the parachutes, and installing washers). This training was given in a period of three weeks and was administered by the Wing Ordnance Mining Officer. The course was of necessity brief, and only absolutely essential information was stressed at the time, because the Wing was then engaged in an all-out incendiary blitz operation against the Japanese Empire. Stress was placed especially on careful handling necessitated by the sensitive nature of the Torpex filler used in many of the mines.

It is significant to note that mine handling and loading was different and more complicated than the handling and loading of bombs. Each separate mine, selected from among 200 different types, had to be loaded on a specific bomb station in a particular airplane, in contrast to bomb loading in which bombs are loaded in any bomb station in any airplane. Nevertheless with proper organization it was possible in the later stages of the mining operation to "Mine up" a bomb group just as rapidly as it was possible to "Bomb up" the same group.

PROBLEMS

The first few mining missions were full Wing efforts which presented many difficulties. The greatest of these resulted from the traffic tie-ups which occurred in the dumps. These were caused by the simultaneous activities of many crews attempting to obtain certain types of mines from the same revetment. The difficulty was eased somewhat by dispersing the mines to several revetments and by scheduling crew trips. The magnitude of the Wing operations made it impossible to relieve the situation completely; in a single day as many as 360 vehicles were engaged in hauling mines.

After the decision was made to do mining at Group level, the traffic problem was eliminated almost entirely, and the whole loading operation was greatly facilitated mainly because closer supervision could be devoted to all phases of the activity.

Other problems arose during the mine handling operations, and as the occasion demanded, solutions were worked out with the cooperation of MAD 4.

Finally, a procedure was developed which worked very well during the last months of the mining operation. It is believed that this procedure or a system organized along similar lines would serve advantageously in any future mining operations.

PROCEDURE

The procedure which was finally developed was devised for hauling and loading mines for a B-29 Group. It was based on the premise that approximately 30 sorties would be flown every two days. Careful planning and close liaison with Wing Operations, Group Operations, Group Ordnance, Group Armament, and the Mine Assembly Depot were vital to successful operations. The procedure operated as follows:

Early in the morning of the day

before the scheduled mission, the Ordnance Mining Officer secured from Wing Operations, on a prepared form, details as to the number of sorties to be flown, the size of the mines to be carried on each sortie and the mine field to which each sortie was to be flown.

This information was taken to Group Operations who determined on an Assignment form, which sorties would be assigned to each of the several squadrons, taking into consideration equal distribution of loads, distance to be flown and risk involved. In a series of missions, rack changes in planes were kept to a minimum by equal distribution of 1,000 lb. and 2,000 lb. loads.

The Ordnance Mining Officer and the Group Ordnance Officer then made a Consolidated List of the mines to be carried by each squadron, obtaining the number and the type from the Wing Mining Master Load Plan. This Consolidated List was also used by Mining non-coms as a basis for issuing parachutes, release mechanisms, soluble washers, and delayed arming cells.

The consolidated list of mines was then taken to the Mine Assembly Depot. There the Issuing Officer determined where each required mine was stocked and made revetment assignments. Issue Cards were then made up from the Consolidated List plus revetment assignments. Each Issue Card contained the exact type and quantities of mines to be drawn by one Ordnance crew (a load for one M6 BST and two M5 trailers, or one M-27 BST and one M5 trailer).

Each squadron was assigned a time schedule to report to the mine ready dump to draw its mines. Simultaneously, the Squadron Ordnance Officer was given the Issue Cards for the mines his crew were to load. He in turn assigned one Card (or load) to each of his crew chiefs who proceeded to the assigned revetments and drew their mines. A triple check was kept on

each load by requiring the crew chief, the crane operator, and the sentry at the exit gate to certify that the exact mines called for on the cards were drawn.

The mines were then hauled to the flight line in the squadron area.

At a specified time during the day before the mission, each Squadron Ordnance Section drew in bulk all parachutes, release mechanisms, soluble washers and delayed arming cells required for preparing its mines for loading on the following day. At the same time the Squadron Ordnance Section was given an Instruction form for the use of these accessories. The form gave the size of the parachute for each type of mine, the color of the proper soluble washers to be used in each type, and all other information considered necessary. The form was intended as a ready reference and was used to avoid any confusion or error caused by misunderstanding.

In the meantime, Group Operations had assigned planes and air crews to each sortie, and Armament had changed any racks necessary in each aircraft to carry the size of mines specified in the assigned sorties.

At the close of the day before the mission, all mines and accessories were on the line, aircraft were assigned to sorties, and planes were ready for mine loading.

Early in the morning on the day of the mission, an individual Mine Loading Plan was given to each Ordnance crew. This plan contained the size and code numbers of the mines for a particular sortie. The Ordnance crew then obtained the necessary mines from the squadron area on the line and hauled them to the assigned aircraft for loading.

The Armament crew chief of the aircraft then checked the loading plan for dropping sequence, chalking the rack number and location of the bomb

WING ORDNANCE

station on the mine and entering this information on the Mine Loading Plan. The Ordnance crew then attached release mechanisms and parachutes, inserted soluble washers or delayed arming cells as necessary, and delivered the mines under the bomb bay. Armament crews hoisted the mines to the correct bomb stations; Ordnance attached the static lines, and the aircraft was ready to takeoff.

Sheet No. 1 of the Mine Loading Plan was given to the bombardier who indicated after "Mines Away" the actual sequence in which they were dropped. The bombardier returned the sheet to the Wing Ordnance Office where it was filed for reference.

LESSONS

Certain lessons were derived in the mine handling operation. Since future mining operations may again involve the use of inexperienced and untrained personnel to handle mines, some suggestions as to the manufacture of mines are presented here for consideration. It is believed that if all or some of these suggestions are heeded, training in mine handling can be greatly facilitated and the chances of malfunctions because of incorrect preparation can be minimized or eliminated to a great extent.

1. Parachutes should be uniform in manufacture, at least as far as external appearance is concerned. In particular, the pouch containing the static cord should be located in the same position on all packs (for ease in orientation).

During the loading of the mines a constant inspection was maintained by the Wing Ordnance Mining Officer.

To insure the correct loading of the mines the completed job required checking and certification by the Armament Crew Chief, the Ordnance Crew Chief and the Squadron Ordnance Officer on the Mine Loading Plan sheets 1 and 2, and the Ordnance Check-off List for mine loading.

The procedure as described was subject to modification to suit the size and timing of the operation. The general principles proved to be very successful and resulted in the least possible confusion during mine loading and handling.

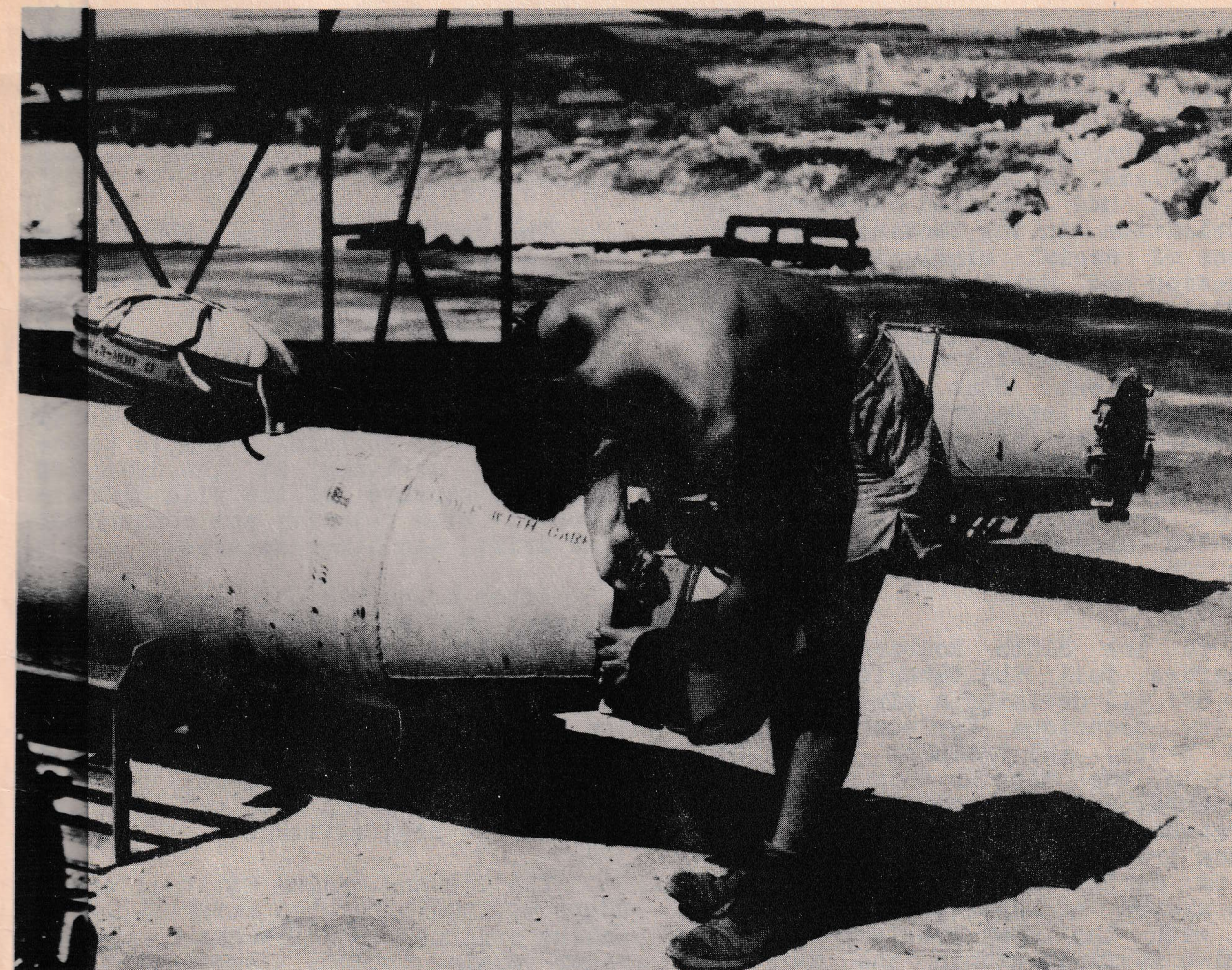
2. Clock starter and extender wells should be located in the same position in all mines.

3. Clock starter and extender mechanisms should have the same external appearance and should have the same type covers (to eliminate confusion and difficulty in removing one type and replacing another type after washers are installed).

4. Clock starter and extender mechanisms should be color-coded (for easy identification).

5. All soluble washers should be of the same size.

6. All retaining nuts for soluble washers should be of the same size, and the stems of the mechanisms should be uniform in size and threading.



A TYPICAL ORDNANCE OPERATION

Attaching parachute release mechanism. This releases parachute from mine when it hits water and drags the chute below the surface.

WING OPERATIONS

BACKGROUND

The initiation of the aerial minelaying operations assigned to the 313th Bombardment Wing posed a number of problems. Although the cadre of the Wing had received a general indoctrination in the tactics and techniques of aerial minelaying, the instruction had not been implemented by sufficiently detailed and actual training to permit the immediate undertaking of precision radar minelaying operations. What would normally have been a straightforward problem was complicated by the fact that no simple low altitude minelaying tactics especially suited to the B-29 and its combat crew had been devised at the time the decision was made to undertake the mining of Japanese home waters.

To the 313th Bombardment Wing, therefore, fell the threefold assignment of: (1) devising a simple but effective technique for planting mines from B-29s; (2) training all combat crews in the Wing in this minelaying procedure, and concomitantly training all ground ordnance and armament crews in the preparation, handling and loading of aerial mines; and (3) setting up a system of operations that would deal with the many problems peculiar to mine warfare within the existing operations structure of the Wing organization. How this assignment was initially accomplished and then further modified as mining operations progressed is described below.

MINELAYING TECHNIQUE

It is well to point out before considering the tactical factors involved in minelaying, that the mining problem differed from the bombing problem in two basic respects: (1) Aerial mines used in B-29 operations were equipped with parachutes which retarded their rate of fall and caused them to drift with the wind in their fall to the target, and (2) the point at which a mine is aimed is by nature

in the water, and therefore can only be determined with reference to nearby land-water boundary aiming points. Both of these particulars ruled out the use of a visual bombsight, and pointed to the use of radar as the logical solution to the problem.

The original mining program directive from the XXI Bomber Command (Twentieth Air Force) to the 313th Bombardment Wing, dated 26 January 1945, directed that altitudes between 200 and 30,000 feet be used for training flights in minelaying. This extreme range in altitude complicated the problem of devising a simple technique for arriving at the dropping position, because of the wide differences of wind velocity and consequent mine drift, and other factors.

After a number of experimental missions had been flown, it was found that certain compromises had to be made. Consequently, it was decided to develop a straightforward technique for dropping mines accurately at approximately 5,000 ft. altitude, and then to use a more or less complex system for adapting this technique to dropping at high altitude.

The low and medium altitude technique adopted consisted essentially of making a course good towards or over a radar aiming point, releasing the first mine when at a pre-determined slant range (forward or backward) from the radar aiming point, and releasing the remaining mines on a timed run from the first release position. (This technique is illustrated in ANNEX B.) Wind drift of the mine could be neglected because it was of the same order of magnitude as radar navigational errors at the altitudes being used. In the case of high altitude minelaying, however, provision had to be made for computing the wind drift of the mines, which in many cases would be several miles. The final system adopted for making this wind drift computation and then carrying out the desired corrections is outlined in the Tactical SOP for minelaying (ANNEX B).

When actual minelaying operations were undertaken, it was found that, as had been anticipated, enemy opposition was not too great, so the necessity for employing a high altitude technique was completely eliminated. At the same time, the heights of surrounding terrain in the vicinity of most of the mining targets ruled out very low altitudes of attack. As a result of these factors and of detailed analysis of enemy AA capabilities, the mining altitudes most frequently employed quickly centered between 5,000 and 8,000 feet. After extensive experience in this altitude region, the Tactical SOP for minelaying was rewritten to refine the older method directed in the original SOP and to eliminate the considerations that no longer applied. (The original SOP formed the basis for all except one mission against the enemy.)

TRAINING

A small amount of flight training was given to selected crews of one Group while a fundamental minelaying technique was being evolved between 27 January and 8 February 1945. In order to determine the minimum training requirements for normal combat crews, it was thought best to indoctrinate also one crew from each Group in the technique adopted; this was carried out between 13 and 28 February 1945. On the basis of the results obtained by these crews, it was decided that one training flight would be adequate for each combat crew to learn a satisfactory medium altitude technique, provided sufficient ground training preceded the flight.

The entire month of March up to the date of the first mission was then devoted to an intensified ground and air training program in mine warfare. Lectures and movies were presented in each of the Bomb Groups, not only on subjects of general minelaying interest, but also on basic radar techniques applicable to the mining problem. At the same time, training in mine preparation and loading was given

to bombardiers and to ordnance and armament ground crews. Flight training lagged initially, but then increased in intensity during the final week, so that on the eve of the first operation scheduled on 27 March, all combat crews had been trained and the four Bomb Groups were prepared to undertake the largest scale operation of this type ever attempted.

OPERATIONS

The tactical planning for the first and subsequent mining missions was carried out by the 313th Bombardment Wing, using basic directives from the XXI Bomber Command (the Twentieth Air Force) specifying the dates and areas of attack, approximate numbers of sorties and density of minefields, mine settings, and general limitations on the altitude of attack.

Experience gained in previous low level incendiary attacks on Japanese cities provided a rough guide to the scheduling system that would most probably saturate enemy defenses in night operations. However, other problems peculiar to minelaying had yet to be solved. For one, it was necessary to pin-point each string of mines in a location of proper depth, with a distribution of mine types in the string suited to "catch" a maximum number of ships. Also, it was necessary to spread the mines over as large an area as possible in order to complicate enemy countermeasures. Further, because of the radar problem involved and the high degree of accuracy sought, it was necessary to have a prominent radar aiming point along the axis of attacks for each string. Finally, the most favorable axis of attack would have to be selected so that the string of mines would present a maximum threat along the direction of ship movement, and, at the same time, so that the aircraft planting the strings would be subjected to minimum danger from anti-aircraft defenses and surrounding terrain.

From the outset it was apparent

WING OPERATIONS

that all aircraft within a given area at the same time would have to be moving in the same general direction. This narrowed down the basic tactical plan to either of two alternatives: (1) Selection of an IP approximately 30 miles from the area to be mined, and scheduling all aircraft through this IP on slightly different axes of attacks, so that they would "fan out" over the minefield, or (2) selection of the most favorable axis of attack, using this axis for all aircraft, and then computing coordinate turning points (or individual IP's) separately for each aircraft. Both of these methods were tried by different forces in the first minelaying mission. It was found that the second method proved far more difficult than the first from the viewpoint of both planning and tactical execution, and at the same time offered no advantages over the first method. Therefore, for subsequent missions, the method involving a single IP and individual axes of attack from this point was adopted as SOP.

The differences involved in mining and bombing missions also called for additional methods of specifying aircraft loadings and of briefing combat crews for minelaying beyond those normally used in bombing operations. Each mine setting had to be tailored to the area in which the mine was to be planted. This meant that each mine would have to be prepared properly by the Mine Depot, loaded in the proper station in the bomb bay of the aircraft and then released at the precise moment in the mining run so as to land in the briefed position on the sea bottom. The method devised for assuring the proper execution of this sequence is outlined here briefly.

Following the general directives of the XXI Bomber Command, the Mining Section of the 313th Bombardment Wing made a preliminary design of each minefield in order to determine the settings required on all the mines to be laid. On the basis of this design, a Mine Assembly Order was issued to the Mine Depot, and if necessary, a Mine Modification Order to the Mine Modification Unit, ordering the assem-

bly of the exact numbers of mine types desired and specifying the delivery date. To simplify handling and recognition of prepared mines, a code was used for specifying mine preparation, and each prepared mine was stenciled with its proper code number before being issued to ready storage. When an adequate supply of mine types was assured, the Mining Section of the Wing then designed each minefield and prepared for each aircraft taking part in the mission, two types of data: (1) A Mine Loading Plan for the use of the Group Ordnance and Armament personnel in obtaining the proper mines from ready storage and then loading them in a specified dropping sequence in the aircraft, and (2) a navigator's Minelaying Chart, showing the exact position for each mine to be planted, the radar aiming point, axis of attack, and all other data for making the mining run. These loading plans and navigator's charts were then transmitted to the minelaying Bomb Group for distribution to the armament personnel concerned, and for use in specialized navigator and bombardier briefings. Additional data for operations officers and for the general mission briefing, as well as a master loading plan and composite minefield charts, were then transmitted to the Group in the form of a Wing Field Order. (For additional details outlining these operational relationships, see ANNEX E.)

This technique, in essence, formed the basic operations scheme used in all minelaying operations by the 313th Bombardment Wing. As experience was gained in planning missions, and as the emphasis changed from infrequent minelaying by the entire Wing to sustained operations on a Group level, various refinements in the system were introduced. In the latter series of operations, the planning reached a fairly fixed schedule which is outlined briefly as follows.

For sustained Group efforts, basic directives were issued to the Wing by the XXI Bomber Command (Twentieth Air Force) at approximate intervals of one month, and modified intermittently as intelligence on enemy reactions was obtained. A long-range

planning schedule was laid out on the basis of this directive by the Wing Mining Section, which specified the minefields to be mined on each date and the number of aircraft to be assigned to each minefield. A Mine Assembly Order for one month was then prepared from this plan and given to the Mine Depot, along with a schedule of preparation requesting the completion of mines for each planned mission at least 48 hours before the take-off time scheduled. About 80 hours before take-off time, a planning meeting was held between the Wing Mining Section and Group Operations; at this meeting the minefields and number of aircraft assigned to each field was given to the Group, and the IP and other data for each minefield was decided upon. Following this meeting, the Group planned the route and transmitted it to the Wing A-3 while the Wing Mining Section made the final minefield design and prepared the loading plans and navigators' charts. About 48 hours before take-off, a tactical brief was submitted by the 313th Wing to the Twentieth Air Force and to other Wings stating the time, route, number of aircraft, number of mines to each field, and other data pertinent to the mission. Then at 36 hours before take-off the hauling of mines from ready storage to hardstands began and at 12 hours before take-off, loading of the aircraft and specialized briefings were initiated. Thus, aircraft and crews were readied in ample time for the mission. In all other respects, operational procedures were very similar to those employed for bombing missions.

The schedule described above was found to offer maximum flexibility for last minute changes, and at the same time gave sufficient time allowance for accurate, detailed work.

REPORTING

Assessment of results and data for future minesweeping operations could only be made if accurate knowledge of the positions of all mines was obtained. For this reason, an SOP was set up at the very outset for taking radar scope photographs during each

mining run, which were later used for plotting the release position of all mines dropped. Where such pictures were not obtained, navigators were interrogated for all information relating to the dropping position. The tactical mission reports then included a section for mining specialist information which contained plots of all mines planted in primary targets, and coordinates of all those either jettisoned or planted in alternate fields, together with additional information required by the Assistant Chief of Air Staff, Intelligence, Hqs. AAF.

CONCLUSION

On the basis of the experience gained in this series of mining operations, it was found that a Heavy Bombardment Wing could be readily adapted to aerial minelaying with the addition of a small section of specialized mining personnel, who could train operations, ordnance, armament and combat crew personnel of the Wing and its Groups in general minelaying techniques, and then handle the detailed work peculiar to mining operations. It was further found that minelaying, when properly organized and scheduled, could be carried out at just as efficient a rate as bombing, notwithstanding the more complex nature of the mining problem.

PSYCHOLOGICAL WARFARE

Early in the mining operation, Twentieth Air Force planning conceived the idea of a psychological warfare campaign designed to drive home to the Japanese people the spectre of starvation implied in the mining blockade.

Plans were made for the preparation and dropping of propaganda leaflets which would capitalize on the mining operation and help further to reduce the enemy will to fight on. The plans however, met with opposition, and the Psychological Warfare Section of this theater was not permitted to undertake the project.

The refusal was based on the grounds that there was no precedent for an open propaganda campaign built around a mining operation. In the past, secrecy was one of the factors which contributed to the success of a mining campaign. Aerial mine fields had been laid for the most part either as attrition fields in which it was hoped the enemy would sustain ship losses before he discovered the presence of mines in the area, or as small fields laid in support of tactical operations which would follow immediately. In either case, the less the enemy knew of the mining, the better.

However, the unique type of strategic blockade undertaken in the Twentieth Air Force mining operation, posed an entirely new set of conditions. Secrecy was no longer a factor. Our first accounts of our own mining operations actually and invariably came from translations of Japanese home broadcasts (since our mine laying aircraft observed radio silence during the mission). These broadcasts were accurate move-by-move descriptions of the minelaying aircraft from the time they approached the islands of Japan until they were well on the way back to the Marianas.

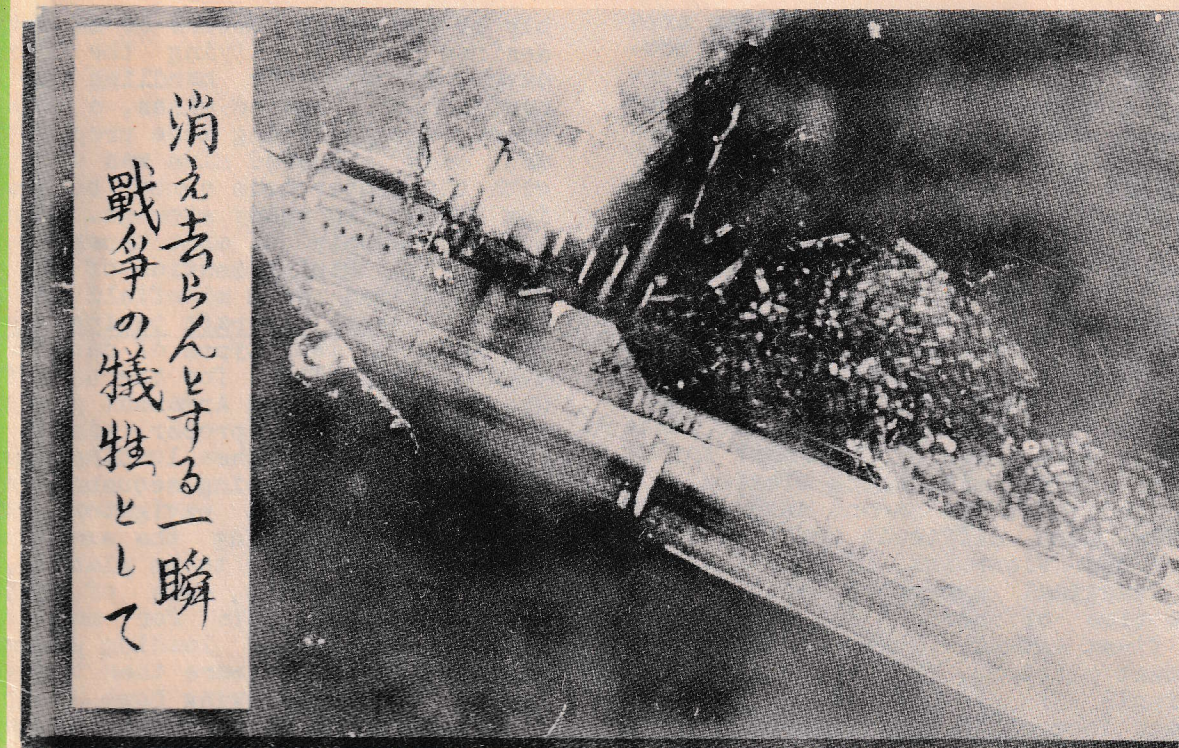
The very objective of our strategic mining blockade was an additional factor which made secrecy pointless. It was to our advantage strategically to make the enemy fully aware of the location of our mine fields. The

knowledge would deter him from risking his ships in dangerous waters; they would remain bottled up in their anchorages and an immediate blockade would be achieved.

Permission to launch the proposed psychological warfare campaign around the mining operations was finally granted as the result of a letter addressed on 29 May 1945 by the Commanding General, XXI Bomber Command, through channels to the proper authorities. This letter pointed out the desirability of explaining the implications of the mining blockade to the uninformed Japanese civilian, with the aim of lowering ebbing enemy morale even further. Permission was asked to emphasize these points:

1. That Japanese food supplies were rapidly being depleted by our fire raids.
2. That it was impossible for the Japanese homeland to raise and distribute enough food to sustain its population.
3. That adequate imports of food were now impossible because of the minefields planted by B-29s in all the harbors and shipping lanes of Japanese home waters.
4. That because of their government's insistence on running ships through the minefields in order to feed iron and coal to the war machine, a high rate of shipping losses was being sustained.
5. That if this loss was maintained much longer, it would be impossible to feed Japan's hungry people even after peace had been obtained, because of a lack of ships.
6. That finally, if the present policy continued, the whole Japanese nation would face inevitable and inglorious starvation.

The Psychological Warfare Section of CinCPac, working in close coordination with the Mining Section of the Twentieth Air Force accordingly pre-



Propaganda Leaflet Serial Number 2096

This is the first of the series of propaganda leaflets dropped on the Japanese Homeland which make specific use of the B-29 Aerial Mine Blockade, of the Japanese Empire.

Photo Caption: Casualty of war. The moment before sinking.

Text Caption: VANISHING TREASURE SHIPS.

Text on Reverse Side: One of the excuses the militarists gave you for beginning this war was that it was essential to ensure the supply of food from overseas. And so you have been at war for many years. Now, however, the militarists are saying that your food supplies have sunk to an unprecedented low, and that, in the future, food rations will become smaller and smaller. The militarists are, however, concealing the fact that their blunders are sacrificing the people of Japan.

What has happened to the ships which in peacetime transported provisions to Japan? Many ships carrying war materials have been sunk by American submarines and planes. Moreover, the B-29s have laid mines in the various harbors and coastal waters. "A new threat to shipping has thus been added."

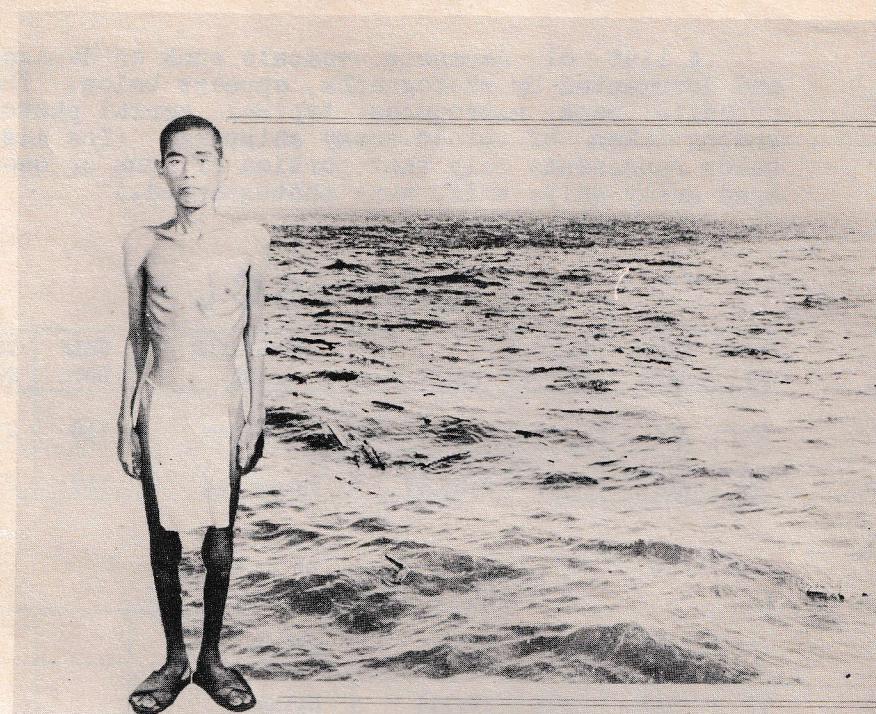
How long will you allow the militarists wantonly to drive the people of Japan to starvation?

pared a series of four propaganda leaflets on the subject of mine warfare. Four and one-half million of the first three leaflets were dropped widely

over the entire Japanese Homeland during the final phase of the mining campaign. The fourth leaflet was in preparation when the war ended.

PSYCHOLOGICAL WARFARE

ANNEX H



南海の孤島補給絶えて一年
大海を漂流する此の断片が、此の兵士が、
戦争の真相を語つてゐる。

Propaganda Leaflet Serial Number 2097

This is the second of a series of propaganda leaflets dropped on the Japanese Homeland which make specific use of the effects of the B-29 Aerial Mining Blockade of the Japanese Empire.

Text Caption: "MARITIME JAPAN---WITHOUT SHIPS!"

Text on Reverse Side: Your loved ones have been abandoned on isolated Pacific islands where they do not receive one grain of rice or one round of ammunition. Their single hope is that ships will come to rescue them. Now that artery, too, has been severed.

Numberless mines have been laid in the harbors of Japan. Day after day the B-29s are extending the network of mines. In rapid succession, the precious lives of your countrymen and the raw materials which are the nation's life blood are being blown up.

Japan is bound hand and foot. Unable to act, she can only suffer in silence under the present deadly bombardment. When will Japan be released from the network of mines and submarines? When will you be able to roam over the vast ocean in search of the bounty of the sea?

Each one of you holds the key to this problem. Save your loved ones on the by-passed islands! Save your native land! Throw down your weapons and come forward to build a new Japan.



機雷はかうして敷設されます

Propaganda Leaflet Serial Number 2098

This is the third of the series of propaganda leaflets dropped on the Japanese Homeland which make specific use of the effects of the B-29 Aerial Mining Blockade of the Japanese Empire.

Photo Caption: This is how mines are laid.

Text Caption: "MINEFIELDS OF DEATH"

Text on Reverse Side: Your harbors and waterways are full of mines. Trying to clear these minefields is like trying to dry up the ocean with a cup. You remove one mine and, immediately, the B-29s come and lay new ones.

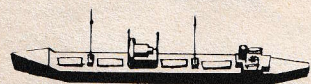
The minefields simply cannot be cleared, and militarists best know why. Yet they have to supply their war plants with iron and coal, so they recklessly order ships through the mined areas.

Because of this insane policy, the vessels which are essential to the Japan of the future are being sunk by mines in daily increasing numbers. If this continues, Japan will soon have no ships left.

The militarists are sacrificing Japan's future. How long will you permit their reckless actions to continue?

SUNKEN SHIPS PHOTOGRAPHED

Of the estimated 1,000,000 tons of Japanese shipping sunk or damaged in Twentieth Air Force minefields, some 131,000 tons were documented photographically. These ships, although sunk or damaged, remained sufficiently above water to permit their photographing from the air.



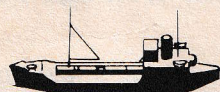
SBL (A-Mod)

NO.	PHOTO DATE	MISS-ION #	PRINT NO.	MINEFIELD AREA	SHIP LGTH	EST. TONS
1	28/5	244	3L:70,71	Shimonoseki S	445	6670
2	21/6	289	2:47,48	Shimonoseki S	445	6670
3	2/7	312	1V:61,2:55	Shimonoseki S	445	6670
4	23/7	348	2:34	Tokuyama	445	6670
5	7/8	390	4R:86,87	Shimonoseki S	445	6670
6	7/8	390	2:65,66	Wakamatsu	445	6670
7	7/8	391	2:29	Moji	445	6670



SCS

8	21/6	289	2:47,48	Shimonoseki S	210	880
9	22/7	345	2:61-65	Kobe	210	900
10	7/8	390	4R:100	Shimonoseki S	210	900
11	7/8	390	2:65,67	Wakamatsu	210	900
12	7/8	390	2:65,67	Wakamatsu	210	900
13	7/8	390	4R:110,111	Ube	210	900
14	7/8	385	3R:79,80	Wakamatsu	210	900
15	4/7	314	1V:56	Osaka	180	800



SAS

16	2/7	312	3L:100	Shimonoseki S	210	1000
17	5/8	374	1V:2	Fusan	230	1150
18	6/8	383	3L:212,214	Oo Harbor	210	1000

Although the mining operations began in March 1945, very little documentary evidence in the form of photographs was available until July. The reason for this lack of evidence was that minefield areas were not photographed to any appreciable extent until early in July.



FTC

NO.	PHOTO DATE	MISS-ION #	PRINT NO.	MINEFIELD AREA	SHIP LGTH	EST. TONS
19	6/7	382	3R:67	Maizuru	435	6250
20	29/7	368	6R:173,174	Niigata	260	1550
21	29/7	368	6L:173,174	Niigata	270	1925
22	7/8	390	2:65,67	Wakamatsu	260	1550
23	7/8	385	3R:86,87	Shimonoseki S	260	1550
24	14/8	404	3R:104,105	Tsuruga	300	2245



TA

25	6/7	382	2:34	Maizuru	515	10200
----	-----	-----	------	---------	-----	-------



SBS

26	22/7	345	1V:48	Kobe	260	1490
27	7/8	390	4R:110,112	Ube	330	3000



SAL

28	6/8	383	3R:203,206	Oo Harbor	517	10000
29	7/8	390	3:4	Tokuyama	517	10000



FTD

30	7/8	391	2:29	Shimonoseki S	210	880
31	7/8	390	4R:100	Shimonoseki S	200	810
32	7/8	390	4R:100	Shimonoseki S	200	810
33	7/8	390	2:65,67	Wakamatsu	220	1100

A list of Japanese vessels sunk or damaged and documented by photographs, appears below. The opposite page reproduces typical aerial photographs taken of mined enemy shipping. (The list below represents only that portion of sunk or damaged enemy ships which were photographed.)



SCL

NO.	PHOTO DATE	MISS-ION #	PRINT NO.	MINEFIELD AREA	SHIP LGTH	EST. TONS
34	7/8	390	2:65,67	Wakamatsu	310	2300
35	7/8	390	2:65,67	Wakamatsu	310	2300

UNIDENTIFIED

36	29/7	368	1V:114	Niigata		
37	29/7	368	1V:114	Niigata		
38	2/7	312	3L:83,84	Shimonoseki S		

ESCORT (KAIBOKAN)

39	5/8	374	3R:3,4,12	Fusan	220	1000
----	-----	-----	-----------	-------	-----	------



TB

40	5/8	374	5:2:2	Fusan	340	3420
----	-----	-----	-------	-------	-----	------



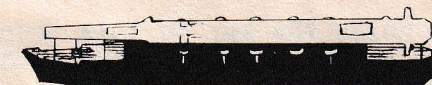
SEA TRUCK

41	7/8	390	4L:111	Ube	200	800
----	-----	-----	--------	-----	-----	-----



MERCHANT

42	7/8	385	1V:64,65	Fukuoka	210	900
----	-----	-----	----------	---------	-----	-----



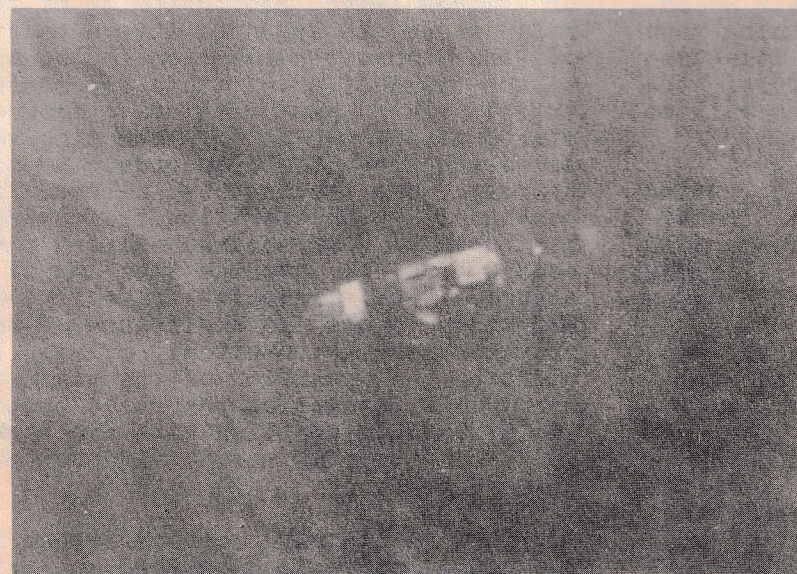
CVE (KAIYO)

43	11/8		7 AF Photo	Beppu Wan		10000
----	------	--	------------	-----------	--	-------

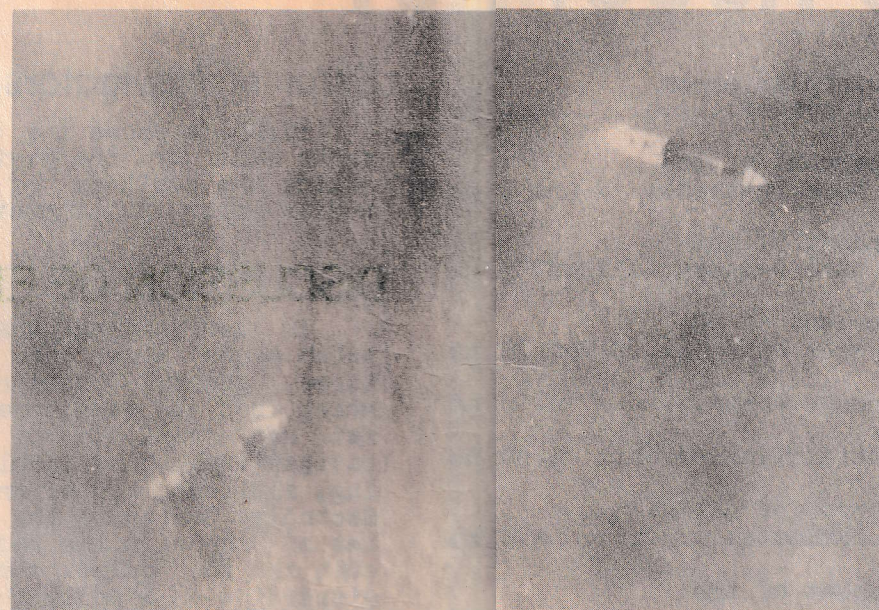
SUNKEN SHIPS PHOTOGRAPHED (Typical Example of Mine Attrition)



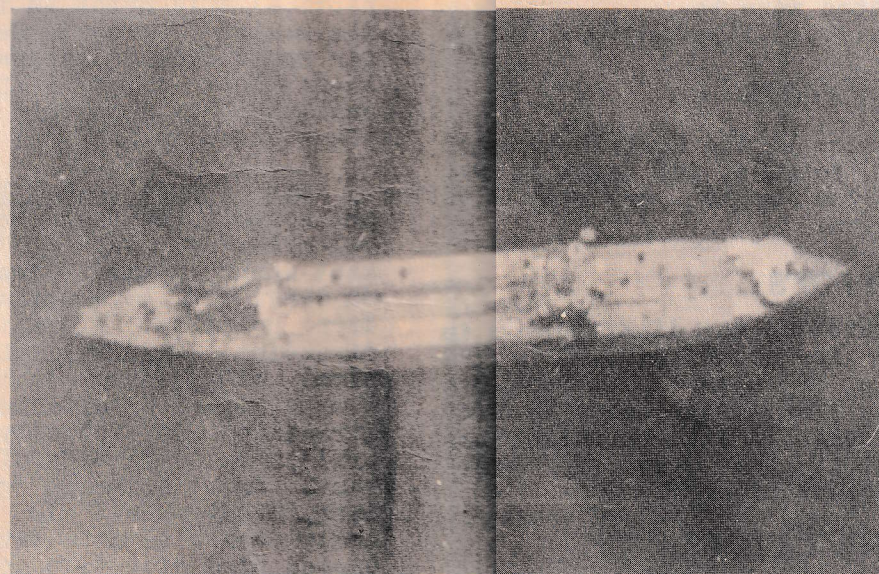
FTD; 210 feet; 880 tons. Only the bridge, bow and stern of this ship are visible above the water. Photographed in the minefield near Moji on 7 August 1945. (See No. 30 in list on opposite page for additional details.)



FTC; 300 feet; 2245 tons. Decks are awash, with bow low in the water. Photographed in the minefield at Tsuruga Harbor on 14 August 1945. (See No. 24 in list on opposite page for details.)



Two SCL's Type D (Mod), both 310 feet long and each approximately 2300 tons. Only the bows and sterns appear above water. Photographed in the minefield at Wakamatsu Harbor on 7 August 1945. (See Nos. 34 and 35 in list on opposite page.)



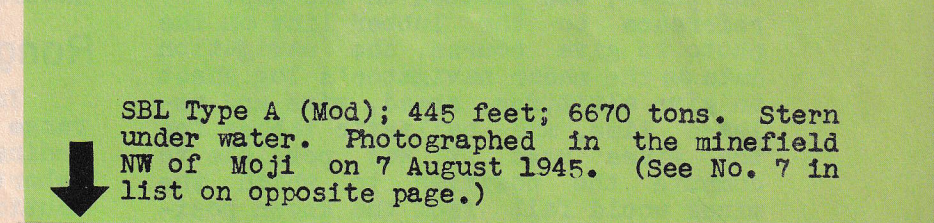
SAL; Type TL (Mod); 517 feet; 10,000 tons. Aground and listing to starboard. Photographed in the minefield of Sakoshi Bay opposite Oo Harbor on 6 August 1945. (See No. 28 in list on opposite page.)



SBL Type A (Mod); 445 feet; 6670 tons. Sunk in the mined anchorage NW of Kammon Harbor. Decks awash. Photographed 7 August 1945. (See No. 5 in list on opposite page.)



↑ SBS; 330 feet; 3000 tons. Photographed in minefield at Ube Harbor. Decks are awash. Photographed 7 August 1945. (See No. 27 in list on opposite page.)



↓ SBL Type A (Mod); 445 feet; 6670 tons. Stern under water. Photographed in the minefield NW of Moji on 7 August 1945. (See No. 7 in list on opposite page.)



RADAR MINELAYING ACCURACY

INTRODUCTION

This study considers the accuracy with which XXI Bomber Command B-29s laid mines in Japanese waters. All mines were laid at night with the use of APQ-13 radar. The actual position at which each mine hit the water was not known, since it could not be observed. This position was calculated from the known location and course of the aircraft at the time of dropping, as determined by radar scope photos and known mine ballistics (including the effect of wind drift).

Radar scope photos of adequate quality for plotting were obtained for 50 percent of the sorties flown. This study covers more than 600 sorties flown in the last 39 missions, mining over 40 separate targets. The mining missions considered are Missions 8 to 46 inclusive; all of the targets mined during these missions are represented in the study.

All mine positions were plotted through the use of radar scope photo negatives. The negative was projected onto a 1/115,000 scale map of the area. By adjusting the size of the projected image to coincide with the map, the aircraft position in the air, which is represented by the center of the photo, was plotted on the map. By reference to the lubber line on the photo to give course, the navigation data on the radar navigator's log sheet to give altitudes, speed, wind and release time, and ballistic tables for the mines used, it was possible to compute the position to which the mines would fall from the known position in the air. This computed position was then compared with the planned position for that particular stick of mines, to give the error in laying.

CONCLUSIONS

It was concluded from the study that the following accuracy in nautical miles was attained:

Median circular error
(radial error)..... 0.94 nm

62.5 percent of the
drops were between... 0 and 1 nm

34 percent of the
drops were between... 1 and 5 nm

3.5 percent of the
drops were between... 5 and 10 nm

Median range error..... 0.49 nm

Median deflection error.. 0.58 nm

Median error of naviga-
tor's estimate..... 1.2 nm

40 percent of the
estimates were be-
tween..... 0 and 1 nm

52 percent of the
estimates were be-
tween..... 1 and 5 nm

8 percent of the
estimates were be-
tween..... 5 and 10 nm

Circular Errors

In Figure 1 the distribution of error of a total of 649 cases is represented. The median error is 0.94 nautical miles.

Range Errors

In Figure 2 the distribution in range error is shown, divided by the ordinate in an "over" set and in a "short" set. The median error is 0.49 nautical miles. It will be noted that 69.5 percent of the drops are "over" and 30.5 percent "short".

Deflection Errors

In Figure 3 the distribution in deflection error is shown divided by the ordinate to a "right" set and a "left" set. The median error is 0.58 nautical miles. The errors were approximately equally divided between right and left.

Error of Navigators Estimate

Figure 4 shows the distribution of error made by the navigator in estimating the position of his drop. The median error is 1.2 nautical miles.

DISCUSSION OF ERRORS

In determining the accuracy with which mines have been laid there are three general categories of error which must be considered. The first set of errors to be considered are navigational; they involve wind, heading, altitude, and aircraft stability. Secondly, there are the possible sources of error in the radar instrument, such as the pulse width, and screen dispersion. Finally the actual plotting of mine drop position involves some error.

Navigational Errors

True Air Speed. An error of .02 nautical miles will result from a 10 nautical mile error in True Air Speed. The maximum error in determining True Air Speed will in general be less than 10 nautical miles. Therefore, the maximum error from this source will be .02 nautical miles.

Wind Direction and Velocity. Using the normal wind velocity of 30 nautical miles per hour at 8000 feet, a 10 knot error in wind velocity will cause an error of .10 nautical miles in the drop position. A variation in wind direction of 10° will give an .07 nautical mile error. It has been possible to make a reliable check on wind direction and velocity by using several independent sets of wind measurements from aircraft going over the same target area. In comparing this individual wind data with that of predicted wind direction and velocity, it was determined that in most cases the error in the wind direction was less than 10°, and of velocity about 10 knots. Therefore, an error of .17 nautical mile (.10 plus .07 nm) is the maximum to be expected because of wind direction and velocity error.

Altitude. The pilot can fly so close to the briefed altitude that any error caused by variation in altitude is negligible and not worth considering.

Unstable Aircraft. For every degree an airplane varies around its horizontal or longitudinal axis the radar beam will be caused to intersect the surface of the earth .023 nautical mile from the point indicated on the scope. An assumption of a 3° variation is very liberal for mining conditions at night. The relatively low altitudes (6000 to 12000 feet) at which mines were laid resulted in particular stability of the aircraft. With a 3° variation, the maximum error will be .07 nautical mile.

Radar Errors

Photograph Timing Error. While not strictly a radar instrument error, the 3 second sweep time of the sweep beam does produce an apparent error in the radar scope photo. At the moment of "Mines Away", photographing of the radar scope is begun to give a record of the aircraft's position in the air at the time of drop. This procedure, except for psychological errors, starts at the moment of the mine release and requires 3 seconds. An additional one second is allowed for personnel lag in operating the camera. The total of four seconds elapsed time should give an average time lag of 2 seconds. The aircraft traveling at 230 knots would go a distance of approximately .15 nautical miles. In plotting the position of the aircraft using the center of the scope photo, the aircraft's position will constantly be plotted as being .15 nautical miles "over".

This is clearly shown in Figure 2. The range curve is displaced approximately 0.2 nautical miles on the over side.

Pulse Width Error. This error is caused by the fact that a transmitted radar pulse makes pin points appear to be .027 nautical miles in diameter.

RADAR MINELAYING ACCURACY

Beam Width Error. The 3° width of the beam on the radar scope causes a pin point to cover 3° in azimuth. The maximum error caused by beam width would be 1.5° in azimuth. Using a distance of 5 miles slant range as the average distance to targets, the error would be 0.13 nautical miles.

Screen Dispersion. The coating on the inner face of the radar scope causes a beam of electrons to create with perfect focus, a light mark of 0.02 of an inch. On the 10 mile range scale this represents 0.08 nautical miles. Since the pin point is actually spread 0.01 of an inch in all directions to make the 0.02 diameter dot, the actual maximum error will be 0.01 of an inch or 0.16 nautical miles.

Plotting Errors

A series of identical radar photos were given to two individuals to plot separately. The positions of the plots were compared and it was found that there was an average error of 0.12 nautical miles between the two sets, and that the greatest disparity between plots was 0.14 nautical miles. The errors were random in direction.

Effect of Errors

In summarizing the mine errors, all except those resulting from photographic timing are assumed to be random errors. The root mean square value for all errors, except timing, is 0.08 nautical miles.

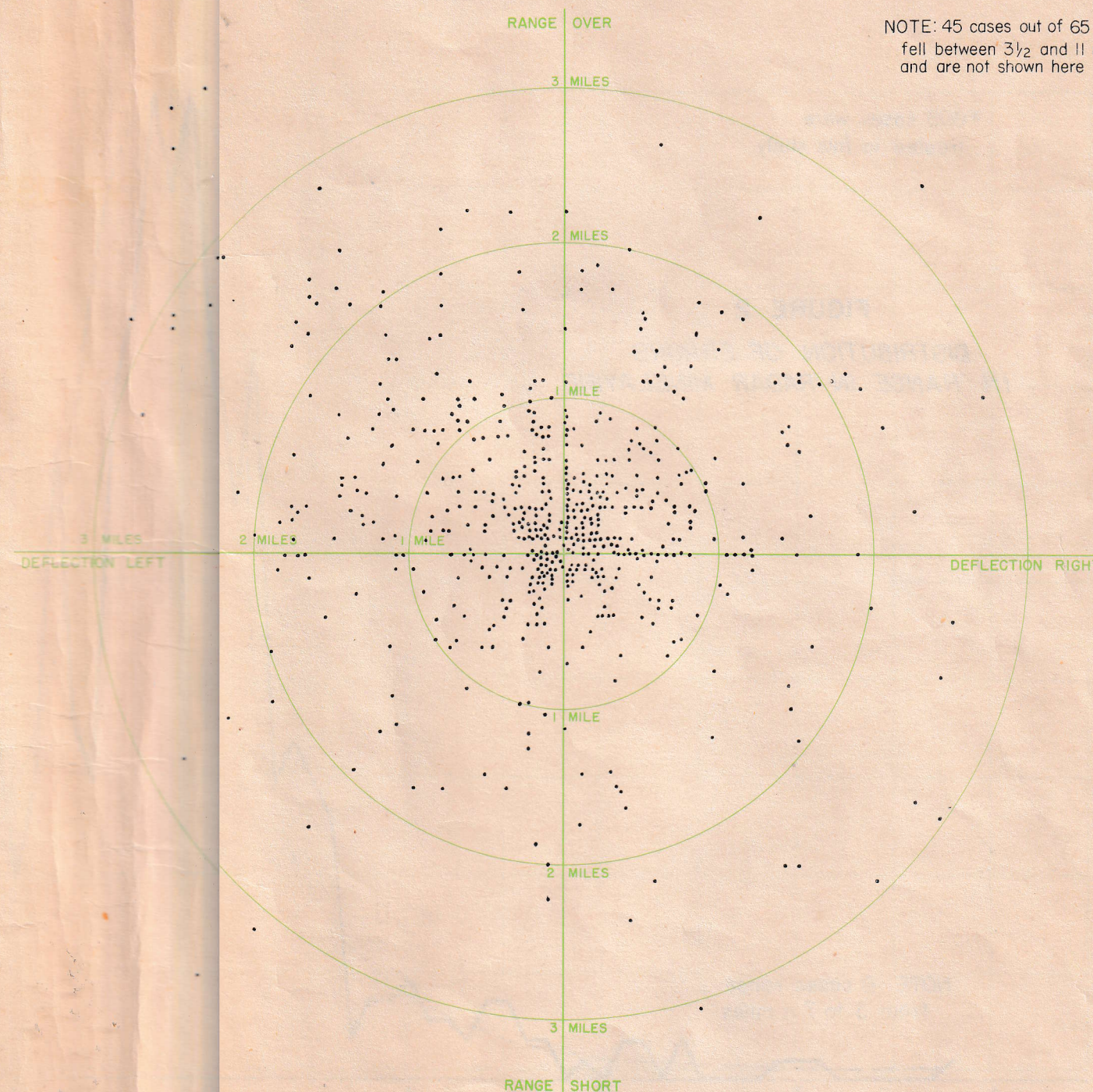
Of greatest significance is the photographic timing error, because of the fact that it always shows the aircraft to be 0.15 nautical miles past the actual point of release. The displacement of the curve for range error in Figure 2 is 0.20 nautical miles on the over side, and so correlates very closely with the calculated value of 0.15 nautical miles.

It is concluded that the median error of 0.94 nautical miles is not appreciably affected by errors in plotting or computation, and represents closely enough the accuracy actually obtained in minelaying.

Error in Navigators Estimate

About 50 percent of the drop positions reported in all missions are based solely upon the estimated position of the drop as made by the radar navigator. For purposes of mine planning it was assumed that the accuracy of the drops was the same as those verified by radar scope photos. For the purpose of minesweeping, however, it was essential to obtain an independent measure of the error in the navigator's estimate.

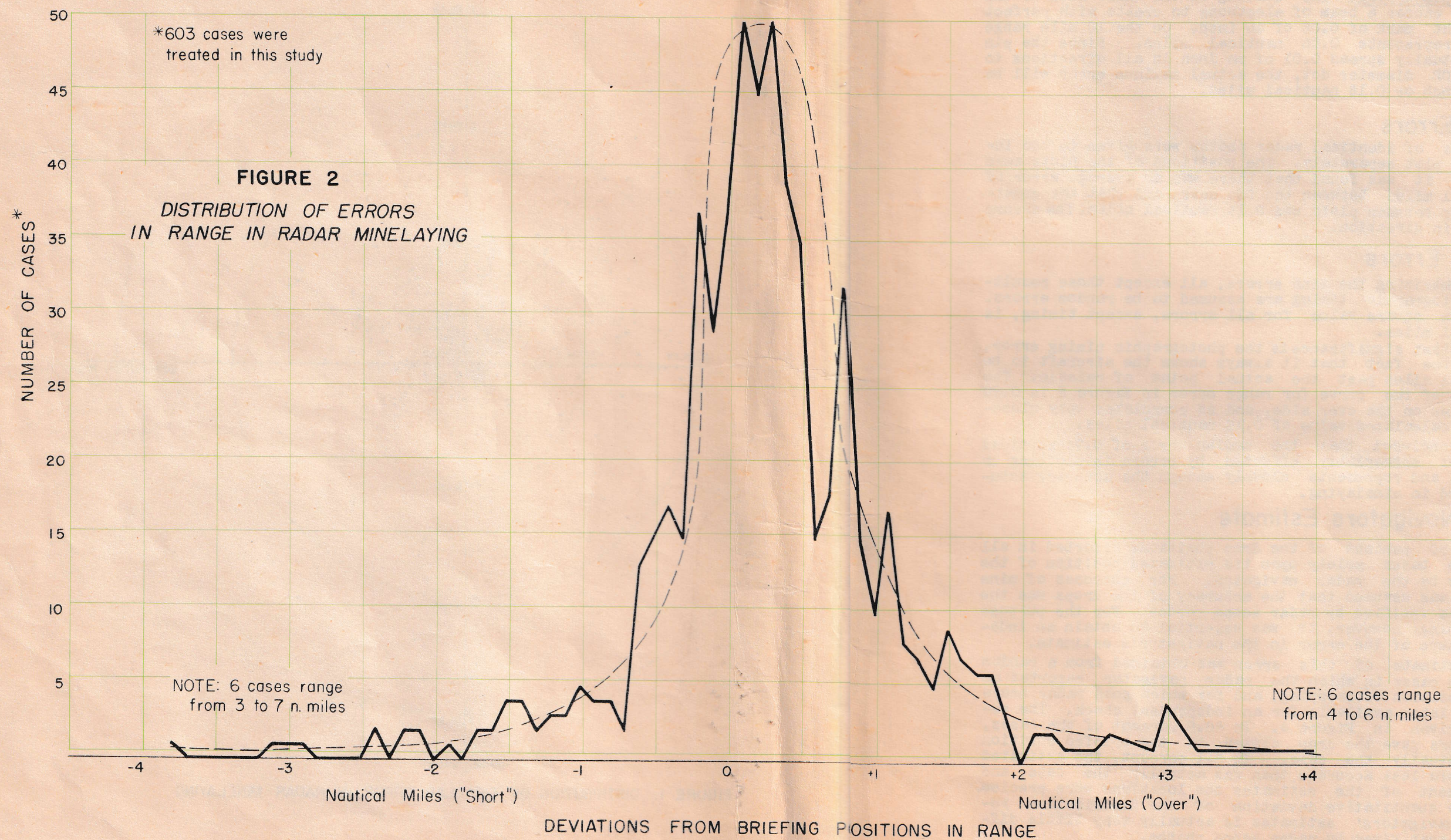
The estimate of this error was obtained from a random sample of 78 cases in which the radar navigator reported an estimated position of dropping, and for which good radar scope photos were later available for an independent check. The results are given in Figure 4. In 88.5 percent of the cases, the navigators gave the drop closer to the briefed position than was actually the case. In 5.1 percent, the estimated positions were less accurate than was actually the case, and in 5.4 percent of the estimates the locations were precise. However, the quantitative deviation of the distribution reported by navigators' estimates is actually very little different than that given by radar scope photos.



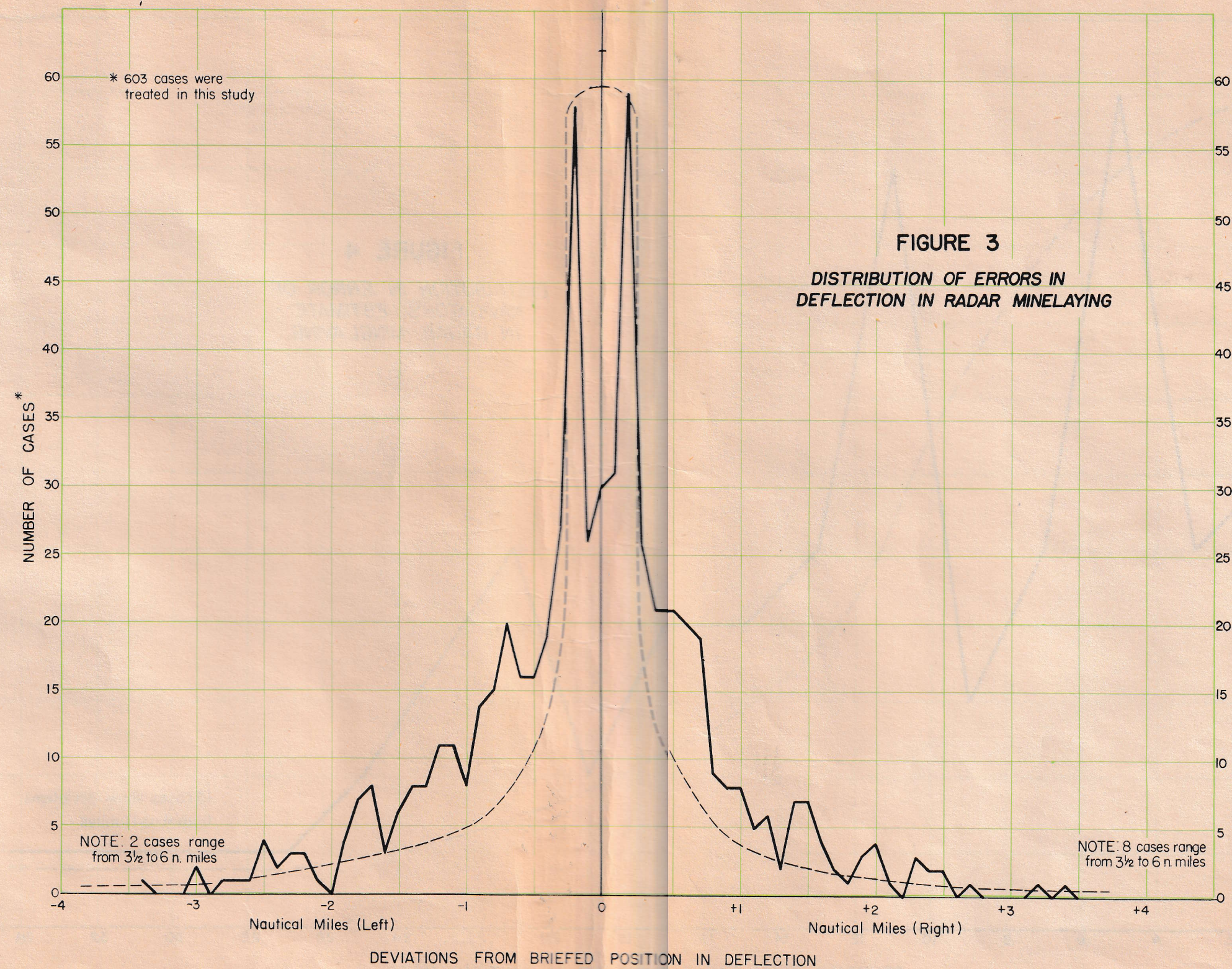
NOTE: 45 cases out of 65 fell between $3\frac{1}{2}$ and 11 miles and are not shown here

FIGURE 1. DISTRIBUTION OF CIRCULAR ERROR IN RADAR MINELAYING

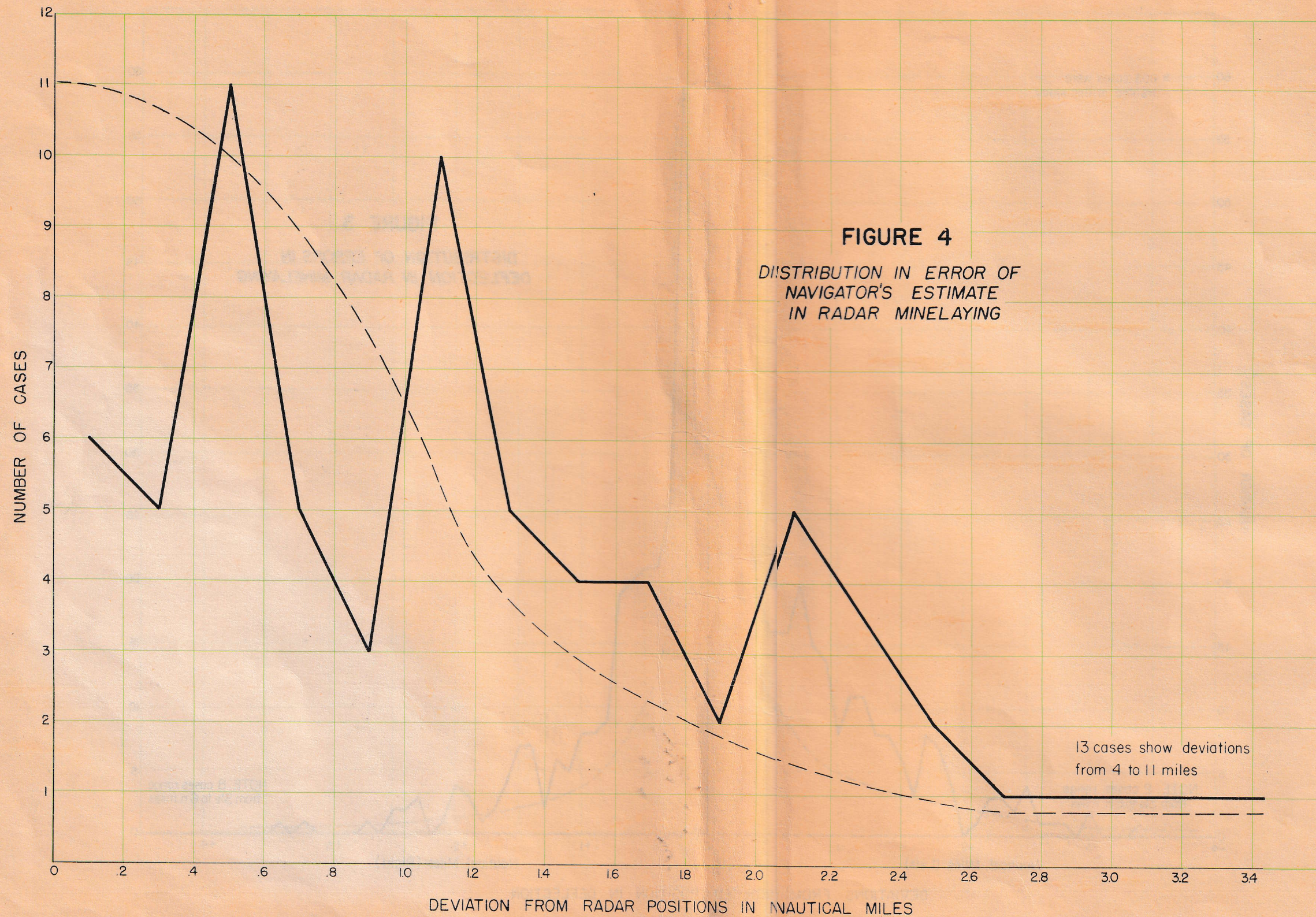
RADAR MINELAYING ACCURACY



RADAR MINELAYING ACCURACY



RADAR MINELAYING ACCURACY



PREPARED BY A-3 TWENTIETH AIR FORCE

REPRODUCED BY 949TH ENGR AVN TOPO CO