3. WESTERN PACIFIC REGION

3.1. TOPOGRAPHY

The physical structure of eastern Asia and adjacent ocean areas exert a significant influence on the weather of the region. The many meteorological conditions described herein are the result of airmass trajectory coupled with modifications imposed by the land and water areas over which the air mass travels. A careful study of the topography of eastern Asia and the bathymetry of adjacent water areas is essential to successful forecasting.

3.1.1. KAMCHATKA AND THE KURIL ISLANDS

The peninsula of Kamchatka extends south-southwestward from the Arctic Circle to approximately 51° North. The Koryak Mountain Range dominates the peninsula, extending the length of Kamchatka. Elevations commonly exceed 8,000 ft (2440 m) with individual peaks ranging between 11,000-16,000 ft (3355-4880 m). Forty volcanoes are known to exist on the peninsula, of which approximately 15-20 are active.

Extending southwest from the tip of Kamchatka are the Kuril Islands. Volcanic in nature, more than 100 cones form the island chain, of which approximately 40 are active. (Figure 3.1.1)

3.1.2. SIBERIA (RUSSIA)

The coastal area of Siberia is mountainous. The Kolyma and Dzugdzhur Ranges extend from the Arctic Circle to 55° North, encircling the western Sea of Okhotsk. Elevations range from 3,000 to 7,500 ft (915 m to 2288 m). Approximately 400 mi (644 km) inland, the Okhotsk-Kolyma Range exceeds 8,000 ft (2440 m).

The Siberian Plateau extends from the Verkhoyansk Range (135° East) to the Ural Mountains (60° East). The eastern region consists of mountains areas, the central region consists of barren highlands and the western area consists of lowlands.

The Sikhote Alin Mountain Range is located northeast of Vladivostok, averaging 3,000-5,000 ft (915-1525 m). North of Vladivostok lie the open plains of the Ussuri River Valley. The plains average 500 ft (153 m) below sea level and 60 mi (97 km) wide along the coast, forming a natural outlet for northerly winds. (Figure 3.1.1)

3.1.3. JAPAN

The Japanese Archipelago is composed of four main islands: Hokkaido, the northern-most island; Honshu, the largest and main island; Shikoku, located to the east of southern Honshu; and Kyushu, the southern-most island. Four-fifths of the country is mountainous, including approximately 165 volcanoes (45 of which are still active). The Japan Alps, located in the central region of Honshu, is the major mountain chain of the Japanese islands, averaging 5,000-12,000 ft (1525-3660 m) in elevation. The mountains of Hokkiado constitute the second major chain, averaging 5,000-6,000 ft (1525-1830 m). The third chain is found on the island of Kyushu, averaging only 5,000 ft (1525 m).

The Ryukyu Island chain forms a 750 mi (1208 km) arc between Japan's southern-most main island of Kyushu and the northern-most tip of the island of Taiwan. This island chain forms a natural boundary between the East China Sea to the west and the Pacific Ocean to the east. (Figure 3.1.3)

3.1.4. CHINA

The coastal areas of eastern mainland China are characterized by extensive low-lying mountain ranges, which have elevations commonly below 3,000 ft (915 m).

The Nangnim Range (southwest of Vladivostok) continues into eastern Manchuria and into northern Korea with elevations of 8,000 ft (2440 m). The Manchurian Plain extends from the foothills of the Nangnim to the Greater Khingan Range on the edge of the western Gobi Desert. The extreme western extent of the Himalayan Mountains dominates central and western China. (Figure 3.1.4)

3.1.5. MONGOLIA

Mongolia lies in central Asia with Russia to the north and China to the south. The Gobi desert, in the southeast region, supports no vegetation and is sparsely populated. Funneling of winds between the ranges of western Mongolia and Manchuria can cause strong winds over the desert area. Airborne sand has been observed as far away as the Yellow Sea and the Sea of Japan. The northern extension of the Himalayas dominates the terrain of northwestern Mongolia. (Figure 3.1.4)

3.1.6. KOREA

The Korean Peninsula extends 600 mi (966 km) from 44° North to 33° North and has a total area, including off-shore islands, of 75,250 sq mi (194,899 sq km). The Peninsula extends to within 120 mi (193 km) of Honshu and the Shantung Peninsula of China.

North Korea extends about 445 mi (716 km) from the southwest to the northeast and is approximately 225 mi (362 km) wide. It is bordered by China to the north and by Russia to the extreme east. About 80% of North Korea is mountain ranges and uplands. The Kaema Plateau, average elevation 3280 ft (1,000 m), bisects the country. The Hamgyong Mountains rim the eastern edge of the plateau, rising to over 8200 ft (2,501 m). The eastern lowlands are a very narrow strip between the plateau and the coast. The western lowlands are a much wider strip.

South Korea also has an abundance of mountain ranges—approximately 70% of the total landmass. The main range, the Taebaek Mountains, roughly parallels the east coast. The other four major ranges (the Charyong, the Kwangju, the Sobaek and the Noryong) form 90° angles from the Taebaek Mountains. Most of the lowlands are located in the western portion of the Peninsula. (Figure 3.1.2)

3.1.7. TAIWAN

Taiwan is mostly mountainous, with peaks of 12,743 ft (3,887m) and 13,114 ft (4,000 m) in the northern and central areas of the island. (Figure 3.1.4)

3.1.8. MICRONESIA

Micronesia consists of more the 2,500 islands and islets, a total land area of 1100 sq mi (2849 sq km) spread over an ocean area of 2.5 million sq mi (6.5 million sq km). Micronesian islands are

classified as high or low, depending on their elevation, and as continental or oceanic according to their geological substructure. A low island will have an elevation of a few feet while a high island may have an elevation of 2,000 ft (610 m). A continental island has a substructure that is built upon piles of lava that have been extruded from volcanic fissures in the sea floor. Many of these islands are ringed or topped by coral growths forming varying types of outer reefs. Oceanic islands have a substructure that does not reach the surface. Rather coralline growths that have accumulated over the centuries are exposed. Most of these formations are atolls, consisting of a barrier or a fringing reef enclosing a number of tiny islets around an interior lagoon. (Figure 3.1.5)

The Belau (Palau) group, Yap and the southern four islands of the Marianas are examples of continental high islands. Chuuk (Truk), Pohnpei and Kosrae in the Eastern Carolines are examples of oceanic high islands. The remaining Micronesian islands are classified as low oceanic islands.

3.1.9. PHILIPPINE ISLANDS

The Philippine islands consist of more than 7,000 individual islands. The islands are grouped into three regions: the Luzon region in the north, the Visayas region in the center and the Mindanao region in the south.

Many of the larger islands have narrow coastal plains and interior highlands and mountain ranges. These ranges, generally oriented north and south, cover almost the entire length of the islands. Three major ranges dominate the island of Luzon: the Sierra Madre in the north and central area, the Ilocos range along the extreme western coast and the Zambales located along the extreme western coast of central Luzon. Many of the larger islands within the Visayas region have ranges that extend their entire length. Mindanao has extensive mountain ranges dominating the eastern and western coastal areas, with a third range dividing the island. (Figure 3.1.4)

Figure 3.1.1 RUSSIA

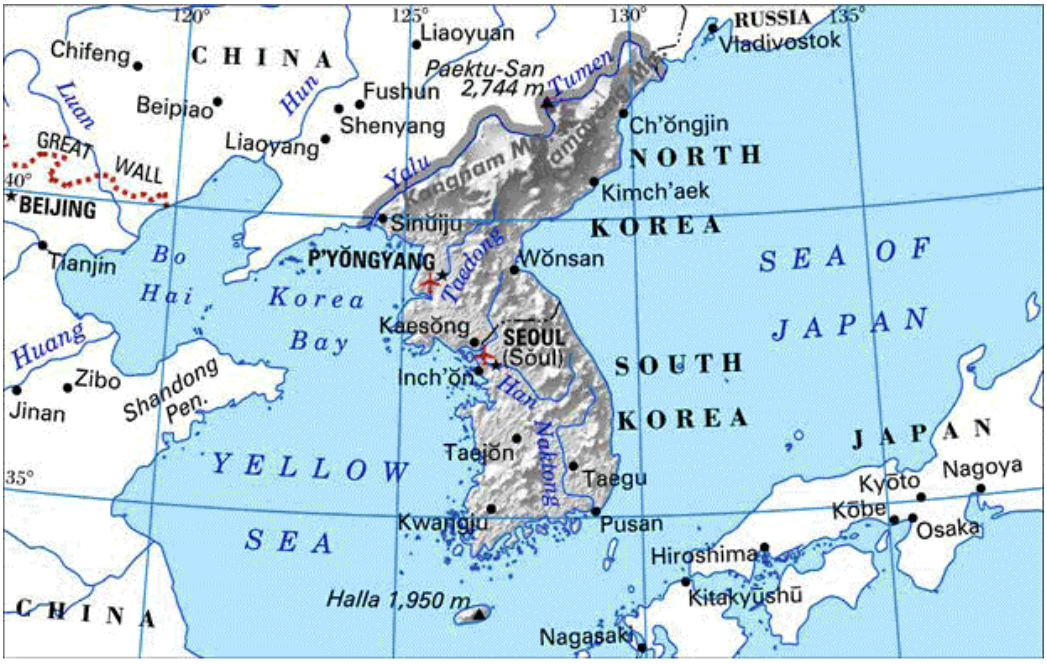

Figure 3.1.2 KOREA

Figure 3.1.3 JAPAN

Figure 3.1.4 CHINA

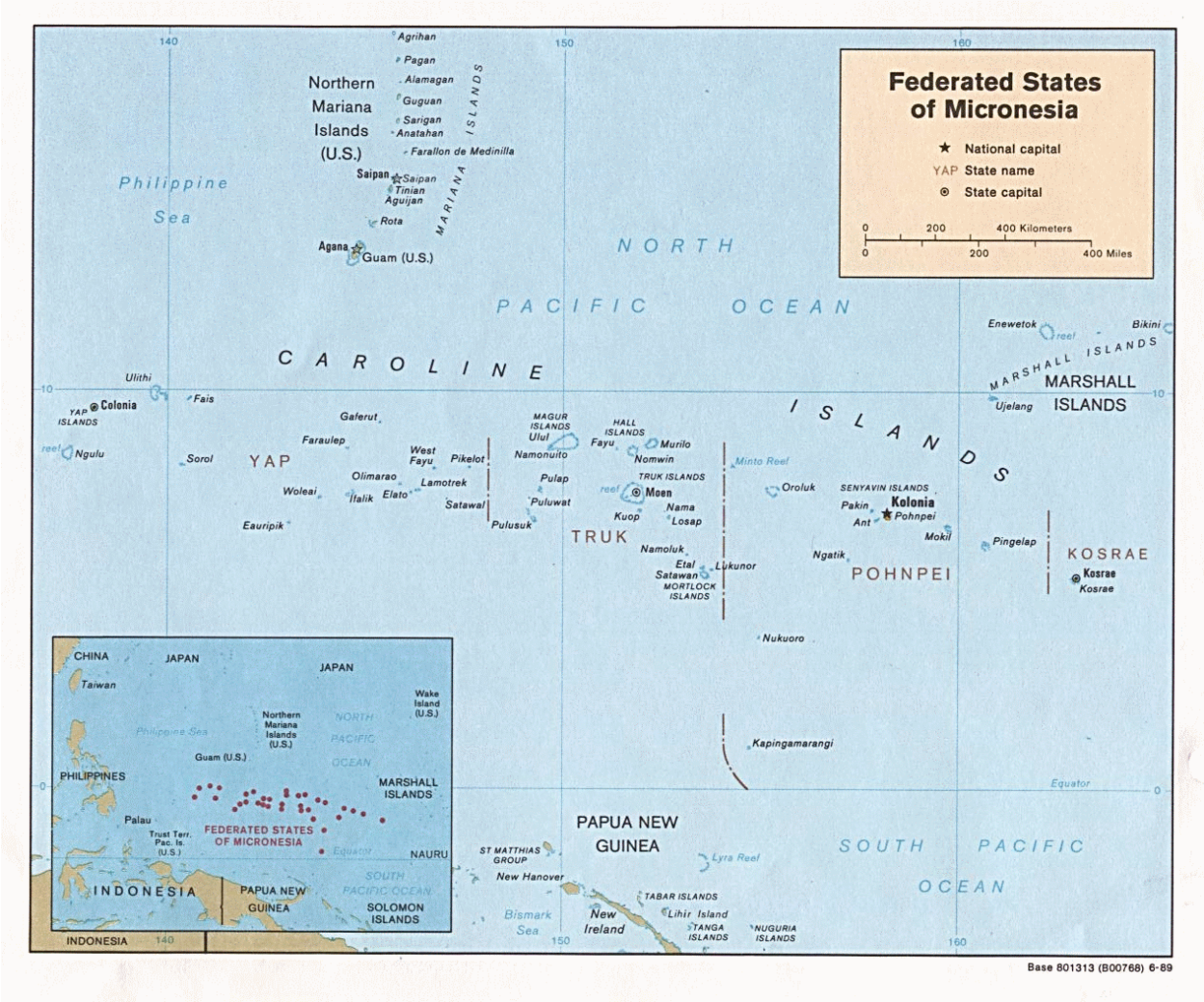

Figure 3.1.5 MICRONESIA

3.2. OCEANOGRAPHY

The oceanic regions of the western North Pacific include both marginal seas and deep ocean areas. Significant differences in physical properties exist between these ocean regimes that impact temperature profiles, salinity and bottom characteristics. These differences determine the region's sound speed profile, which affect acoustic propagation characteristics. Critical features and effects of bottom topography, ocean fronts and eddies and ocean currents will be briefly covered.

3.2.1. BOTTOM TOPOGRAPHY/BATHYMETRY

3.2.1.1. WESTERN NORTH PACIFIC

For purposes of this handbook, the western North Pacific (NWPAC) is limited to the ocean areas west of 180o, to the Japanese and Kuril Islands and from 66° North 180° to the Equator.

The majority of ocean area discussed here is comprised of open ocean, deep basins and trenches.

A fundamental characteristic of the Pacific Basin is the semi-continuous belt of trenches. The Kuril Trench (27,880 ft/8,503 m) parallels the Kuril Island chain, with maximum depths found between Hokkaido and the central Kuril Islands. The Japan Trench (35,440 ft/10,809 m) is located just to the east of northern Honshu, continuing south-southeastward to near 30o North. The Bonin Trench (28,405 ft/ 8,664 m) is found along the eastern edge of the Bonin Island chain. The Mariana Trench extends from the base of the Bonin Trench to approximately 10o North on the eastern periphery of the Mariana-Bonin ridge. The Challenger Deep, at 35,800 ft (10,919 m), is the deepest trench in the world. The Yap-Palau Trenches extend from the base of the Mariana-Bonin Ridge to approximately 7o North along the southeastern perphiery of the Kyushu-Palau Ridge.

West of these deep trenches, the bottom slopes are quite extreme, rising rapidly to the relatively shallow continental shelf of Japan, the Kuril islands and the Bonin islands. (Figure 3.2.1)

3.2.1.2. SEA OF OKHOTSK

The Sea of Okhotsk is one of the marginal seas of the Pacific, situated in the northwestern part of the ocean. It is separated from the Pacific by the Kuril Island chain and the Kamchatka Peninsula. The Kuril Straits connect the Sea of Okhotsk with the Pacific Ocean and the Tartar and Soya Straits with the Sea of Japan.

The Sea of Okhotsk lies within the transition zone from the continent to the floor of the Pacific Ocean proper. There are three categories of bottom topography: continental and island shelves, the central portion and the southern deep-water basin. The shelf area constitutes more than 40% of the entire sea area. Bottom composition is mainly sand and silt. The central shelf consists of a series of ridges and troughs with depths ranging from 656 ft (200 m) to 5,740 ft (1,751 m). The Kuril Basin runs along the inner edge of the Kuril Islands with a maximum depth of 10,253 ft (3,107 m). The basin is surrounded on all sides by steep slopes as steep as 15-20 o . Sedimentary cover over the nearshore summits and slopes of marine rises is mainly pebbly gravel and sand. The majority of the basin is covered in bands of silts, clay and ooze. (Figure 3.2.1)

3.2.1.3. SEA OF JAPAN

The Sea of Japan is a marginal sea of the western north Pacific, surrounded on the east by the Japanese Islands and on the west by coastal Asia. Openings to the Pacific and other seas are through the Tsushima (Korean) Strait to the south, Tsugaru Strait between the islands of Hokkaido and Honshu, the Soya (La Perouse) Strait between Hokkaido and Sakhalin Island and the Tartar Strait between Sakhalin Island and the Asian mainland. The significance of these straits will be covered in later sections.

The central Sea of Japan is dominated by the Japan Basin and Japan Abyssal Plain. The Tartar Trough extends southward from between Siberia and Sakhalin Island to the Japan Basin. The most prominent individual topographical feature in the Sea of Japan is the Yamato Rise, which is divided into the Kita-Yamato Ridge and the Yamato Ridge by the Yamato Trough. Most of the continental shelf area is very narrow except in the extreme northern portion near Hokkaido and Sakhalin Island. Steep slopes of over 30o bound the ridge and trough features.

The Tsushima/Korea Strait is oriented northeast-southwest between the southern Korean coast and the southwestern coast of Honshu. The strait is comprised of East and West channels which are located on either side of Tsushima Island. The topography of the strait is basically a continuation of the continental shelf of the East China Sea. A relatively flat bottom dominates the strait. Major topographical features include: Tsushima Island located approximately in the middle of the straits, the irregular coastlines of Korea to the north and Japan to the south and a depression centered off the northwest coast of Tsushima Island in the West Channel. (Figure 3.2.2)

3.2.1.4. YELLOW SEA

The Yellow Sea is bounded by the People's Republic of China to the west and north, North Korea to the northeast, South Korea to the east and the East China Sea to the south-southeast. The geographic configuration allows for division into three segments: the Gulf of Pohai to the northwest, Korea Bay to the northeast and the Yellow Sea. For purposes of this handbook the Yellow Sea and Korea Bay will be called the Yellow Sea Proper.

The Yellow Sea Proper and Gulf of Pohai form a partly enclosed, wide, flat, shallow marine embayment. The entire area is part of the continental shelf with depths averaging from 197-252 ft (60-77 m). Numerous sand ridges and channels run perpendicular to the coast. Strong tidal currents and numerous rivers carry suspended sand particles into the Sea which then are sorted by the currents. The bottom of the central basin and the Chinese side of the Pohai Bay is composed mainly of muddy silt. (Figure 3.2.1)

3.2.1.5. EAST CHINA SEA

The East China Sea bathymetery is divided into two contrasting areas: the continental shelf which makes up the shallow water area and the Okinawa Trough which constitutes the deep water area.

The shelf area is relatively narrow and elongated. Widths vary from 170 mi (274 km) near Taiwan to 450 mi (725 km) near the northern boundary (33o North). There are a few scattered islands near the outer edge of the shelf. Outflow from the Yangtze (Yellow or Changjiang) River is the primary origin of shelf material. General composition consists of a 85 mi (139 km) belt of mud from the shore with a broader paralleling zone of fine-grained sediments changing to sand at the outer shelf area.

The Okinawa Trough borders the continental shelf with the western side defining the continental slope. The trough extends from Taiwan to Kyushu along the inner Ryukyu Island arc. (Figure 3.2.1)

3.2.1.6. PHILIPPINE SEA

The limits of the Philippine Sea are defined by the Philippine islands of Luzon, Samar and Mindanao on the southwest; the island of Belau (Palau), Yap and Ulithi on the southeast; the Mariana Islands on the east; the Bonin and Volcano Islands on the northeast; the Japanese islands of Honshu, Shikoku and Kyushu on the north; the Ryukyu Islands on the northwest and Taiwan on the west.

The Philippine Sea is an abyssal zone with depths generally greater than 6,500 ft (2,000 m). The bottom topography consists of deep trenches (over 19,600 ft/5,978 m in depth), belts of seamounts and deep basins. The abyssal deep basin is separated into east and west basins by the Kyushu-Palau Ridge. The bottom sediments are pelagic red clays and oozes with volcanic material along the island arcs. (Figure 3.2.1)

3.2.1.7. SOUTH CHINA SEA

The South China Sea (SCS) is bordered on the north through west by the Asian mainland, the southern limit of the Gulf of Thailand and the Malay Peninsula on the southwest through the southern side, the Philippine Islands and Taiwan to the east and northeast.

The China Sea Basin, located in the north central portion of the sea, dominates the majority of the South China Sea with a maximum depth of 17,400 ft (5,307 m). The central portion of the SCS is an abyssal plain. Large reef-studded shoal areas occur within the basin in the southern area.

Mud and sediments dominate the bottom in the vicinity of coastal areas extending outward along the continental shelf. Clay is the main sedimentary feature in the deeper portions of the basin. Volcanic ash is found in layers throughout the basin as a result of numerous volcanic eruptions in the East Indies, most notably the enormous eruption of Krakatao.

3.2.1.8. SULU SEA

The Sulu Sea is bounded on the south-southwest by Borneo, to the west-northwest by the Palawan Island, to the north through southeast by the Philippine Islands and to the southeast by the Sulu Archipelago. The Sulu Sea is divided into a northwestern and a southeastern portion by a row of banks with depths of less than 650 ft (198 m). These banks run parallel to Palawan Island and the Sulu Island group.

The southeastern basin is characterized by steep slopes covered in calcium carbonate ooze except in the vicinity of the Sulu Islands where a zone of coral mud and sand dominates the abyssal plain. Volcanic and terrigenous muds are present off the coast Mindanao.

The northwestern basin has irregular but gentler slopes than the southeastern area. Calcium carbonate ooze dominates the abyssal plain.

3.2.1.9. SULAWESI (CELEBES) SEA

The Sulawesi Sea is located between Borneo and the southern Philippine Islands with the Sulu Archipelago and the southwest coast of Mindanao to the north. To the east are a string of islands which connect the Philippine Islands with Sulawesi. The northern arm of Sulawesi constitutes the southern boundary, and Borneo is the western boundary. The northern opening of the Makassar Strait is located in the southwest corner and connects the Sulawesi Sea to the Flores Sea.

The Sulawesi Basin is of uniform depth and flat with the exception of isolated minor irregularities along the western rim. Terrigenous mud dominates the northern area in the vicinity of Mindinao. A broad area extending across the center of the sea is composed of terrigenous and volcanic mud with volcanic mud dominating the eastern region.

3.2.1.10. MOLUCCA SEA

The Molucca Sea is bordered on the west and the east by rows of volcanic islands, the North Sulawsi-Sangir islands and Halmahera and associated islets. The northeast limit is formed by the Snellius Ridge. The southern border is a line from Obi Major to Sulawesi.

The floor of the Molucca Sea can be divided into three north-south zones. The most western zone dominated by the Sangir trough connects the Davao Gulf in Mindanao with the Gorontalo Gulf. The central zone consists of a broad ridge. The Talaud and Miangas Islands in the north and the Maju and Tifore Islands near the center are part of the ridge. The third zone is composed of a series of depressions with Talaud and Morotai depressions in the north and Mangole-Batjan basins in the south. Bottom sediment consists mainly of terrigenous mud with calcium carbonate found in the basin areas. Coralline mud and sand are conspicuously concentrated around reefs and coral islands.

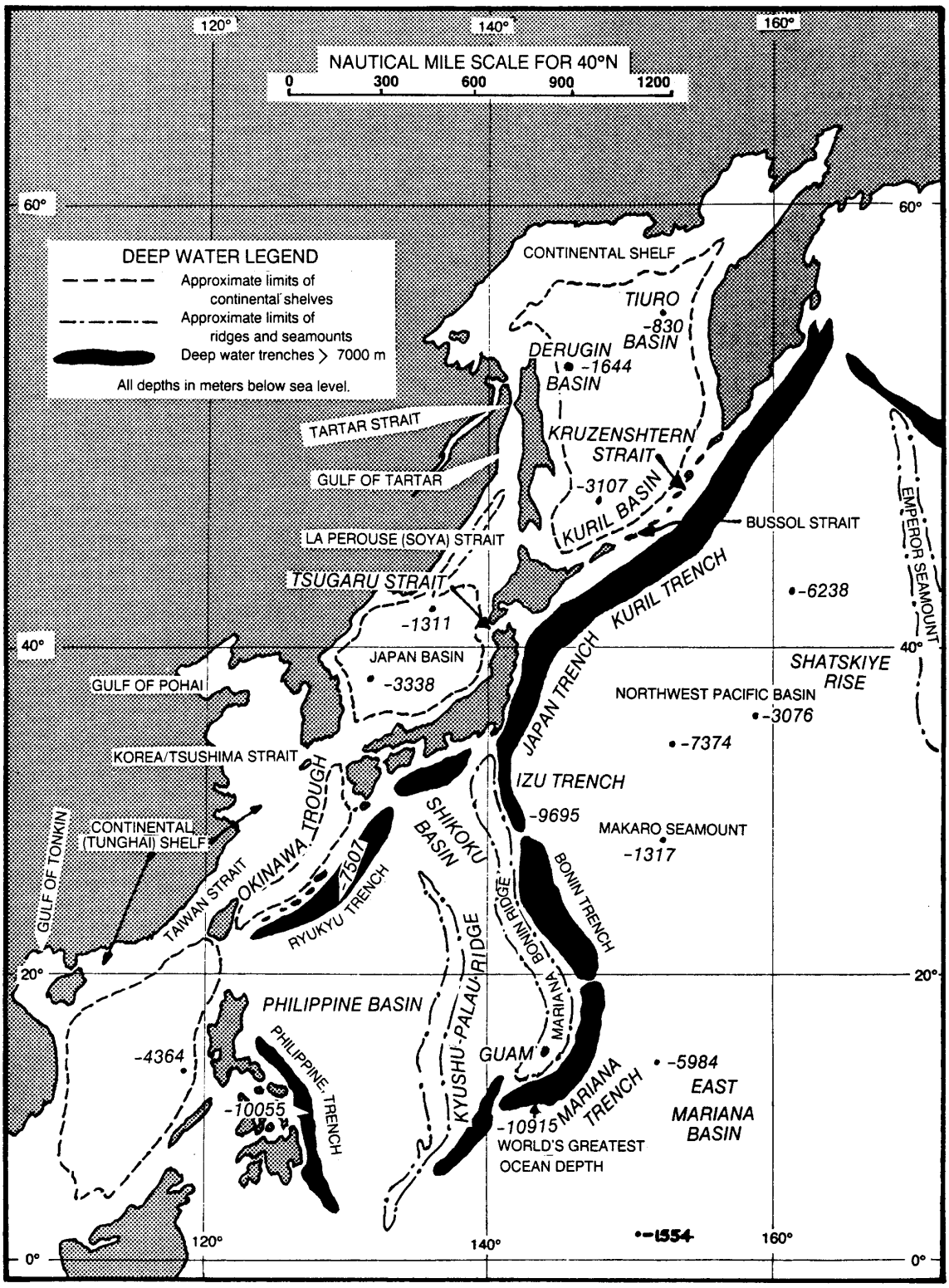

Figure 3.2.1 Bottom Topography Western North Pacific

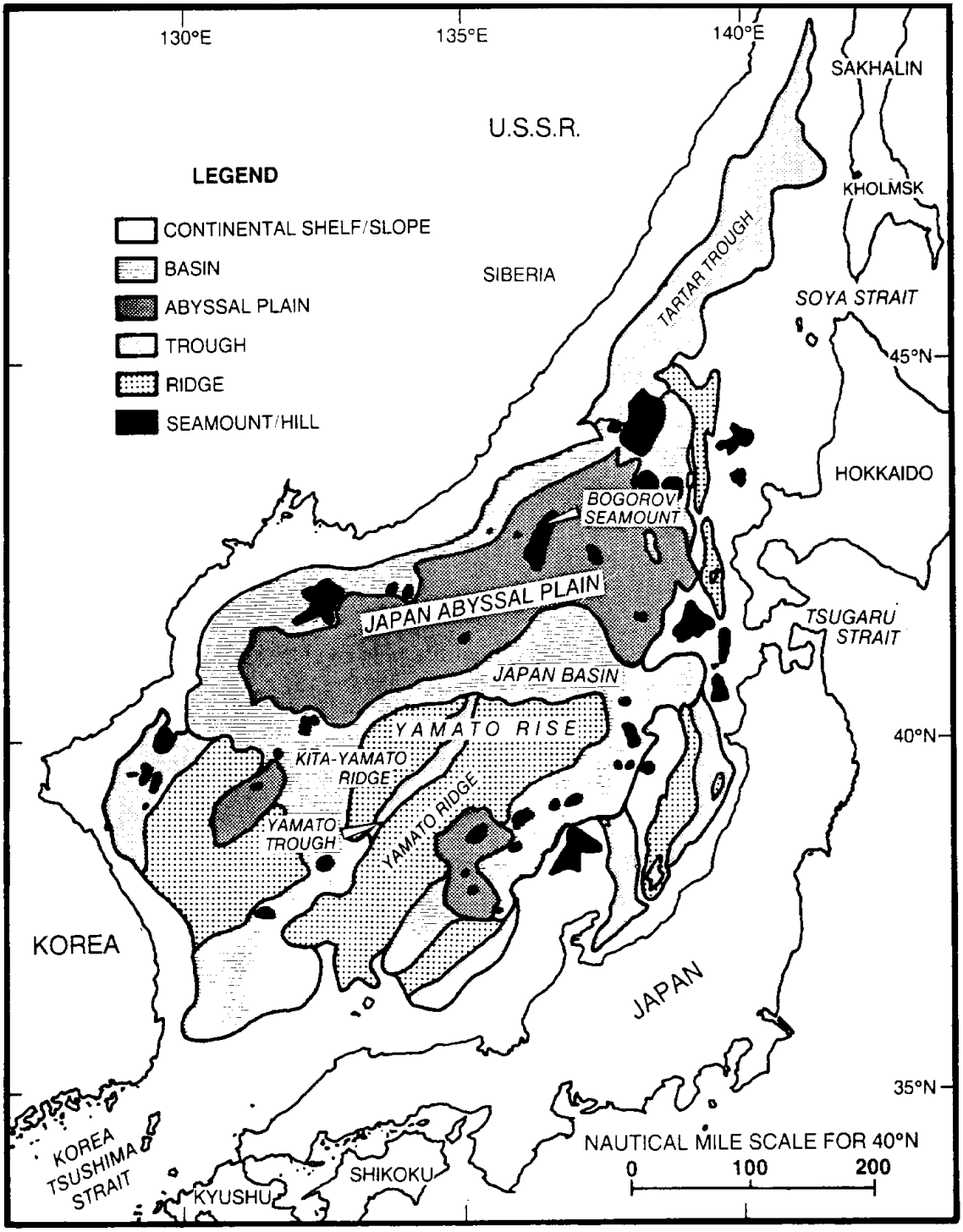
130°E
135°E
140°E
SAKHALIN
U.S.S.R.
LEGEND
CONTINENTAL SHELF/SLOPE
BASIN
ABYSSAL PLAIN
TROUGH
RIDGE
SEAMOUNT/HILL
KHOLMSK
SIBERIA
TARTAR TROUGH
SOYA STRAIT
45°N
HOKKAIDO
BOGOROV SEAMOUNT
JAPAN ABYSSAL PLAIN
TSUGARU STRAIT
JAPAN BASIN
YAMATO RISE
40°N
KITA-YAMATO RIDGE
YAMATO TROUGH
YAMATO RIDGE
KOREA
JAPAN
35°N
KOREA TSUSHIMA STRAIT
KYUSHU
SHIKOKU
NAUTICAL MILE SCALE FOR 40°N
0
100
200

Figure 3.2.2 Bottom Topography Sea of Japan

3.2.2. MAJOR OCEAN FRONTS AND CURRENTS

3.2.2.1. NORTH EQUATORIAL CURRENT (PACIFIC)

The beginning of the North Equatorial current can be found off the coast of Central America, traversing the Pacific in a east-west set analogous to the trades. These winds apparently dictate the strength and speed of the current. The North Equatorial Current is an integral portion of the transport system to return northern waters to southern regions. Characteristic speeds of this current is 0.5-2 knots. (Figure 3.2.3)

3.2.2.2. KUROSHIO CURRENT

The Kuroshio (translated as Black Stream) Current is the dominant ocean current of the western Pacific and resembles the Gulf Stream of the Atlantic. The Kuroshio begins east of northern Luzon in the Philippine Sea before flowing into the East China Sea northeast of Taiwan. In the East China Sea, the Kuroshio follows the Okinawa Trough between the continental shelf and the Ryukyu Ridge. The current then splits into two parts, with the major portion flowing east to south of Shikoku then northward along the southern coast of Japan. The minor branch flows northward through the Korean Strait as the Tsushima current.

During the northeastward set, the current accelerates to 2-5 kt with maximum speed occurring between 132o East and 137o East. While flowing northward, the current parallels the 3,000-9,000 ft (915-2,745 m) contour. (Figure 3.2.3)

3.2.2.3. KUROSHIO EXTENSION

The Kuroshio Extension is a continuation of the Kuroshio Current extending eastward from coastal Japan near 140o East to 160o East and meandering between 35o and 38o North. This meandering path forms a transition zone between the cold waters to the north and the warm subtropical waters to the south. (Figure 3.2.3)

3.2.2.4. OYASHIO CURRENT

The Oyashio Current originates in the Bering Sea and flows southwest off Kamchatka Peninsula and the Kuril Islands, entraining water from the Sea of Okhotsk. The Oyashio current then flows along the eastern coasts of Hokkaido and Honshu before curving eastward to parallel the Kuroshio Current before gradually merging with the Kuroshio Extension beyond 160o East. (Figure 3.2.3)

3.2.2.5. PERTURBED AREA (NORTHWEST PACIFIC)

The Perturbed Area is the boundary between the warm Kuroshio Extension Current and the cold Oyashio Current to the north. The area is roughly 200-300 nm wide and extends well past 160o East.

This boundary area is typically composed of a series of eddies and meanders. Warm eddies, 80 nm in diameter or larger, tend to be stationary and short-lived, while those at least 150 nm in diameter will have a lifetime of at least one year. These large eddies are formed when large northward meanders of the Kuroshio Current break off from the main current just off the eastern coast of Honshu. (Figure 3.2.3)

3.2.2.6. SEA OF JAPAN OCEANIC POLAR FRONT

The Sea of Japan is divided into two sectors based on currents: the warm sector on the Japanese side and a colder sector on the Korean and Siberian side. The warm sector is comprised of the Tsushima current and its extension, the warm East Korea, Tsugaru and Soya currents. The cold sector is comprised of the Liman, North Korean and Mid-Japan Sea Cold currents. (These currents will be covered in following sections.)

A persistent, year-round oceanic "Polar Front" along 38-40o North separates the two sectors. Eddy circulation patterns exist in the frontal zone with accompanying large horizontal variations of physical properties. (Figure 3.2.3)

3.2.3. SECONDARY, COASTAL AND COUNTER CURRENTS

3.2.3.1. EQUATORIAL COUNTERCURRENT

The Equatorial Countercurrent is a west to east flowing current related to the region of low winds speeds located between the northeast and southwest trades. It has its origins along the coast of the Philippines, moving eastward to the American coast. This current, present year round, lies just to the north of the Equator in winter and migrates northward with the shifting weather patterns in the summer. Speeds of up to 2 knots have been observed at the surface. (Figure 3.2.3)

3.2.3.2. KUROSHIO/SUBTROPICAL COUNTERCURRENT

The Kuroshio Countercurrent (KCC) flows north to south along the eastern edge of the Kuroshio transporting large amounts of water southward. Water transport is dependent on the strength of the Kuroshio Meander. The development or continuity of the countercurrent depends on the displacement north of the Kuroshio. It sometimes consists of only sporadic portions along the Kuroshio.

The Subtropical Countercurrent (STCC) connects with the Kuroshio Countercurrent. The STCC will normally be found between 20o North and 24o North. Found throughout all seasons, it is usually best developed during winter. (Figure 3.2.3)

3.2.3.3. EAST SAKHALIN CURRENT

The East Sakhalin Current is part of the cyclonic circulation (Okhotsk Gyre) flow that dominates the Sea of Okhotsk. This oceanic circulation is connected with the atmospheric circulation above the Sea of Okhotsk and the Western Pacific.

The East Sakhalin Current is a narrow nearshore counterclockwise current. It begins in the southeast basin near Kamchatka where water is forced from the Pacific through the northern Kuril Island Straits. (Figure 3.2.3)

3.2.3.4. SOYA CURRENT

The Soya Current flows through the LaPerouse (Soya) Strait that separates the islands of Hokkaido and Sakhalin. The complex topography and extended shelf (depths of less than 650 ft/198 m) results in large fluctuations in volume, speed and path of the warm current flowing into the strait. The Sea of Japan Oceanic Polar Front (previously discussed) and cold waters to the north and west also hinder flow into the Soya Current. At its strongest, the Soya Current will occupy only the southern portion of the strait with cold water in the northern portion. The resulting oceanic front separating the two water masses is quite sharp with current speeds of 1-2 knots within the warm water.

After exiting the strait, the Soya Current turns south along the coast of Hokkaido. This portion is strongest during late summer and will disappear at the surface during the winter. (Figure 3.2.3)

3.2.3.5. TSUGARU CURRENT

The Tsugaru Current is an extension of the Tsushima Current. Due to island topography and shallow sill depth (425 ft/130 m), the current through the channel forms a core approximately 11 nm wide. On either side of the core are eddies which appear to be trapped due to topographical configuration. Maximum current speeds reach 4.5-5.5 knots during the spring tidal phase of summer and winter.

The Tsugaru Current extension into the Pacific displays distinct variations in patterns between periods of weak and strong transport. An extensive anticyclonic gyre is observed during strong outflow mainly in the summer and fall seasons. During weak outflow a coastal pattern is observed and seen mainly in the winter and spring. (Figures 3.2.3/3.2.4)

3.2.3.6. LIMAN, NORTH KOREA, MID-JAPAN SEA COLD CURRENTS

The cold sector of the Sea of Japan is comprised of three cold currents: the Liman current which flows along the Siberian coast, the North Korea current from Vladivostok to the central east Korean coast and the Mid-Japan Sea Cold Current which flows eastward into the central portion of the Sea of Japan. (Figures 3.2.3/3.2.4)

3.2.3.7. TSUSHIMA CURRENT

The Tsushima Current is a warm current that branches off from the left side of the Kuroshio, flowing first through the eastern East China Sea and then entering the Sea of Japan through the Tsushima (Korean) Strait. The main portion of the Tsushima current flows northeastward through the eastern portion of the Sea of Japan.

The Tsushima Current is the source of all the warm currents within the Sea of Japan. The Tsugaru and Soya Warm Currents are the northern extension of the Tsushima as it flows out of the Sea of Japan through the Tsugaru and Soya Straits, respectively. The East Korea Warm and Yellow Sea Currents are western extensions of the Tsushima Current. (Figures 3.2.3/3.2.4)

3.2.3.8. EAST KOREA CURRENT

The East Korea Current diverges from the Tsushima Current upon entering the Sea of Japan. It then flows northward along the Korean coast as far north as Yongil Bay, turning southeast to rejoin the Tsushima Current near 39o North. (Figures 3.2.3/3.2.4)

3.2.3.9. YELLOW SEA CURRENT

The Yellow Sea Current branches from the Tsushima Current near western Kyushu and flows northward into the middle of the Yellow Sea. The speed of the current is less than 0.5 knot. It develops in spring and summer and decays in the fall and winter. (Figure 3.2.3)

3.2.3.10. CHINA COASTAL CURRENT

Completing the gyre of the Yellow Sea is the China Coastal Current which flows southward along the coast. Although present year round, the current strengthens during the winter as it is accelerated by the strong, persistent Northeast Monsoon. (Figure 3.2.3)

3.2.3.11. SOUTH CHINA SEA CURRENTS

The monsoon winds control the surface currents flowing into the South China Sea. In the winter, the surface flow is from the north through the Taiwan Straits and Bashi Channel and from the east

through the Balabac Strait. The flow is generally south. The outgoing flow is mainly through the south into the Java and Flores Seas through the Karimata and Gasper Straits and a little to the west through the Malacca Straits.

During summer months, the surface flow will reverse moving from the Flores/Java Seas through the Karimata and Gasper Straits and entering the South China Sea between Malaysia and Borneo. The flow is generally to the northeast.

3.2.3.12. SULU SEA CURRENTS

During the summer, surface currents in the Sulu Sea are generally southward at rates up to 1.5 knots. During winter, a counterclockwise current system exists in the Sea.

3.2.3.13. SULAWESI (CELEBES) SEA CURRENTS

Surface currents, during the summer, are mainly directed from Mindanao toward the Makassar Strait. During winter months, the south and southwestward current systems are maintained for the larger part of the sea.

3.2.3.14. MINDANAO CURRENT

The Mindanao Current is formed when the North Pacific Equatorial Current encounters the Philippine Islands. Part of the water carried by this current is directed southward toward Mindanao Island. The Mindanao Current carries a significant portion of the North Pacific Equatorial Current along the Philippine Islands between 10o and 5o North before it turns eastward. It merges with several other currents to form the North Equatorial Countercurrent that returns eastward.

3.2.4. GENERAL OCEANOGRAPHIC CONDITIONS

A complete review of ocean thermal and acoustic properties and resulting sound propagation characteristics is beyond the scope of this handbook. General oceanic and acoustic conditions will be discussed.

3.2.4.1. WESTERN NORTH PACIFIC

The change in thermal properties across the Kuroshio Extension and Oyashio Currents is one of the largest found in the open oceans. The thermal variation is most pronounced below the seasonal surface layer and above the deeper stable waters. The gross structure of thermal features across this boundary zone can be detected in satellite infrared imagery during the seasons when the surface has not been heated sufficiently to mask thermal contrasts.

The depth of the Sound Channel Axis (SCA) rises rapidly northward across the Perturbed Area, being very near the surface poleward of 42o North during the warmer months. This is due to the surface warming of the waters. During the colder months, the sound speed minimum reaches the surface and the sound channel will disappear north of 42o North. Sound energy is then transmitted by half-channel mode.

South of the Kuroshio Extension, a deep sound channel is found between 4200-4750 ft (1281-1450 m) in the western area, rising to about 3700-4000 ft (1150-1450 m) near 160o East.

Generally, the highest sea state is found during the winter as the strongest mid-latitude systems migrate through the area. Sea ice may be found during the late fall through early spring along the seaward areas of Kamchatka, the Kuril islands and Hokkaido.

3.2.4.2. SEA OF OKHOTSK

The sound channel axis is located at the surface during the colder months and half-channel mode conditions prevail. During the warmer months, the surface heating results in a near surface sound speed maximum and a shallow SCA. The Sea of Okhotsk begins to freeze in coastal locations during November, reaching its peak ice coverage during March and is nearly ice free by June. Coastal ice will form first in the northeastern and northwestern extremes, then along the remainder of the northern and western boundaries and the Kamchatka Peninsula. The ice edge then advances toward the center of the basin, reaching maximum coverage by March. The sea surface will not completely freeze over except during an unusually cold year.

3.2.4.3. SEA OF JAPAN

Large seasonal changes occur in the thermal properties of the near-surface waters. During late summer and autumn, a convectively mixed two-layered thermal structure prevails. As the cold air flows over the surface removing heat from the near surface-layer, the seasonal mixed layer and thermocline are destroyed resulting in a surface-to-bottom homogeneity in the cold sector. In the warm sector, a deep thermocline persists throughout the year as the winter cooling is not sufficient to completely remove the heat and destroy the thermocline.

Full channel conditions exist throughout the entire Sea of Japan in the summer and autumn and year-round in the warm sector. During winter and spring, half-channel conditions are found in the cold sector. Highly variable conditions will be found in the vicinity of the frontal zone.

A general decrease in depth of the sound channel axis occurs from east to west and south to north. The deepest axis is found in the Korean Strait 1640-2000 ft (500-600 m) in association with the Tsushima Current. Near the central Japan Islands, in the area of the Tsushima Current, the axis is found near 1300-3000 ft (397-915 m). Values off the Siberia coast range from surface to 650 ft (0-198 m).

Sea ice begins to form in the Tartar Straits around mid-November and in the northern Sea of Japan by mid-February. Along the northern coast of Korea, sea ice is limited to coastal bays and harbors.

3.2.4.4. YELLOW SEA

The circulation of the Yellow Sea is strongly influenced by regional atmospheric forcing and bottom topography. The major ocean currents play only a limited role in the circulation. The atmospheric monsoon regime that prevails over the area provides cyclic seasonal changes that dominate the region's oceanographic processes. Atmospheric forcing occurs in two modes: in winter, cooling and mixing occur due to strong, cold, dry northerly winds; and in the summer, extensive precipitation, river run-off and solar heating occur which produces a well-stratified water column with a warm, low-salinity surface layer. Seasonal conditions are further agitated by strong winter cold outbreaks and occasional summer typhoons.

The Yellow River is the major source of fresh water influx into the southwest region of the Pohai. Other sources include the Luanhe and Liaohe Rivers entering the western and northern Pohai and the Yalu, Han and lesser rivers of Korea.

Two regions of upwelling are found in the Yellow Sea: the eastern region of the Shandong Peninsula and off the southern tip of Liaodong Peninsula. Water temperatures off the tips of these two peninsulas are found to be 3-5o C lower than surrounding areas during May and August. Cold water from upwelling extends seaward 15-30 nm off the Shandong Peninsula, while the Liaodong Peninsula upwelling is limited to about 10 nm off the coast.

Sea ice is observed as far south as 36o North along the Korean coast and south of the Shangdong Peninsula. The major concentration of sea ice (0.1-0.4 octaves coverage) is limited to the western and northern Gulf of Pohai and eastern Korea Bay.

3.2.4.5. EAST CHINA SEA

The East China Sea is influenced by the same atmospheric forcing as discussed in the Yellow Sea. The conditions within the East China Sea are influenced on the western side by the discharge of the Yangtze River and on the eastern side by the Kuroshio Current, its branches and extensions which mix with coastal waters.

Coastal upwelling occurs off the Zhejiang Peninsula (Chinese coast north of Taiwan to near 30o North), mainly as a summer phenomena and is directly related to the intensity of the Southwest Monsoon surface wind.

Tidal currents show a wide variety of ranges, especially in the vicinity of islands. Maximum heights of 2-3 feet (.5-2.8 m) occur around the Ryukyu Island with tidal current speeds of 2-3 knots. Tidal ranges of 15-20 ft (4.5-6 m) occur around Taiwan and to over 30 ft (9 m) in the mainland Hangchow Bay southwest of Shanghai.

3.2.4.6. PHILIPPINE SEA

Several major currents affect operations within the Philippine Sea: the North Equatorial Current, the Equatorial Countercurrent, the Kuroshio Countercurrent, the Subtropical Countercurrent and the Kuroshio Current. Origins and tracks of these currents were covered in previous sections.

The correlation between oceanic fronts and large bottom slopes are a common feature within the Philippine Sea. These conditions present special problems to ASW operations as grid point or single point data do not account for the loss or redirection of bottom bounce propagation.

The SCA is quite deep throughout the area with a maximum depth of over 4900 ft (1495 m) year round near 30o North, 135o East. The SCA rises to about 2300-2600 ft (702-793 m) near the western and northern boundaries except during winter when the channel depths are about 2900-3200 ft (886-976 m). Water depths are a limiting factor not only in coastal areas but over the lesser depths along the Ryukyu and Mariana/Bonin Island Chains.

3.2.4.7. SOUTH CHINA SEA

The temperature structure of the water column between the surface and 650 ft (198 m) is influenced by the seasonal changes that take place over the region.

During the winter season northeast winds dominate the South China Sea deflecting surface water toward the Vietnamese coast. The mixed layer above the sharp thermocline becomes deeper near the coast as surface water is deflected and reaches depths of 500 ft (153 m).

The summer southwest monsoon winds develop strong southerly currents that extend all along the coast and through the South China Sea. The thermocline rises and pronounced upwelling takes place near the coast with the maximum upwelling occurring off the coast of south-central Vietnam.

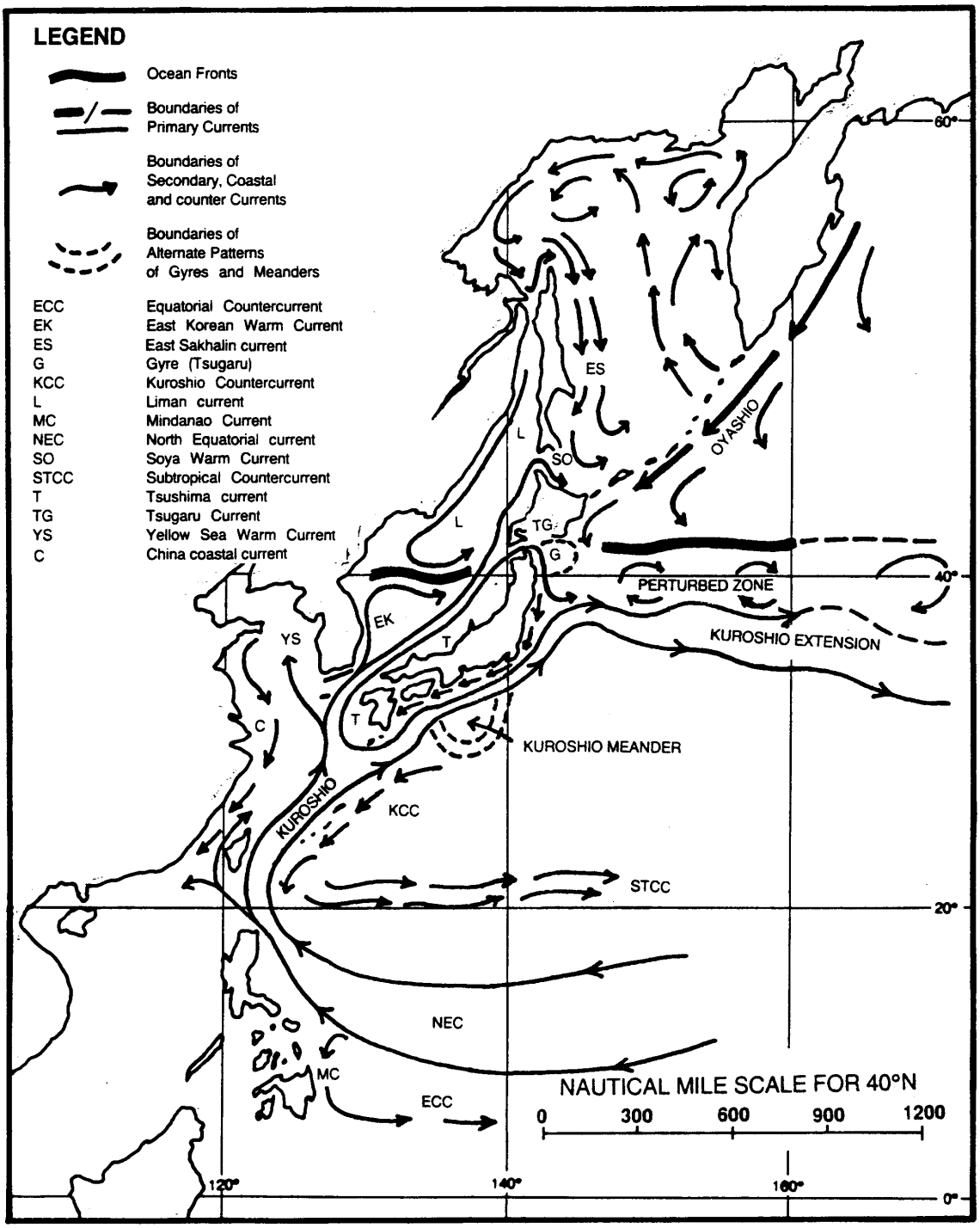

Figure 3.2.3 Northwestern Pacific Ocean Fronts and Currents

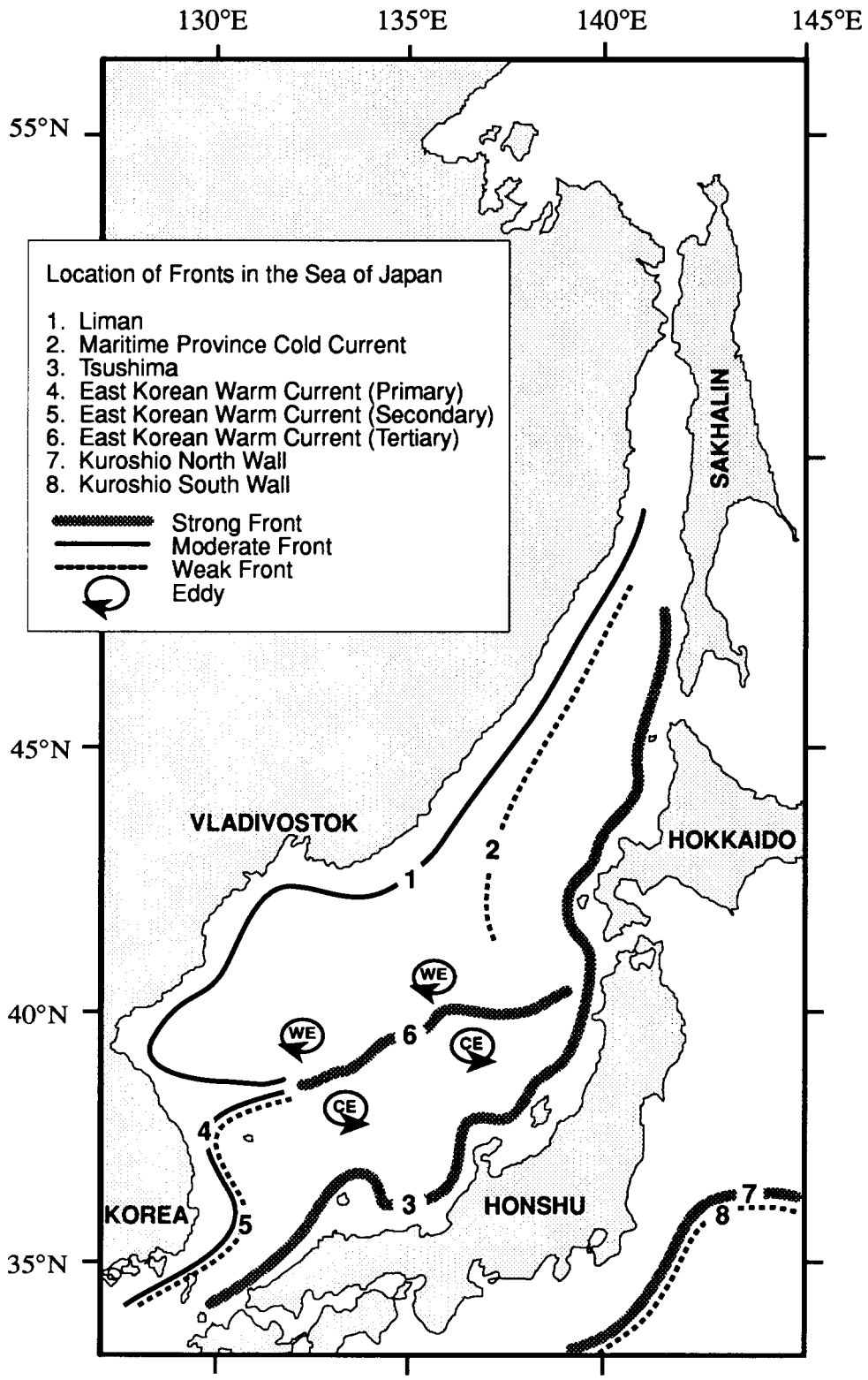

Figure 3.2.4 Sea of Japan Ocean Fronts and Currents

3.3. METEOROLOGY

The climatology discussed within this section covers from the Arctic areas to the Equator. General large scale features will be discussed first. Some generalized local features affecting water areas will also be discussed.

3.3.1. MIGRATORY LOWS

3.3.1.1. SEASONAL STORM TRACKS

Numerous storm systems develop, dissipate and regenerate in the Northern Hemisphere. Storms which develop and move across the Atlantic Ocean fall into two general categories as they approach Europe and Asia: (a) storms which move northeastward through Iceland, into the Barents Sea, then southeastward through Asia and (b) the mid-latitude storms which move through the Mediterranean Sea (these will be covered in a future chapter). Tracks of category (a) include:

1. The Icelandic Storm Track is defined as those storms which move through Iceland and the Barents Sea then drop southeastward toward Mongolia.
2. The Siberian Storm Track is defined as those storms which move through Iceland and are routed northward over Franz Josef and Spitsbergen by a sharp amplitude long wave ridge, then drop southward toward the Sea of Japan.
3. The Yellow Sea, Shanghai and Taiwan Storm Tracks (Southern Storm Tracks) are defined as dynamic by-products of the numerous splits in the storm track impulses which move across Asia.

Tropical cyclone tracks will be covered in detail in future chapters.

3.3.1.2. NORTHERN LOWS

The Northern Lows will normally generate/regenerate in northern China or southern Russia. The lows will then depart their source regions tracking eastward to the northern Sea of Japan/Sakhalin Island before reaching the Western Pacific. These low pressure systems are all formed by movement of upper level short wave troughs through low pressure source regions. These systems are enhanced by downslope adiabatic warming as they traverse from their mountainous regions toward the coast.

1. LAKE BAIKAL LOW - Develops in the vicinity of Lake Baikal in central Siberia as winter storms progress along the Siberian Storm track. This system may develop during any season but is most common during spring. The average speed of this system is 22 knots. The track of the Lake Baikal Low (similar to the Manchurian Low) passes through the Soya (La Perouse) Straits before entering the northern Western Pacific. Again, very little weather is associated with the Lake Baikal Low until it reaches the open waters of the Pacific. (Figure 3.3.1)

2. MANCHURIAN LOW - Develops over the northern border of Manchuria, moving eastward over central Sakhalin Island before exiting into the Sea of Okhotsk. This system occurs primarily during the autumn and spring. Average speed of this system is 20 knots. The Manchurian Low generally has very little weather associated with it since the source region of Siberia offers little moisture until reaching the open ocean. (Figure 3.3.1)

3. SOUTH MONGOLIA LOW - Caused by leeside troughing over the Altai Mountains when a storm impulse aloft approaches from the west along the Icelandic Storm Track. It generally tracks from its source region southeastward to northern North Korea before exiting into the Sea of Japan. The South Mongolian Low will normally turn to the northeast, tracking over Hokkaido before reaching the southern Sea of Okhotsk and the Western Pacific. It can develop during any season, with an average speed of 20 knots. (Figure 3.3.1)

3.3.1.3. SOUTHERN LOWS

The Southern Lows generally form over central and southern China, then track eastward to either the Sea of Japan or south of Japan between Kyushu and Okinawa. These systems may occur year round and produce widespread precipitation, low ceilings, poor visibility and occasional squall lines. The source region for the three major systems in this group is the Shanghai area. The generation area of the supporting upper level short wave troughs which form these lows and their subsequent tracks further delineates these systems.

1. YELLOW SEA LOW - Occurs primarily during the summer and autumn, tracking at an average speed of 20 knots. It develops in the area between Shanghai and Osan and tracks to the northeast over Korea, through the Sea of Japan and across northern Japan to the western Pacific. This system may also produce a double-eyed system south of Kyushu or Shikoku within 12 to 18 hours after entering the Yellow Sea. Without development of the "double-eye" system, strong southwest winds will develop on the leeside of Japan. (Figure 3.3.1)

2. SHANGHAI LOW - Occurs most frequently during the spring. The Shanghai Low is subject to rapid intensification as it moves over the warm waters of the Kuroshio current (much like the "Hatteras Low" along the east coast of the U.S.). It moves from the source region in central China, often developing along a stagnating frontal system, tracks to the east or northeast to the southern coast of Japan. The average speed of the system is 20 knots as it passes south of Kyushu. The main low center sometimes tracks into the Sea of Japan with a secondary low forming on the leeside of Japan near Shikoku. The two low pressure centers of this double-eyed system will track northward together until they merge over northern Honshu/southern Hokkaido and move into the Western Pacific. (Figure 3.3.1)

3. TAIWAN LOW - Generates over China near 250 North and 1000 East, occurring most frequently from autumn through spring. This system will form as a wave on an active stationary front and track northeastward at an average speed of 25 knots. The Taiwan Low will always pass south of Japan; however, depending on the long wave pattern, the system may pass close enough to Japan to produce precipitation over the islands. Wave formation along the front associated with a Taiwan low is common and forms under several circumstances:

a. Formation of a migratory high over mainland China with an eastward track over Honshu. A wave will form behind the high as it resides and the front stagnates. This wave will then move eastward over southern Honshu.

b. During late spring through early autumn, a cyclone family will form along the polar front generated by low formation. If the system takes a more northerly track, north of 32o North, precipitation will dominate the Japanese islands. (Figure 3.3.1)

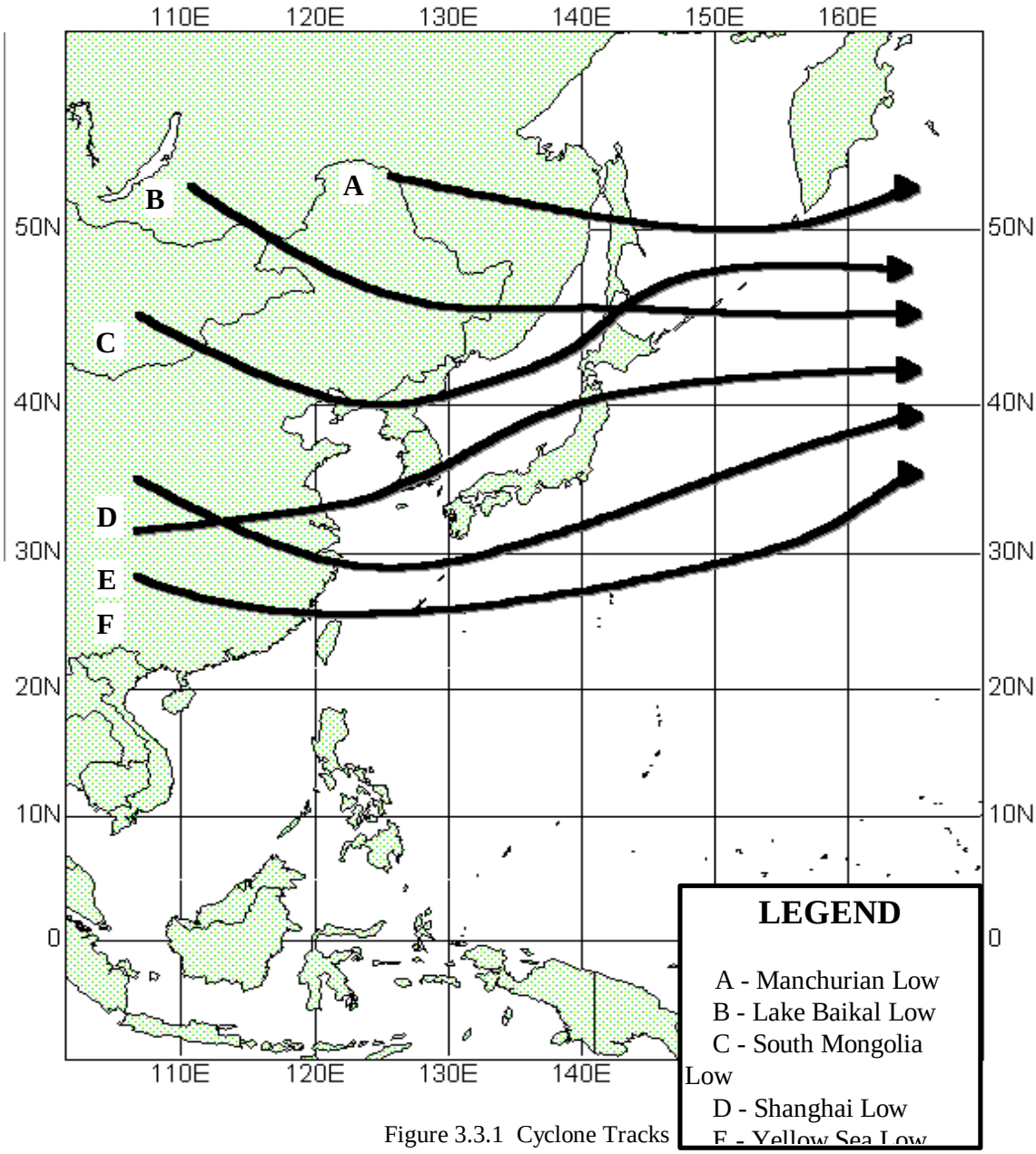

Figure 3.3.1 Cyclone Tracks

3.3.2. STATIONARY SYSTEMS

3.3.2.1. SEA OF OKHOTSK LOW

A stationary system will develop in the Sea of Okhotsk extending from the surface through the 500 mb level. This system serves as the anchor low, indicating that the long wave trough is in the vicinity of 150o East. Lows tracking along the northern storm tracks will be steered toward the anchor low. Northern systems will be relatively dry as migratory lows will not reach the western Pacific. Further development of the Shanghai and Taiwan lows will be supported when strong impulses move along the

central and southern storm tracks. Combination of the anchor low with the dynamic system causes a retrograde action of the long wave to a northeast-southwest orientation.

3.3.2.2. MEI-YU (CHINA/TAIWAN)/BAI-U (JAPAN) FRONTS

The Mei-Yu/Bai-U front is a quasi-stationary system occurring during the transition period between the Northeast Monsoon in the winter and Southwest Monsoon in the summer. The front initially develops as the western extension of the subtropical high extends over southern China and Taiwan. Dissipation occurs when the seasonal monsoon becomes fully established.

The Mei-Yu/Bai-U front is a subtropical front with differing characteristics than those associated with a Polar front. It is a relatively shallow feature, developing only in the lower troposphere, thus characterized by only a narrow band of precipitation with areas of embedded showers and isolated thunderstorms. A significant low-level jet (LLJ) is also associated with the Mei-Yu/Bai-U front. Jet maxima are located near the 700 mb level and usually 180 nm southeast of the most active areas of convection.

Weak mesoscale circulations, with embedded clusters of convective cells, compose the frontal structure of the Mei-Yu/Bai-U front. Along the active front in the vicinity of Taiwan, frontal lows develop every 17 to 20 hours, moving eastward at 10-15 knots. South of Japan, lows form every 20 hours; however, the speed of movement increases to 25-30 knots. Deepening of these lows will occur if the front interacts with a mid-latitude upper level trough east of 135o East.

3.3.3. CYCLOGENESIS

3.3.3.1. INTRODUCTION

The east coast of Asia and the south coast of Japan provide a naturally favorable climate for recurring cyclogenesis. Continental polar air masses are either in close proximity to warm maritime air masses or are undergoing rapid modification as they move over the warmer waters of the East China Sea, Yellow Sea or the Sea of Japan. Several synoptic patterns that aid in cyclogenesis or frontogenesis are described in the following sections.

3.3.3.2. BUBBLE HIGH CYCLOGENESIS

The most reliable indicator for cyclogenesis in the cool season is the off-shore movement of a cold, migratory high pressure cell from the Siberian High commonly known as a “Bubble High”. Cyclogenesis will normally occur 24 to 48 hours after the high moves off the coast. Its location will roughly correlate with the latitude of the Bubble High. Highs that track north of 35o North will generate lows that move into the Sea of Japan. Highs that track south of 30o North will generate lows that move south of Honshu. Cyclogenesis will normally occur in the Yellow or East China Seas (Yellow Sea or Shanghai Lows respectively). (Figure 3.3.2)

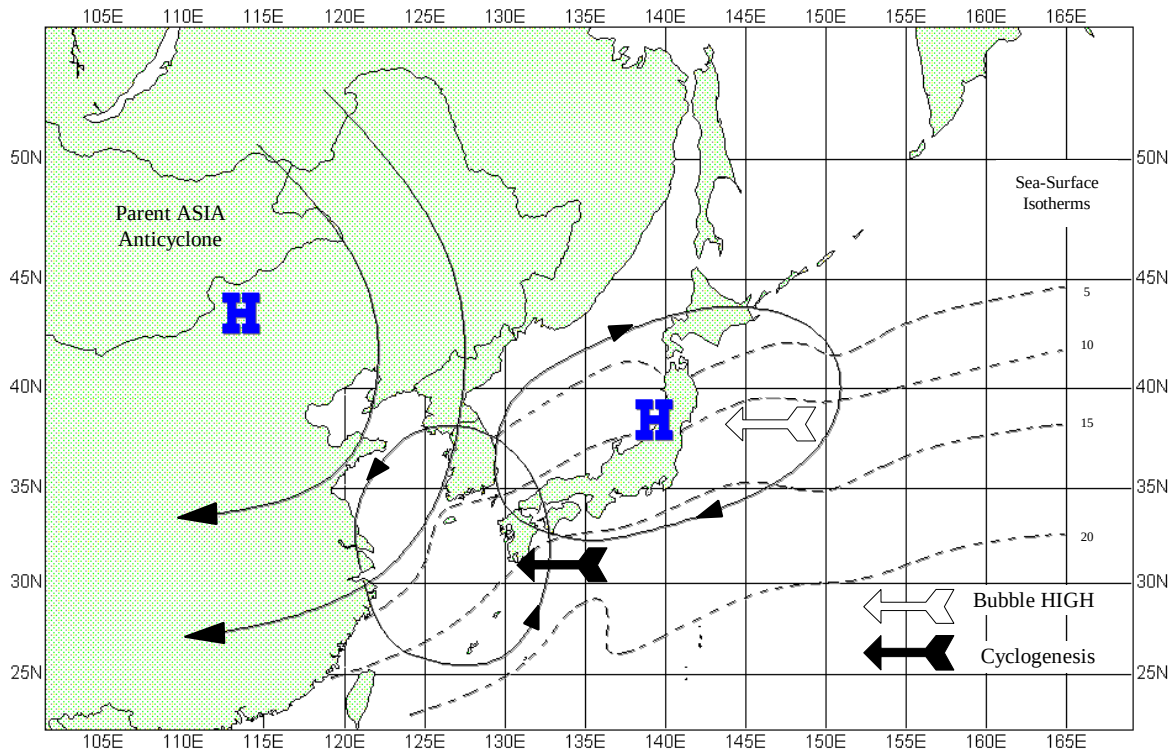

Figure 3.3.2 Bubble High Cyclogenesis

Highs moving off-shore between 30-35o North produce lows whose movement depends upon their position within the jet stream. Lows that develop north of the jet will initially move southeast toward the southern boundary of the jet, deepening rapidly as they pass under the jet core.

Bubble High Cyclogenesis has been such a consistent weather phenomena that it can be reliably forecasted with little error. The lag period between the high moving offshore and the formation of the low is 24-36 hrs in the winter and 36-48 hrs in the spring and summer.

If a pre-existing low exists to the northwest of the area of cyclogenesis when the high initially moves off-shore, two cyclones or one elongated north-south cyclone south of the bubble high will usually form. This system will become better organized as it reaches the East China Sea, having moved off the central China coast, producing a Shanghai Low. This pattern is typical during the winter and has a lag period of 24 hrs.

When a pre-existing cold front is present to the northwest of the bubble high, cyclogenesis will usually occur along the front in the vicinity of the northern Yellow Sea. The low, with an inactive warm front, will move northeastward through the Sea of Japan. This Yellow Sea Low usually occurs in early or late winter and has a time lag of 24-36 hrs. If cyclogenesis doesn't occur, weather will be restricted to a narrow band along the front.

When no existing low or front is present at the time of cyclogenesis, a wave cyclone will form in the central and southern coastal regions of China and move along the southern coast of Japan, producing a Taiwan Low. These lows usually occur in spring and autumn, with a lag period of 36 hrs and will usually take 3 to 4 days to pass east of the Japanese coast. Once these lows form, they deepen rapidly, averaging a 10-15 mb pressure drop in 24 to 36 hrs. This rapid deepening of the Taiwan Low is due to favorable upper air conditions, but primarily due to the thermal contrast between land and water.

3.3.3.3. COOL SEASON CYCLOGENESIS

Cyclogenesis will occur along the southern coast of Japan when surface troughing is evident over the Kuroshio current south of Japan, the pressure gradient is weak, upper level short wave troughs moving through the area are slow and the air-sea temperature difference is greater than 13o F (7o C). Lows developing in this area are called "Oshima Lows" since they develop in the vicinity of Oshima Island. The development of this low is seen as a wave on the 850 mb level with a developing system in the Sea of Japan near 125-130o East. Another indication of low formation is the presence of a low-level jet from the south in the vicinity of Hachijo Jima.

During cool season cyclogenesis, there is a marked onshore flow over southern China with cold continental air in close proximity to cool maritime air. Development of a Taiwan Low is possible during this period. An 850 mb short wave trough bringing a surge of cold air to the area will be a major factor influencing cyclogenesis.

3.3.3.4. WARM SEASON CYCLOGENESIS

A short wave trough moving into a well defined cool/cold tongue indicates a possible area of cyclogenesis. Cyclogenesis will usually occur when the short wave trough approaches to within 41-50o F (5-10o C) of the cool tongue of air. Warm Season Cyclogenesis is most prevalent in the Yellow Sea and Sea of Japan.

3.3.3.5. STATIONARY FRONT CYCLOGENESIS

Cyclogenesis along a stationary front south of Japan generally occurs when the following two conditions are met: upper level winds must be from the west to southwest and the front is stalled within 300 nm of the southern Japanese coast. The formation of a lee-side depression between Oshima Island and Hamamatsu will occur when the low-level winds along the southern coast are from the west-southwest and from the north-northeast along the southeastern coast of Honshu. Cyclogenesis will be indicated by thermal packing on the 850 mb chart.

Cyclogenesis along the stationary front will also occur when an upper level, cold low is located in the Manchuria-Siberia region, with cyclonic flow occurring near the polar front.

3.3.3.6. TRANSITION SEASON CYCLOGENESIS

An area of possible cyclogenesis will establish itself off southern Kyushu in the deep cool easterly flow, becoming active when the gradient winds along the southern coast of Japan veer northeasterly and the 850 mb winds are light and southerly. This pattern typically occurs in the spring when the ridge line is established over the Kanto Plain.

During late summer and early autumn, the subtropical ridge will establish a deep easterly flow over Japan and low-level cool air is present in the generating area, such as when a cool high pressure system tracks southeastward off southern Japan and advects cold air into the region. The trigger is usually a short wave trough moving over the Korean peninsula.

3.3.3.7. LEE-SIDE DEPRESSIONS

Weakening of the local pressure gradient over the Sea of Japan accompanied with moderate to strong west to southwest low level wind flow parallel to the mountains of southeast Japan will generate lee-side depressions/troughs along the southeast coast of Japan.

Lee systems may develop when these conditions exist :

1. Northerly flow along the mountains of south central Honshu.
2. A short wave approaching the area.
3. A low moving through the Sea of Japan.
4. Cold fronts approaching Japan, parallel to the coastal mountains.

Pressure falls and troughing will occur south of Kyushu and/or Shikoku. These systems should be closely monitored for explosive deepening and rapid movement.

3.3.4. MIGRATORY HIGHS

Many regions of Asia are favorable high pressure producers due to extensive hours of darkness over vast cold land masses during the winter seasons. As with the low pressure systems discussed above, these high pressure systems follow a definite pattern or track according to the season. There are three significant stagnating, semi-permanent high pressure cells from which dynamic highs affecting the Western Pacific originate. These cells are predominantly cold weather features which disappear during the summer months. They are important to the forecaster since they give a “first-glance” clue to the presence or absence of blocks to winter storm tracks.

3.3.4.1. WEST LAKE BAIKAL HIGH

The West Lake Baikal High is a semi-permanent feature which will disappear for short periods under the influence of impulses traveling along the Icelandic track. When the West Lake Baikal High is firmly established, a storm must track either along the Siberian storm track or along the southern track. The West Lake Baikal High has the highest central pressure of any system in the Northern Hemisphere, averaging 1055 mb and reaching 1088 mb during very cold winters.

3.3.4.2. EAST LAKE BAIKAL HIGH

The East Lake Baikal High is mainly a summer and early autumn feature. This high will generally move to the southeast over northern Korea, through the Sea of Japan and over northern Honshu and Hokkaido.

3.3.4.3. NORTHEAST LAKE BAIKAL HIGH

The Northeast Lake Baikal High is a semi-permanent feature which disappears for short periods of time under influence of strong impulse traveling along the Siberian or Icelandic Storm Tracks. When the high is firmly established, a blocking situation sets up along the northern tracks. At various times during a winter season, the Northeast Lake Baikal and the West Lake Baikal High will combine into one smoothed system, the Siberian High.

3.3.5. WESTERN PACIFIC MONSOONS

3.3.5.1. INTRODUCTION

A significant portion of eastern Asian weather is dominated by the Asiatic monsoon. Monsoon, derived from the Arabic word “Mausim”, was originally applied to the wind regimes of the Northern Arabian Sea. This will be covered in a later chapter. Monsoon is usually defined in terms of seasons.

Surface winds will generally blow from one direction during one season and from a markedly different direction during another season.

3.3.5.2. NORTHEAST WINTER MONSOON

The Northeast Winter Monsoon is a result of the strong high pressure cells which dominate Siberia in the winter. As high pressure cells migrate southeastward, they result in a strong north to northeasterly wind flow over eastern Asia and adjacent waters. The winter monsoon season dissipates as the cold highs weaken during the spring, resulting in the migration of the Polar Front north to its summer position.

3.3.5.3. SOUTHWEST SUMMER MONSOON

Conversely, during summer months, thermal lows develop over Asia, creating the Southwest Summer Monsoon. Warm, moist air is transported northward over the coastal areas of Asia. The Southwest Monsoon of Asia is less intense than that of the Indian Ocean. This is due to :

1. Less intense heating at higher latitudes resulting in a weaker thermal pattern.
2. Periodic invasions of cold air from the north.
3. A wider range of sea surface temperature.
4. The periodic formation of an extratropical or tropical cyclone which eliminates the heat low.

Gale force winds seldom occur and then only when associated with strong flow into a tropical cyclone or with channeling through constricted waters such as in the Taiwan-Luzon Straits.

3.3.6. SEASONS

Generally, the seasons of the northern Western Pacific (north of 35° North) are similar to other mid-latitude areas. The seasons south of 35° North are defined in terms of monsoon activity.

	North of 35° North	**South of 35° North**
November through March	Winter	Northwest Monsoon
March through May	Spring	Transition
May through October	Summer	Summer Monsoon
October through November	Fall	Transition

These seasons may show variation of up to two weeks. The most reliable transition is in the fall, due to the fast transition of the hot-cold regions of central and southern China and Russian Siberia. The coming of a cold surge signals the end of the southwest monsoon. The spring transition has many vacillations between southwest and northeast before the heat low becomes firmly entrenched in Central Asia.

3.4. FORECASTING RULES

Forecasters need to understand the climatological aspects of the area for which they are forecasting. Forecasters must also understand the limitations of forecast aids and the effect topography has on these aids. This section will explain model tendencies and local effects gathered over years of experience by many forecasters.

3.4.1. NOGAPS 3.4 MODEL TENDENCIES

3.4.1.1. SURFACE PRESSURE LOW

Developing oceanic surface lows tend to be underforecast (weak) and slow to deepen with an Average Center Pressure Error (ACPE) of 2 to 3 mb weak by 48/72 hr. Filling oceanic lows tend to be overforecast (deep) and slow to fill after bottoming-out with a center pressure error of -3 to -4 mb by 48/72 hr. Directional bias for deepening or filling lows is very slight. However deepening lows tend to be behind the analyzed track, especially in zonal flow. Mature filling lows tend to be to the left of the analyzed track (toward the cold air) in meridional flow.

Surface lows north of the jet tend to be too deep. Lows forming to the south of the jet and bottom-up type of developing lows are minimally slow to deepen. Land lows are usually deep throughout with an ACPE of -3 to -5 mb by 48 hr.

Initial and secondary cyclogenesis in association with U/L short-wave troughs has improved from previous models. Systems still tend to be weaker and slow to deepen and move. Secondary cyclogenesis is minimally underforecast and slow moving.

Complex lows tend to be merged into one slightly deeper system, especially near the northern Japanese Islands. Lows moving though the Sea of Japan will tend to form leeside systems. Indications of leeside formation are normally 12-24 hr later than actual time. If the model indicates a secondary system, it will be reflected as an elongated isobar rather than a separate system.

Surface lows associated with the formation of U/L cut-off lows, mainly in the cool season, are minimally overforecast (deep). Mature cut-off lows are slow to fill after bottoming out. Occasionally, NOGAPS exhibits a False Alarm forecast tendency by overforecasting the deepening rate of surface cut-off lows, especially at the extended forecast periods. The instances of overforecasting of “cut-off lows” may reflect the occasions where valid ship reports are erroneously rejected by the operational Optimum Interpolation (OI) surface analysis.

Extra-tropical lows associated with former tropical cyclones are significantly underforecast and slow to move.

Tropical cyclone (TC) development/intensification rate is generally overforecast even before the automated bogus input is made. In the development stage, forecast TC’s are slow to move. After reaching maximum intensity, mature TC’s continue to be slow to move.

1. During the primary NWPAC tropical cyclone season, (June through November), cyclone development tends to be overforecast in the size of the circulation even before the automated tropical cyclone bogus in input to the OI analysis.

2. NOGAPS tends to overforecast the number of TC systems, especially at the extended forecast period.

3.4.1.2. SURFACE HIGH PRESSURE SYSTEMS

The western oceanic high pressure cells tend to be slightly stronger by 48 hr.

Mid-ocean high pressure cells tend to be 1 to 2 mb stronger than actual by 48 to 72 hr.

3.4.1.3. UPPER LEVEL

Upper level (U/L) troughs moving in zonal flow tend to be “fast to move” at the extended forecast period.

U/L short-wave troughs in strong zonal and broad meridonal flow are minimally weak. The associated surface lows tend to be 3-4 mb weak and slow to deepen.

U/L lows north of the polar jet tend to be slightly deep.

U/L highs south of the jet are minimally strong.

The formation of U/L cut-off lows continues to be well forecast. The associated surface low in minimally overforecast (deep) throughout.

Wind speed forecast variability is greatest in the 300-250 mb jet stream region and shows a mean error of 6-7 m/s by 48 hr.

3.4.2. NORAPS 6.0 MODEL TENDENCIES

ASIA NORAPS provides a good depiction of cyclogenesis and depicts complex surface lows better than NOGAPS. NOGAPS will often depict a single, deeper low pressure system while NORAPS will often depict two or more centers, especially around Japan.

NORAPS surface low underforecasting tendency is slightly greater than NOGAPS. NORAPS is minimally weaker than NOGAPS during the developing phase. Position and directional bias are minimal, but NORAPS appears slow to move surface lows.

NORAPS 1000 mb and 500 mb forecast heights are generally higher than NOGAPS at 36 hr, indicating a greater positive height bias at both levels.

NORAPS and NOGAPS surface wind forecasts over the West Pacific basin tend to be 5-6 kt weak by 36 hr.

3.4.3. GLOBAL WAVE ACTION MODEL (GWAM) 4.0 MODEL TENDENCIES

The Global Wave Action Model (GWAM) is the primary tool (coupled with experience) used by forecasters for producing the 36 HR Significant Wave Prognosis and the high seas warning. The GWAM converts the marine layer winds and sea surface frictional effect into a unit of energy. These units are then converted into the significant wave heights seen on the prognostic charts. Significant wave height is defined as the height of the highest one-third of the waves.

The GWAM has several limitations:

1. GWAM, in confined areas (South China Sea, Yellow Sea and Sea of Japan), tends to overforecast seas.

2. Small topographic features are not considered; therefore, sea heights for confined straits are usually low. Island chains such as the Kurils that break up long fetches are not considered, so downwind sea height forecasts in these areas are often too high.

3. GWAM consistently underforecasts sea height in tropical areas mainly due to long period swell wave diffusion.

4. Sea heights need to be closely examined when associated with tropical cyclones. GWAM has a 12-24 hr delay in depicting developing and decaying systems. Mature storm sea heights are analyzed well.

5. GWAM does not consider shoaling, which results in sea heights being underforecast in the Luzon Straits and the South China Sea.

3.4.4. LOCAL FORECASTING RULES

3.4.4.1. COLD SURGE

The forecaster's challenge during the northeast monsoon is principally one of forecasting cold air surges into the Chinese coastal region and the formation of mid-latitude systems in the East China Sea and the Philippine Sea. During the winter season, cold air from the vicinity of Lake Baikal will surge south-southeastward into China and the adjacent waters every 4-6 days. Following a strong surge, sustained winds may reach 40 knots with seas building to 10-14 ft (3-4 m) in the East China and South China Seas. Gale force winds and seas near 18 ft (5.5 m) will spread rapidly throughout the northern two-thirds of the South China Sea. Winds over the Taiwan Straits will be appreciably higher than the pressure gradient would indicate mainly as a result of the funneling effect between China and Taiwan.

Two conditions must exist for the cold surge to reach the South China Sea:

1. Strong cold air advection must occur in the vicinity of Lake Baikal: -04° to -13° F (-20° to -25° C) at 850 mb and northerly winds of 40 knots.
2. A long wave trough of considerable amplitude must exist or develop along the East China coast.

If these conditions are not present the cold air tracking out of the Lake Baikal area will modify before reaching the coast. A long wave trough over eastern Japan will ensure a surge over the Yellow Sea and northern East China Sea, but the trailing cold front will become stationery before affecting the South China Sea.

3.4.4.2. MID-LATITUDE SYSTEM

The three northern lows (Lake Baikal, Mongolian and Manchurian) are often weak with very little precipitation. Moisture is obtained when the system moves over the open waters of the Sea of Okhotsk and Western Pacific. A typical system may exhibit cloudy skies on both sides of the occlusion or show a cold front with little change in temperature on either side before reaching the ocean. When considerable precipition and cloudiness are present, the low and frontal system will be associated with unstable air and move rapidly eastward.

During the winter, expect cyclogenesis in the Manchurian basin following cold frontal passage over the Korea-Japan area. Within 24 hours, these lows will deepen and move eastward over the Sea of Japan and form well-defined fronts.

Low level wind flow (surface to 700 mb) from the east through south over Korea/Japan will produce widespread inclement weather over the Sea of Japan, lasting up to 72 hours. A series of waves usually exists over the East China Sea and along the southern coast of Japan. The extent of development depends upon on the proximity of other systems and upper level support.

Southerly wind flow over the NWPAC, near Kamchatka and the Kuril Islands can produce extensive fog. Condensation occurs as the warm air flows over the cold Oyshio current. The fog may persist from several days to two weeks depending on the synoptic situation. High pressure to the east, producing this southerly wind flow, is the optimum situation for persistent fog.

If a low south of Japan moves in a northeasterly direction so that it reaches a position approximately 1,000 nm or more east-northeast of a low in the Sea of Japan, the low in the Sea of Japan will deepen and move northeastward.

If a low south of Japan moves to within 800 nm of a low in the Sea of Japan, the low south of Japan will become the major system. The system over the Sea of Japan will move eastward behind the major system or will be absorbed by the stronger southern system.

A low developing over Manchuria and moving into the Sea of Japan will be influenced by the intensity of the quasi-stationary low pressure system south of Kamchatka and the 700 mb flow. If the lows

are within 1,000 nm of each other, the Sea of Japan low will not deepen and will move easterly over northern Honshu. If the distance is greater than 1,000 nm, the Sea of Japan low will deepen rapidly and move northeasterly.

When the isobars are oriented northeast to southwest in line with the islands of Japan, weak cyclones frequently form off southern Kyushu. This type of pattern will often occur when cyclones have passed southern Japan. The trailing cold fronts associated with these lows are often slow moving and tend to stagnate off the coast of Japan.

Refer to section 3.3.3.2 for Bubble High Cyclogenesis.

3.4.4.3. NORTH WALL

The North Wall Effect is a function of a cold air mass moving over the warm Kuroshio Current similar to that seen on the East Coast of the United States. As the air/sea temperature contrast increases, instability increases, creating the possibility of winds stronger than the pressure gradient would indicate.

Two basic scenarios are associated with the North Wall Effect:

1. If the wind flow associated with a cold front is perpendicular to the Kuroshio (northwest), increased winds and seas will be generated at or just downwind from the North wall of the Kuroshio. Maximum seas occur 50-150 nm further downwind. Winds and seas associated with this scenario can increase by as much as 25-50% over what normally would be forecast for the same system.

2. If the wind flow opposes the direction of the Kuroshio (northeast), a more drastic increase in seas may occur. If the wind-driven seas oppose the flow of the current, the wave length decreases and wave height increases. Seas may increase by 50-100% if the sea direction directly opposes any significant ocean current.

Special attention must be paid to the areas offshore southern Honshu. Although not technically a product of the Northwall, increased wind and seas are often reported due to funneling through mountain passes and interaction with the Kuroshio as it flows northward.

3.4.4.4. SHEARLINE

Shearlines are the extreme southern extensions of cold fronts. A shearline separates two air masses that differ mainly in wind speed and direction.

This tropical feature is usually associated with clouds and precipitation resulting from weak to moderate cyclonic shear caused by significant variations in wind velocity to the north and south of the shearline. Cloud types tend to be more stratiform as opposed to the cumuliform cloud types usually found in tropical areas. Movement of shearlines, once they reach the tropics, is slow and erratic (progressive, retrogressive or stationary).

Expect shearline passage over Guam within 12-24 hours after the surface pressure at Chichi Jima reaches 1024 mb.

3.4.4.5. SHIPBOARD ICE ACCRETION

Shipboard icing is caused by a combination of atmospheric and sea conditions. In sub-freezing temperatures, precipitation can result in the formation of ice layers on exposed portions of the ship. In addition, high winds may cause particularly heavy icing due to dense seawater spray produced by bow slamming.

Major factors affecting shipboard icing are:

1. Air temperature,

2. Wind velocity,
3. Water temperature,
4. Geometry of accreting surface.

There are no exact methods of predicting ice accretion for ships at sea. Icing rates will vary with geometry of structure and orientation to wind and seas. Extensive research and observations by scientists and mariners has led to some fairly reliable indicators that can be plotted graphically.